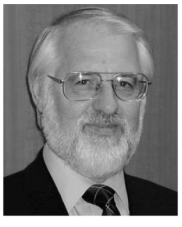
Editorial Board

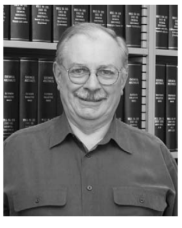
Executive Editor

Alan Katritzky was born in London, U.K. and educated at St. Catherine's College, Oxford, of which he became an Honorary Fellow in 2006. He was a Founder Fellow of Churchill College, Cambridge, and then founding Professor/Dean of the School of Chemical Sciences at the University of East Anglia, before crossing the Atlantic in 1980 to become Kenan Professor and Director of The Center for Heterocyclic Compounds at the University of Florida. He has researched, published, lectured, and consulted widely in heterocyclic chemistry, synthetic methods, and QSPR. He created the non-for-profit foundation ARKAT and since 2000 has organized the annual "Florida Heterocyclic and Synthetic Conferences" (Flohet), and publishes the "Archive for Organic Chemistry" (Arkivoc) completely free on the Internet at arkat-usa.org. His honors from 20 countries include 14 honorary doctorates.

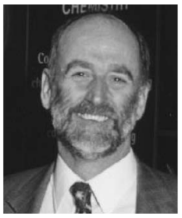
Editors-in-Chief



Chris Ramsden was born in Manchester, U.K. in 1946. He is a graduate of Sheffield University and received his PhD (W. D. Ollis) in 1970 and DSc in 1990. After post-doctoral work at the University of Texas (M. J. S. Dewar)(1971-3) and University of East Anglia (A. R. Katritzky)(1973-6), he worked in the pharmaceutical industry. He moved to Keele University as Professor of Organic Chemistry in 1992. His research interests are heterocycles, *ortho*-quinones and three-center bonds, and applications of their chemistry to biological problems.



Eric Scriven is a native of Wales, U.K. After working at BISRA and Esso Ltd, he attended the University of Salford and graduated in 1965. He obtained his M.Sc. from the University of Guelph, and his Ph.D. from the University of East Anglia (with Professor Katritzky) in 1969. After postdoctoral years at the University of Alabama and University College London, he was appointed Lecturer in Organic Chemistry at the University of Salford. There, his research interests centered on the reactivity of azides and nitrenes. While at Salford, he spent two semesters at the University of Benin, Nigeria. He joined Reilly Industries, Inc. in 1979 and he was Director of Research & Development from 1991 to 2003. He is currently at the University of Florida. He edited *Azides & Nitrenes* (1984), and he and Professor H. Suschitzky were founding editors of *Progress in Heterocyclic Chemistry*, which has been published annually since 1989 by the International Society of Heterocyclic Chemistry. He collaborated with Professors Katritzky and Rees as Editors-in-Chief of *Comprehensive Heterocyclic Chemistry II* (1996). Currently, he is Publishing Editor of *Arkivoc*, an online journal of organic chemistry that is free to readers and authors.



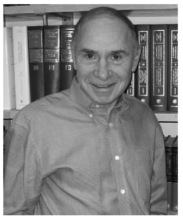
Richard J. K. Taylor is currently Professor of Organic Chemistry at the University of York, where his research focuses on the development of novel synthetic methodology and the synthesis of natural products and related compounds of biological/medicinal interest. The methodology is concentrated primarily on organometallic, organosulfur, oxidation and tandem processes, and the targets include amino acids, carbohydrates, prostaglandins and polyene and polyoxygenated natural products, particularly with activity as antibiotics and anti-cancer agents.

He is a graduate and postgraduate of the University of Sheffield (Ph.D. with Dr. D. N. Jones). He then carried out postdoctoral research at Syntex, California (Dr. I. T. Harrison) and at University College London (Professor F. Sondheimer). His first academic appointment was at the Open University in Milton Keynes. This post gave Professor Taylor the opportunity to contribute to Open University textbooks, radio programs and television productions on various aspects of organic chemistry. He then moved to UEA, Norwich, where he established his independent research program, before taking up his present position in York in 1993.

Richard Taylor was Chairman of the Royal Society of Chemistry's Heterocyclic Group (2000–2001), President of the Organic Division of the Royal Society of Chemistry (2001–2004), and is currently President-Elect of the International Society of Heterocyclic Chemistry. His awards include the Royal Society of Chemistry's Tilden Lectureship (1999), the RSC Heterocyclic Prize (1999) and the RSC Pedlar Lectureship (2007). He is currently the UK Regional Editor of the international journal *Tetrahedron*.

Volume Editors

Editor of Volume 1



Albert Padwa was born in New York City. He received both his B.A. and Ph.D. degrees from Columbia University. After a NSF postdoctoral position at the University of Wisconsin, he was appointed Assistant Professor of Chemistry at the Ohio State University in 1963. He moved to SUNY Buffalo in 1966 as Associate Professor and was promoted to Professor in 1969. Since 1979, he has been the William Patterson Timmie Professor of Chemistry at Emory University. He has held visiting positions at University Claude Bernard, France, University of California at Berkeley, the University of Wurzburg, Germany, Imperial College of Chemistry, UK, and the University of Melbourne, Australia. Professor Padwa has been the recipient of an Alfred P. Sloan Fellowship, John S. Guggenheim Fellowship, Alexander von Humboldt Senior Scientist Award, a Fulbright Hays Scholarship, Senior Award in Heterocyclic Chemistry from the International Society of Heterocyclic Chemists, ACS Arthur C. Cope Scholar Award and is the coauthor of more than 650 publications. He served as the Chairman of the Organic Division of the ACS and as President of the International Society of Heterocyclic Chemistry. He has also served as a member of the editorial boards of the *Journal of the American Chemical Society*, *Journal of Organic Chemistry*, *Organic Letters*, and has been the volume editor of *Comprehensive Heterocyclic Chemistry*, *the Synthesis of Science* (Vol. 27) and is currently one of the Associate Editors of the *Journal of Organic Chemistry*. His research interests include heterocyclic chemistry, dipolar cycloadditions, alkaloid synthesis, tandem transformations, organometallic chemistry, and organic photochemistry. Aside from chemistry, his other passion is mountain climbing in various parts of the world.

Editor of Volume 2

Christian V. Stevens (1965) is professor at the Department of Organic Chemistry at the Faculty of Bioscience Engineering (Ghent University, Belgium). He graduated as engineer of chemistry and biochemistry in 1988 and obtained his PhD in 1992 as fellow of the National Fund for Scientific Research under the direction of Prof. N. De Kimpe at Ghent University. During his PhD, he also worked as a research assistant of the University of Southern California (USC), Los Angeles in collaboration with Prof. C. E. McKenna. In 1992–93, he did post doctoral work at the Center for Heterocyclic Compounds at the University of Florida, USA under the direction of Prof. A. R. Katritzky as a NATO Research Fellow and became group leader in 1993. He returned to the faculty of Bioscience Engineering as a postdoctoral fellow of the National Fund for Scientific Research. In 1994, he performed a short postdoctoral stay at the University of Alicante (Spain) under the direction of Prof. M. Yus.

In 1995, he became group leader of the National Fund for Scientific Research and guest professor in 1997 at Ghent University. In 2000, he became professor at the Faculty of Bioscience Engineering.

Prof. C. V. Stevens published over 100 international peer reviewed scientific papers and reviews and lectured worldwide at the occasion of several international symposia (USA, Japan, India, Canada, Lithuania, China, . . .). He holds several patents on the synthesis and applications of renewable resources.

He is scientific editor and member of the editorial board of "Arkivoc", an international electronic journal on all aspects of heterocyclic chemistry, member of the Organizational Committee of the FLOHET meeting (Gainesville, Florida, USA) and executive board member of the Alumni society of the Faculty of Bioscience Engineering (Ghent University).

He is the editor of the first overview book on the use of renewable resources for non-food applications and is Editor of the Series on Renewable Resources that is currently being developed by Wiley. He has been coordinator of the European working group on Renewable Resources, directing a group of universities of 14 different European countries. He recently became consultant editor of "Biofuels, bioproducts and biorefining".

His research interest is focused on heterocyclic chemistry and organophosphorus chemistry related to agrochemical and medicinal applications, and on the use of renewable resources for the industry.

He received several awards including the prize of the alumni of the Faculty of Bioscience Engineering, the prize of the Royal Society of Engineers Flanders and he is laureate of the Royal Academy of Sciences of Belgium.

He is an active member of the Flemish Royal Chemical Society, member of the Royal Society of Chemistry Britain and member of the American Chemical Society.

Editors of Volume 3

Gurnos Jones was born in Breconshire, South Wales, in 1928. First degree (1949) and Ph.D. (1952) from Sheffield University, Ph.D supervisor Professor T. S. Stevens. Post doctoral work at Nottingham University with Professor F.E. King (1952–1954). Appointed to the University College of North Staffordshire (later University of Keele) in 1955, rising to full professor, Head of Chemistry, and Dean of Science. Visiting fellow at NIH, visiting professor at ANU, Canberra and the University of Michigan. Publications in many areas of heterocyclic chemistry and natural products. Editor of the Quinoline volumes of the Weissberger–Taylor series and of Volume 8 of CHEC 2. Author of many review articles in Organic Reactions, Advances in Heterocyclic Chemistry, CHEC 1 and CHEC 2. Founding secretary of the Chemical Society Heterocyclic Group, recently celebrating its 40th anniversary.

Volume 3 was co-edited by Christopher A. Ramsden (Editor-in-Chief).

Editor of Volume 4

John Arthur Joule was born in Harrogate, England but grew up and attended school in Llandudno, North Wales, going on to study for B.Sc., M.Sc., and Ph.D. (1961; with Dr. George F. Smith) degrees at The University of Manchester. Following post-doctoral periods in Princeton, USA (Dr. Richard K. Hill) and Stanford, USA (Dr. Carl Djerassi) he joined the academic staff of the University of Manchester where he served for 41 years, retiring and being appointed Professor Emeritus in 2004. Sabbatical periods were spent at The University of Ibadan, Nigeria, Johns Hopkins Medical School, Department of Pharmacology and Experimental Therapeutics, and the University of Maryland, Baltimore County. He was William Evans Visiting Fellow at Otago University, New Zealand (2004). Dr. Joule has taught many courses on heterocyclic chemistry to industry and academe in the UK and elsewhere. He has published some 190 original papers and 35 reviews in the areas of alkaloid chemistry and synthesis, and heterocyclic chemistry. *Heterocyclic Chemistry*, cowritten with his Ph.D. supervisor, was first published in 1972; a fourth edition appeared in 2000, written jointly with a former Joule research student then GSK chemist, Dr. Keith Mills; these authors also published *Heterocyclic Chemistry at a Glance* in 2007. Dr. Joule is Associate Editor for *Tetrahedron Letters*, Scientific Editor for *Arkivoc*, and Co-Editor (with Dr. Gordon Gribble) of *Progress in Heterocyclic Chemistry*.

Editor of Volumes 5 & 6

Viktor V. Zhdankin was born in Ekaterinburg, Russian Federation. His M.S. (1978), Ph.D. (1981), and Doctor of Chemical Sciences (1986) degrees were earned at Moscow State University in the laboratory of Heterocyclic Compounds under guidance of Professor Nikolay S. Zefirov. He moved to the University of Utah in 1990, where he worked for three years as Instructor of organic chemistry and Research Associate with Professor Peter J. Stang. In 1993 he joined the faculty of the University of Minnesota Duluth where he is currently a Professor of Chemistry. He has published 200 research papers including 21 reviews and book chapters. His main research interests are in the field of organic chemistry of hypervalent main-group elements (iodine, phosphorus, sulfur, and xenon) with particular recent emphasis on the chemistry of hypervalent iodine heterocycles.

Editor of Volume 7

David Black was born in Wollongong in 1938 and after working at Monash University from 1965–1982 was appointed to the Chair of Organic Chemistry at UNSW in 1983. He graduated B.Sc. and M.Sc. at the University of Sydney and was awarded an Overseas Scholarship of the Royal Commission for the Exhibition of 1851 to undertake a Ph.D. in Cambridge (with Lord Todd). He was then a Postdoctoral Research Associate at Columbia University (with Tom Katz) before taking up his appointment at Monash University. He has spent periods of study leave at the ETH Zürich in 1968–69 (with Albert Eschenmoser), Würzburg University in 1974 (with Siegfried Hünig) (as an Alexander von Humboldt Fellow) and Cambridge University in 1980 (with Alan Battersby). He has also held Visiting Professorships at the Science University of Tokyo (1988), the University of Auckland (1992), Göttingen University (1994), Innsbruck University (1999) and Kobe Pharmaceutical University (2000) and given numerous invited lectures at international conferences and major universities. He has won the Rennie Medal (1970), H. G. Smith Medal (1993), the A. J. Birch Medal (2003), and the Leighton Medal (2004) of the Royal Australian Chemical Institute (RACI), and in 1990 was the Liversidge Lecturer of the Royal Society of New South Wales and also the Royal Society of Chemistry Lecturer. He was President of the RACI in 1998, and was Chair of the National Committee for Chemistry from 1999–2003.

He has been a committee member of the Division of Organic and Biomolecular Chemistry of the International Union of Pure and Applied Chemistry (IUPAC) (1994–2003), and was Secretary (2000–2001) and Vice President (2002–2003). He was elected Secretary General of IUPAC from 2004–2007, and recently re-elected for a second four-year term. From 1993 until 2007, he was Leader of the Joint Selection Team for Australian Development Scholarships for Indonesian postgraduate students. At UNSW he was Head of the School of Chemistry from 1987–1990, and acting Dean of the Faculty of Science from January to July 1987. He was Associate Dean (Research) for the Faculty of Science and Technology and then the Faculty of Science from 2000–2003.

His research, described in more than 250 publications, has led to the synthesis of new types of organic molecules and the discovery of new synthetic methodologies, especially in heterocyclic chemistry. He has also written a monograph (with J. M. Swan) entitled "Organometallics in Organic Synthesis".

Editor of Volume 8

Alan Aitken was born in the Dumfries and Galloway area of SW Scotland. He studied at the University of Edinburgh where he obtained a B.Sc. in 1979 and his Ph.D. in 1982 under the direction of Dr I. Gosney and Professor J. I. G. Cadogan. After spending two years as a Fulbright Scholar in the laboratories of Professor A. I. Meyers at Colorado State University he was awarded a Royal Society Warren Research Fellowship and moved in 1984 to the University of St Andrews where he has been a Senior Lecturer since 1997. His research interests are in the area of synthetic and mechanistic organic chemistry including asymmetric synthesis, synthetic use of flash vacuum pyrolysis, heterocyclic chemistry, organophosphorus and organosulfur chemistry.

Editor of Volume 9

Kenneth Turnbull was born in Edinburgh, Scotland in 1951. He received his B.Sc. and Ph.D. degrees from Heriot-Watt University, Edinburgh. After two years as a postdoctoral research associate at the University of Toronto he joined the chemistry faculty at Grinnell College in Grinnell, Iowa. Since 1980 he has been at Wright State University in Dayton, Ohio, where he is presently Professor and Chair of the chemistry department. His research interests focus mainly on heterocyclic chemistry, especially sydnones.

Editor of Volume 10

Ray Jones started his chemistry career as an undergraduate and then completing a Ph.D. at Cambridge University under the supervision of Professor Sir Alan Battersby, in the area of alkaloid biosynthesis. After a year as an ICI Postdoctoral Fellow in the laboratories of Professor Albert Eschenmoser at the ETH Zurich, he was appointed as Lecturer in Organic Chemistry at University of Nottingham in 1974. He progressed to Senior Lecturer at Nottingham and then took up the Chair of Organic Chemistry at the Open University in 1995, before moving to the Chair of Organic and Biological Chemistry at Loughborough University in 2000.

His research interests span heterocyclic and natural product chemistry, with over 100 publications. Example topics include the acyltetramic acids and pyridones; Mammea coumarins; spermine and spermidine alkaloids; imidazolines as templates for (asymmetric) synthesis; dipolar cycloadditions; and unusual amino-acids and peptide mimetics.

Editor of Volume 11

Janine Cossy's early career was spent in Reims, where she did her undergraduate and graduate studies at the University of this city, working on photochemistry under the supervision of Pr Jean Pierre Pète. After a postdoctoral stay with Pr Barry Trost, for two years at the University of Wisconsin (USA), she returned to Reims where she became, in 1990, Director of Research of CNRS. In the same year, she moved to Paris to become Professor of Organic Chemistry at the ESPCI (Ecole Supèrieure de Physique et de Chimie Industrielles de la Ville de Paris) and, in 1991, she was nominated Director of the CNRS Unit at the ESPCI, UMR 7084.

Janine Cossy's research interests focus on the synthesis of natural products and biologically active molecules (anti-cancer agents, antibiotics, anti-inflammatory agents and central nervous system drugs). The synthetic methodologies that she develops and applies include radical reactions, photochemistry, thermal reactions, organometallic reactions, catalysis, ring expansions, opening of strained rings, methods for the synthesis of heterocyclic compounds, stereoselective reactions and synthesis on solid support. Her research efforts have resulted in more than 350 publications and patents.

In addition, Janine Cossy is currently on the international advisory boards of numerous journals, and associate editor of Organic Letters since 2005.

Editor of Volume 12

Keith Jones was born in Manchester. He studied at Cambridge University for his B.A. in Natural Sciences (1976) and stayed to carry out research with Professor Sir Alan Battersby obtaining his Ph.D. in 1979. In 1979, he moved to a lectureship at King's College London. In 1984, he caught up with his postdoctoral research by spending a year working with Professor Gilbert Stork at Columbia University, New York. After returning to King's College, he became a reader in 1995. In 1998, he moved to a chair in organic and medicinal chemistry at Kingston University. In 2005, he moved to a chair in synthetic chemistry at The Institute of Cancer Research at Sutton, London. At The Institute, he leads a team of chemists carrying out a range of projects in cancer drug discovery, focusing on the inhibition of chaperones and signaling proteins. In addition to cancer drug discovery, he retains an active interest in heterocyclic chemistry and the use of radicals and other reactive intermediates in synthesis. He was Secretary of the Heterocyclic Group of the RSC from 1995–1998 and Chairman from 2005–2007

Editor of Volumes 13 & 14

George R. Newkome received his BS and PhD in chemistry from Kent State University. He joined Louisiana State University in 1968 becoming a full professor in 1978 and Distinguished Research Master in 1982. In 1986, he moved to the University of South Florida as Vice President for Research and Professor of Chemistry, becoming a Distinguished Research Professor in 1992. In 2001, he was appointed as Oelschlager Professor of Science and Technology at the University of Akron, where he is also Professor of Polymer Science and Chemistry, Vice President for Research, Dean of the Graduate School, and President of the University's Research Foundation. He has 20 edited and authored books, over 400 journal publications, and numerous patents resulting from research in supra(macro)molecular chemistry, molecular dendritic and fractal assemblies, nanochemistry, inorganic-organic interfaces, molecular inclusion chemistry, molecular electronics, and photonics.

Introduction

Alan R. Katritzky, Christopher A. Ramsden, Eric F. V. Scriven, and Richard J. K. Taylor

1 Scope, Significance, and Aims

1.1 Scope

Heterocyclic compounds possess a cyclic structure with two or more different kinds of atoms in the ring. This work is devoted to organic heterocyclic compounds in which the ring contains at least one carbon atom; all atoms other than carbon are considered as heteroatoms. Carbon is still by far the most common ring atom in heterocyclic compounds, but the number and variety of heteroatoms in the rings of known compounds has increased as the years go by and thus there is a steady transition to include the expanding domain of inorganic heterocyclic systems. Since rings can be of any size, from three-membered upwards, and since the heteroatoms can be drawn in almost any combination from a large number of the elements (though nitrogen, oxygen, and sulfur are still by far the most common), the number of possible heterocyclic systems is almost limitless. An enormous number of heterocyclic compounds is known and this number continues to increase very rapidly. The literature of the subject is correspondingly vast and of the three major divisions of organic chemistry, aliphatic, carbocyclic, and heterocyclic, the last is by far the largest. Over 31 million compounds are now recorded in *Chemical Abstracts* and a very large proportion of these are heterocyclic.

1.2 Significance

Heterocyclic compounds are very widely distributed in nature and are essential to life, playing a vital role in the metabolism of all living cells. For example, the following are heterocyclic: the pyrimidine and purine bases of RNA and DNA; three of the essential amino acids (proline, histidine, and tryptophan); several vitamins and coenzyme precursors (thiamine, riboflavine, pyridoxine, folic acid, biotin, and the B_{12} and E families of vitamins); the photosynthesizing pigment chlorophyll; the oxygen-transporting pigment hemoglobin and its breakdown products, the bile pigments; many hormones (kinetin, heteroauxin, serotonin, and histamine); and most sugars. There are a vast number of pharmacologically active heterocyclic compounds, many of which are in regular clinical use. Some of these are natural products, for example antibiotics such as penicillin and cephalosporin; alkaloids such as vinblastine, ellipticine, morphine, and reserpine; and cardiac glycosides such as those of digitalis. However, the large majority of pharmaceuticals are synthetic heterocyclics which have found widespread use, *inter alia* as anticancer agents, analeptics, analgesics, hypnotics, and vasopressor modifiers.

Other heterocyclics serve as pesticides, insecticides, herbicides, and rodenticides. Further important practical applications include dyestuffs, copolymers, solvents, photographic sensitizers and developers, and antioxidants and vulcanization accelerators in the rubber industry. Many heterocycles are valuable intermediates in synthesis.

The successful application of heterocyclic compounds in these and many other ways, and their utility in applied chemistry and in more fundamental and theoretical studies, stems from their very complexity; this ensures a virtually limitless series of structurally novel compounds with a wide range of physical, chemical, and biological properties, spanning a broad spectrum of reactivity and stability. Another consequence of the varied chemical reactivity of heterocycles, including the possible destruction of the heterocyclic ring, is their increasing use in the synthesis of specifically functionalized nonheterocyclic structures.

1.3 Aims of CHEC-I, CHEC-II and CHEC-III

The above aspects of heterocyclic chemistry are mirrored in the contents of the present work. The scale, scope, and complexity of the subject, already referred to, with its correspondingly complex system of nomenclature, can make its study initially somewhat daunting. A main aim of the original edition of *Comprehensive Heterocyclic Chemistry,* (CHEC-I), of its first update (CHEC-II) and of the present work (CHEC-III), is to alleviate this problem by presenting a comprehensive account of fundamental heterocyclic chemistry. The emphasis is on basic principles and, wherever possible, on unifying correlations in the properties, chemistry, and synthesis of different heterocyclic systems and the analogous carbocyclic structures. The motivation for this effort was the outstanding biological, practical, and theoretical importance of heterocyclic chemistry, and the absence of an appropriate major modern treatise when CHEC-I was conceived in 1980.

At the introductory level there are several good heterocyclic chemistry texts, although the subject is scantily treated in most general textbooks of organic chemistry. At the specialist, research level there are two established ongoing series, "Advances in Heterocyclic Chemistry" edited by Katritzky and "The Chemistry of Heterocyclic Compounds" edited by Weissberger and Taylor, both devoted to a very detailed consideration of all aspects of heterocyclic compounds, which together comprise almost 200 volumes. CHEC-I was designed to fill the gap between these

two levels, i.e., to give an up-to-date overview of the subject as a whole (particularly in the general chapters) appropriate to the needs of teachers and students and others with a general interest in the subject and its applications, and to provide enough detailed information (particularly in the monograph chapters) to answer specific questions, to demonstrate exactly what is known or not known on a given topic, and to direct attention to more detailed reviews and to the original literature. Encouraged by the extensive practical uses of heterocyclic compounds, a large and valuable review literature on all aspects of the subject has grown up over the past fifty years. Appropriate references to these reviews are included in CHEC-III as well as in both CHEC-I and CHEC-II.

2 Arrangement of the Work in Volumes

2.1 Relationship of CHEC-III to CHEC-I and CHEC-II

CHEC- I and CHEC-II, published in 1984 and 1996 respectively, together covered the literature through 1995. Since then, the field has continued to proceed apace. The success of CHEC-II has encouraged us to bring it up to date with a new edition, CHEC-III. The present new work, CHEC-III, concentrates on material published in 1996 and later.

CHEC-III retains essentially the organization of the material used in CHEC-II.

2.2 Arrangement of CHEC-III in Volumes

Heterocyclic compounds are normally classified according to the size of the heterocyclic ring and the nature and number of the heteroatoms. The present work is organized on this basis.

Volume 1 covers three-membered heterocycles, together with all fused systems containing a three-membered heterocyclic ring.

Volume 2 covers four-membered heterocycles together with all fused systems containing a four-membered heterocyclic ring.

Volume 3 covers five-membered rings with one heteroatom together with their benzo- and other carbocyclic-fused derivatives.

Volumes 4 covers five-membered rings with two heteroatoms with their fused carbocyclic compounds.

Volume 5 covers triazoles, oxadiazoles, thiadiazoles, and their fused carbocyclic derivatives.

Volume 6 covers other five-membered rings with three or more heteroatoms and their fused carbocyclic derivatives.

Volumes 7, 8, and 9 cover six-membered rings with one, two, or more than two, heteroatoms, respectively, again each with fused carbocyclic compounds.

Volumes 10, 11, and 12 cover systems containing at least two fused heterocyclic five- and/or six-membered rings. Volume 10 deals with such biheterocyclic rings without a ring junction heteroatom. Volume 11 deals with bicyclic five-five and five-six fused ring systems with at least one bridgehead nitrogen. Volume 12 covers six-six bicyclic fused systems with one nitrogen, bicyclic systems with two nitrogen bridgehead atoms, other bridgehead heteroatoms, together with polycyclic and spirocyclic systems.

Volume 13 covers seven-membered heterocyclic rings including fused derivatives.

Volume 14 covers eight-membered and larger heterocyclic rings including fused derivatives, plus some less common seven-membered rings.

Volume 15 contains the Subject Index.

2.3 Arrangement of CHEC-II in Volumes

Volume 1 (Parts 1A and 1B) covers three- and four-membered heterocycles, together with all fused systems containing a three- or four-membered heterocyclic ring.

Volume 2 covers five-membered rings with one heteroatom together with their benzo- and other carbocyclic-fused derivatives.

Volumes 3 and 4 cover five-membered rings with two heteroatoms, or more than two heteroatoms, respectively, each with their fused carbocyclic compounds.

Volumes 5 and 6 cover six-membered rings with one, or more than one, heteroatom, respectively, again with fused carbocyclic compounds.

Volumes 7 and 8 cover systems containing at least two fused heterocyclic five- and/or six-membered rings. Volume 7 deals with such biheterocyclic rings without a ring junction heteroatom. Volume 8 deals with those containing ring junction heteroatoms, together with systems with three five- and/or six-membered fused heterocyclic rings and with spiro cyclic systems.

Volume 9 covers seven-membered and larger heterocyclic rings including all fused derivatives (except those with three- or four-membered rings which are included in Volume 1).

Volume 10 contains the Author and Ring Indexes.

Volume 11 contains the Subject Index.

2.4 Arrangement of CHEC-I in Volumes

Volume 1 deals with (a) the nomenclature and the literature of heterocyclic compounds (Chapters 1.02 and 1.03); (b) various special topics (Chapters 1.04-1.16); and (c) rings containing less common heteroatoms (Chapters 1.17-1.22).

The literature chapter presents an organized collection of references to leading papers, review articles, and books dealing with all aspects of heterocyclic chemistry which span more than one ring system. Other reviews which deal with a specific ring system are reported in the appropriate monograph chapter.

The special topics discussed are (a) the biological aspects of heterocyclic compounds, i.e. their biosynthesis, toxicity, metabolism, role in biochemical pathways, and their uses as pharmaceuticals, agrochemicals, and veterinary products; (b) the use of heterocyclic compounds in polymers, dyestuffs and pigments, photographic chemicals, semiconductors, and additives of various kinds; and (c) the use of heterocyclic compounds as intermediates in the synthesis of nonheterocyclic compounds.

The less common heteroatoms are those other than nitrogen, oxygen, and sulfur (and selenium and tellurium which are treated alongside sulfur), i.e., phosphorus, arsenic, antimony, bismuth, the halogens, silicon, germanium, tin, lead, boron, and the transition metals.

Volumes 2 and 3 deal with mono- and polycyclic compounds with one or more six-membered heterocyclic rings, with nitrogen, oxygen, and sulfur as the heteroatoms. Volume 2 contains the six-membered rings with one nitrogen atom and Volume 3 the six-membered rings with two or more nitrogens and with oxygen and sulfur heteroatoms.

Volume 4 covers five-membered heterocyclic rings with one oxygen, sulfur, or nitrogen as the heteroatom and **Volumes 5 and 6** covers the same sized rings with more than one heteroatom. Rings with two or more nitrogen atoms only are in Volume 5 and those with nitrogen, oxygen, and sulfur are in Volume 6.

Volume 7 covers heterocyclic compounds with rings smaller than five and larger than six. (The separate monograph chapters deal with three-membered rings with nitrogen, oxygen, and sulfur, with two heteroatoms, and their fused derivatives, four-membered rings with nitrogen, oxygen, and sulfur, with two or more heteroatoms, and their fused derivatives, cephalosporins, penicillins, seven-membered rings with nitrogen, oxygen, sulfur, and with two or more heteroatoms, eight-membered rings, larger rings, crown ethers and cryptands, and heterocyclophanes.)

Volume 8 contains the Author and Subject Indexes, together with a Ring Index and a Physical Data Index which are described in Section 1.01.7.

3 Rationale for Arrangement of Material in Individual Volumes

3.1 Major Divisions of Carbocyclic and Heterocyclic Chemistry

Carbocyclic compounds are very usefully divided into (a) saturated compounds denoted as alicyclic compounds, (b) aromatic compounds, and (c) the intermediate partially unsaturated compounds also denoted as alicyclic compounds. Heterocyclic compounds can be subdivided in much the same way, and this is equally useful.

On the whole, the physical and chemical properties of saturated and partially unsaturated (i.e. alicyclic) carbocyclic compounds closely resemble those of the analogous acyclic compounds formally derived by cleavage of the carbon ring at a point remote from any functionality. Significant differences in properties can arise from conformational effects and from strain effects in small rings. Usually relatively small, these differences can be striking in properties which are particularly sensitive to molecular shape.

In marked contrast to the alicyclic derivatives the fully "unsaturated" aromatic compounds, epitomized by benzene, contain carbocyclic rings which formally consist of a conjugated set of alternating single and double bonds. Such systems have a specially stabilized cyclic π-electron system in which all of the bonding molecular

orbitals are completely filled and the anti bonding orbitals are all empty. The concept of aromatic properties initially associated with six-electron systems, as in benzene, the cyclopentadienyl anion, and the cycloheptatrienyl cation, was later extended to any planar, monocyclic, fully conjugated polyene with a closed shell of $(4n+2)$ π-electrons. Although not easily rigorously defined and quantified, the concept of aromaticity has been of enormous value in the understanding of carbocyclic chemistry. Since it is associated with molecular orbital energies, aromaticity is not particularly sensitive to the nature and number of the ring atoms and the concept is thus of equal importance in heterocyclic chemistry. The main features of carbocyclic aromatic systems are (a) their stability, and hence their ready formation and regeneration after chemical attack, (b) their tendency to undergo substitution reactions which preserve the aromatic system rather than addition reactions which destroy it, (c) the uniformity of the bond lengths in the ring which are not alternating single and double, and (d) their special spectroscopic characteristics, particularly NMR. All of these features reappear, to a greater or lesser extent, in heteroaromatic chemistry.

3.2 Saturated Heterocyclic Compounds

As noted above, the formation of an alicyclic ring from an acyclic compound makes relatively little difference to the properties of the compounds. The same principle applies to the formation of a saturated heterocyclic compound from the corresponding acyclic compound, providing that the environment of the heteroatom is not changed significantly. Thus, saturated cyclic ethers, sulfides, and amines are very similar in physical and chemical properties to the analogous dialkyl ethers, sulfides, and dialkyl- and trialkylamines. Differences arise in small ring compounds where chemical reactivity is enhanced greatly by strain in three-membered rings and to a lesser, but still significant, extent in four-membered rings. Furthermore, properties which depend critically on steric requirements, particularly of lone pairs of electrons on the heteroatom, can be significantly altered. Thus a very good approximation of the properties of tetrahydropyran and piperidine can be obtained from those of ethyl propyl ether and ethylpropylamine, respectively. Piperidine is a typical secondary aliphatic amine of about the same base strength as ethylpropylamine. However, it is substantially more reactive as a nucleophile, because of the reduction in the steric encumbrance of the nitrogen lone pair caused by ring formation.

3.3 Partially Unsaturated Heterocyclic Compounds

The same general principles also extend to the partially unsaturated rings, although with extra complications expected from the presence of the double bond(s), especially in small rings. If the double bond is conjugated with the heteroatom, then the expected consequences of electron delocalization are observed; thus such oxygen and nitrogen compounds of this type can be considered as enol ethers and enamines, respectively, and will show the appropriate modified reactivity. Again, as expected, dihydro-heteroaromatic compounds frequently oxidize readily to the corresponding aromatic compound.

3.4 Heteroaromatic Compounds

Although the range of heteroaromatic structures has expanded considerably in the last half century, the central core of the heteroaromatic structures is still based on 6π-electron systems. These structures are related to, and formally derived from, benzene by successive replacement of (i) single annular CH groups by trivalent heteroatom groups, and/or (ii) of a pair of adjacent CH groups by a divalent heteroatom. In each of these cases the overall pattern of filled bonding molecular orbitals is retained. Thus replacement of one benzene CH group by O^+, S^+, or N gives respectively the six-membered pyrylium, thiapyrylium, or pyridine systems, and replacement of two adjacent benzene CH groups by O, S, or NH gives the five-membered furan, thiophene, or pyrrole classes. Multiple replacements are also possible and systems with up to four heteroatoms in five- and six-membered rings are common. The 6π-electron structure is preserved since the trivalent and divalent heteroatoms contribute one and two electrons, respectively, to the aromatic orbitals.

3.5 Characteristics of Heteroatoms in Rings

The replacement of one CH group in benzene by —N= to give pyridine introduces an electron-withdrawing heteroatom into the ring. The electron-withdrawing effect is accentuated when a CH in benzene is replaced by a

positively charged atom (NR^+, O^+, or S^+). Thus the six-membered heteroaromatic rings are electron deficient (π-deficient). The introduction of further heteroatoms into a six-membered ring reinforces these effects. Thus, for example, the chemistry of pyrazine is related to that of pyridine in much the same way as that of pyridine is related to benzene.

The replacement of two CH groups in benzene by a neutral NR, O, or S introduces into the new ring an electron-donating heteroatom. This electron-donor character is accentuated in the pyrrole anion where N^- is introduced. Thus the five-membered rings with one heteroatom are electron rich (π-excessive), and the chemistry of pyrrole, furan, and thiophene is dominated by this effect.

However, five-membered rings containing two or more heteroatoms necessarily possess both a pyridine-like heteroatom *and* a pyrrole-like heteroatom and thus their chemistry shows similarities to both those of the six-membered rings *and* of the five-membered rings with one heteroatom.

3.6 The General Chapters of CHEC-I

Three general chapters on structure, reactivity, and synthesis precede the monograph chapters in each of Volumes 2 through 7 of CHEC-I. The purpose is to introduce each family of ring systems and to emphasize the logical correlations within them, and so to help in the understanding of known reactions and in the prediction of new ones. These 12 general chapters thus provide an overview of the whole subject of heterocyclic chemistry and they are of particular interest to students and teachers. These general chapters also appeared in both the 1985 original and the 2000 2nd edition of the *Handbook of Heterocyclic Chemistry*. It is planned that they will appear in a new 3rd edition of the *Handbook*, presently in preparation.

4 Organization of Individual Monograph Chapters

CHEC-III and CHEC-II are both composed essentially entirely of monograph chapters. Monograph chapters dealing with single ring systems are divided into the three sections dealing with structure, reactivity, and synthesis and are given a fourth section, where appropriate, on applications and important compounds. Where two or more ring systems are covered in one chapter, they are, where appropriate, treated together in the same sections. The following conventions concern the treatment of fused rings in both CHEC-II and CHEC-III.

Fused benzene and other carbocyclic rings are treated as substituents. Thus quinoline, for example, is considered as a substituted pyridine (albeit a very special and important one) and is treated alongside other substituted pyridines in the discussion of its structure, reactivity, and synthesis. Reactions of quinoline at positions 1 to 4 are considered as reactions at ring atoms, whilst reactions at positions 5 to 8 are regarded as reactions of the "substituent". Structures containing two or more *non*fused heterocyclic rings are treated in the appropriate monograph chapter appearing last in the sequence. However, fused heterocyclic ring systems are treated in separate monograph chapters. In the 11 volumes of CHEC-II, fused heterocycles appear in Volumes 7 and 8 unless they contain a small or large heterocyclic ring, which are treated in Volumes 1 and 9 respectively. In the 15 volumes of CHEC-III, the same organization is followed with small and large rings treated in volumes 1/2 and 13/14, respectively, and fused heterocycles with two-, five-, or six-membered rings in volumes 10, 11, and 12.

The applications sections of monograph chapters provide access to important compounds used in medicine or industry, to industrially important sources of compounds, and to key natural products.

As far as practical, a standard arrangement of the material in the various chapters has been followed in the belief that this will:

(a) assist readers in retrieving information;
(b) indicate what is *not known* as well as what is known;
(c) facilitate comparisons between different ring systems;
(d) assist authors in the organization of their material.

Whereas the chapters in CHEC-I were organized in four main sections: structure, reactivity, synthesis, applications; the chapters in both CHEC-II and CHEC-III are organized in 12 sections, as the following overview of the CHEC-III arrangement indicates.

4.1 Introduction

If appropriate, this commences in CHEC-III with a brief historical piece, comments on the relationship of the new chapter to the corresponding chapter in CHEC-II, and provides general references to reviews of the material. The scope of the chapter is outlined with a survey of the various structural types and nomenclature of the parent, its nonconjugated isomers, partially reduced compounds, oxo compounds and benzo derivatives. Distinction is made here between the structural types possible and those which are known and treated in the chapter.

4.2 Theoretical Methods

Since the publication of CHEC-II, theoretical methods have continued to grow in importance. This section outlines the scope of what has been done with both *ab initio* (e.g., DFT) and semiempirical (e.g., AM1) molecular orbital methods, and with molecular mechanics.

4.3 Experimental Structural Methods

Methods covered include X-ray, neutron and electron diffraction, microwave spectroscopy, and their results in terms of molecular dimensions. NMR spectroscopy is treated in some detail as befits its importance, not only proton, but particularly ^{13}C, ^{15}N, and, where appropriate, other nuclei. The section on mass spectrometry briefly covers fragmentation patterns. UV/Fluorescence, IR/Raman, photoelectron spectroscopy, ESR, and dipole moments are covered as appropriate.

4.4 Thermodynamic Aspects

Boiling points and melting points are considered from the point of view of intermolecular forces between the molecules, together with solubilities and chromatographic behavior, both gas and liquid chromatography. The topic of aromaticity and stability in general is covered as befits its importance. Conformations, particularly of the cyclic nonplanar compounds, are dealt with. A section on tautomerism covers both prototropic tautomerism (annular and of substituents) and ring-chain tautomerism.

4.5 Reactivity of Fully Conjugated Rings

CHEC-II and CHEC-III both utilize this heading in place of "reactivity at heteroaromatic rings" used in CHEC-I. The change was made because of the difficulty in defining exactly the term "aromatic". "Cyclically conjugated" is defined here as any ring that does not contain an sp^3-hybridized carbon or nitrogen atom in it. Thus, "fully conjugated" includes all heteroaromatic rings, antiaromatic rings, and some rings that have little aromaticity although they are completely conjugated.

In most cases, the introduction and overview give a general survey of the reactivity and make comparisons with analogous ring systems, as well as referring to the corresponding chapter in CHEC-II. The following sections are then considered in turn:

(a) thermal and photochemical reactions that are unimolecular;
(b) electrophilic attack at nitrogen; the further detailed organization corresponds to the corresponding chapter in the *Handbook of Heterocyclic Chemistry; (both 1st and 2nd Editions);*
(c) electrophilic attack at carbon, organized as in the *Handbook of Heterocyclic Chemistry;*
(d) where the ring contains cyclic sulfur, electrophilic attack at sulfur is next covered;
(e) nucleophilic attack at carbon is dealt with according to the nucleophilic atom which is carrying out the attack;
(f) nucleophilic attack at hydrogen attached to carbon (deprotonation) is considered, for both neutral and cationic rings;
(g) reactions with radicals and electron-deficient species (carbenes, nitrenes) and also reactions at surfaces (heterogeneous catalysis) and reductions;
(h) intermolecular cyclic transition state reactions.

4.6 Reactivity of Nonconjugated Rings

The different types of nonconjugated rings are classified as follows.

(a) Isomers of aromatic compounds are dealt with in two classes: those which are not in equilibrium with the corresponding fully conjugated derivative, and then those which are in such an equilibrium. For the latter class, the main discussion should come under the corresponding tautomeric derivative (which will often be a cyclic hydroxy compound).
(b) Dihydro- derivatives of various types are considered with emphasis on the role of carbonyl compounds and discussion of the ease of aromatization.
(c) Tetrahydro- derivatives are dealt with followed, if appropriate, by hexahydro derivatives.

4.7 Reactivity of Substituents Attached to Ring Carbon Atoms

With this section, the classification in the *Handbook of Heterocyclic Chemistry* has been followed; thus a general survey of the effect of rings on the reactions of substituents is followed by a survey of the effect of rings on reactions of individual substituents in the order: fused benzene rings, C-linked, N-linked, O-linked, S-linked substituents, halogens, and metals. Substituents attached to cyclic nitrogen and sulfur are dealt with as described below.

4.8 Reactivity of Substituents Attached to Ring Heteroatoms

Substituents attached to ring nitrogen are discussed in order of the atom linking the substituent to the ring nitrogen atom just as described above. If the ring contains sulfur, then substituents attached to sulfur atoms are next considered. These are often oxygen, but may also be carbon and nitrogen.

4.9 Ring Syntheses Classified by Number of Ring Atoms in Each Component

A treatment similar to that in CHEC-I and CHEC-II is followed.

4.10 Ring Synthesis by Transformation of Another Ring

A treatment similar to that in CHEC-I and CHEC-II is followed; some methods are dealt with by cross-references.

4.11 Synthesis of Particular Classes of Compounds and Critical Comparison of the Various Routes Available

The present overview is intended to cover materials from both CHEC-II and CHEC-I.

4.12 Important Compounds and Applications

Specialized applications are no longer dealt with in a separate chapter (as was done in CHEC-I) and these sections cover the important advances since CHEC-II.

5 The Reference System

The same reference citation system is employed for CHEC-III as was used for CHEC-I and CHEC-II. It rapidly becomes familiar with use and has distinct advantages over the more common superscript number method. In this system reference numbers appear neither in the text, in tables, in footnotes, nor at the end of chapters. Instead, each time a reference is cited, there appears in angle brackets a letter code assigned to the journal, preceded by the year and followed by the page number. For example, "It was shown <1980TL2727> that . . ." refers to 1980, "TL" to *Tetrahedron Letters* and "2727" to the page number. For journals which are published in separate parts, or which have more than one volume per year, the appropriate part or volume is indicated, for example <2006H(68)879> refers to Heterocycles, 2006, volume 68, p. 879. A full list of journal codes is reproduced in each volume; some journal codes

have been changed to more concise 3 letter codes. Patents have three-letter codes, the first 2 letters indicate the country code and the final letter is 'P' for an issued patent or 'A' for a patent application, for example <1960USP2922790> refers to *US Pat.* 2 922 790 (1960). Books which are frequently referred to are also given a code. Journals and books which are referred to rarely are given a miscellaneous code (MI) starting each year and numbered sequentially 1, 2, 3 etc. Books are indicated by the prefix "B-".

This reference system is considered to be more useful than the conventional superscript number method since it enables the reader to see immediately in which year and in which journal (at least for the more common journals whose letter codes soon become familiar) the work cited was published. The reader is thus able to go directly to the original literature reference without having to consult a bibliography.

All references for chapters in a given volume are collected together in a merged list at the end of that volume (where they are most easily located). There are no separate chapter bibliographies. In the final list, references are given both in code and in full conventional form, with authors' names. They appear in an ordered sequence, numerically by year, then alphabetically by journal code, and finally by page number. Cross-references to the text citation are also given in the reference list.

Chemical Abstract references are given when these are likely to help; in particular they are given for all patents, and for less accessible sources such as journals whose language is other than English, French, or German, company reports, obscure books, and theses.

6 The Indexes

6.1 Ring Index

The Ring Index for CHEC-III is published as part of the online version.

6.2 Subject Index

The Subject Index of over 40,000 entries has been compiled from keywords, names, and formulae in the text and tables. It covers general classes of compound, specific compounds, general types of reactions, specific and named reactions, spectral and other properties, and other topics in heterocyclic chemistry. More details are again given at the beginning of the index in each volume.

Explanation of the Reference system

Throughout this work, references are designated by a number-lettering coding of which the first four numbers denote the year of publication, the next one to three letters denote the journal, and the final numbers denote the page. This code appears in the text each time a reference is quoted. This system has been used successfully in previous publications and enables the reader to go directly to the literature reference cited, without first having to consult the bibliography at the end of each chapter.

The following additional notes apply:

1. A list of journal codes in alphabetical order, together with the journals to which they refer is given in the endpapers of every volume. Journal names are abbreviated throughout using the CASSI "Chemical Abstracts Service Source Index" system.
2. The references cited in each chapter are given at the end of the individual chapters.
3. The list of references is arranged in order of (a) year, (b) journal in alphabetical order of journal code, (c) part letter or number if relevant, (d) volume number if relevant, and (e) page number.
4. In the reference list the code is followed by (a) the complete literature citation in the conventional manner and (b) the number(s) of the page(s) on which the reference appears, whether in the text or in tables, schemes, etc.
5. For non-twentieth-century references, the year is given in full in the code.
6. For journals which are published in separate parts, the part letter or number is given (when necessary) in parentheses immediately after the journal code letters.
7. Journal volume numbers are not included in the code numbers unless more than one volume was published in the year in question, in which case the volume number is included in parentheses immediately after the journal code letters.
8. Patents are assigned appropriate three-letter codes.
9. Frequently cited books are assigned codes.
10. Less common journals and books are given the code "MI" for miscellaneous with the whole code for books prefixed by the letter "B-".

JOURNAL ABBREVIATIONS

AAC	*Antimicrob. Agents Chemother.*
ABB	*Arch. Biochem. Biophys.*
ABC	*Agric. Biol. Chem.*
ABI	*Anal. Biochem.*
ABP	*Acta Biochim. Pol.*
AC	*Appl. Catal.*
ACA	*Acta Chem. Scand., Ser. A*
ACB	*Acta Chem. Scand., Ser. B*
ACF	*Acta Chim. Sin. Engl. Ed.*
ACH	*Acta Chim. Acad. Sci. Hung.*
ACM	*Antibiot. Chemother.*
ACO	*Acta Chim. Slov.*
ACP	*Ann. Chim. (Paris)*
ACR	*Acc. Chem. Res.*
ACS	*Acta. Chem. Scand.*
ACT	*Acta Chim. Sin.*
ADC	*Ann. Chim. (Rome)*
ADP	*Adv. Chem. Phys.*
AEM	*Appl. Environ. Microbiol.*
AF	*Arzneim.-Forsch.*
AFC	*Adv. Fluorine Chem.*
AFF	*Afinidad*
AG	*Angew. Chem.*
AGE	*Angew. Chem., Int. Ed. Engl.*
AHC	*Adv. Heterocycl. Chem.*
AHS	*Adv. Heterocycl. Chem. Supplement*
AI	*Anal. Instrum.*
AIC	*Adv. Inorg. Chem. (book)*
AIJ	*AIChE Journal*
AJC	*Aust. J. Chem.*
AK	*Ark. Kemi*
AKZ	*Arm. Khim. Zh.*
ALD	*Aldrichim. Acta*
ALE	*Anal. Lett.*
AM	*Adv. Mater. (Weinheim, Ger.)*
AMB	*Appl. Microbiol. Biotech.*
AMC	*Advances in Metal-Organic Chemistry*
AMH	*ACH Models Chem*
AMI	*Arch. Microbiol.*
AMR	*Appl. Magn. Reson.*
AMS	*Adv. Mol. Spectros.*
AN	*Analyst*
ANA	*Anal. Chim. Acta*
ANB	*Anal. Bioanal. Chem.*
ANC	*Anal. Chem.*
ANL	*Accad. Naz. Lincei*
ANS	*Anal. Sci.*
ANY	*Ann. N. Y. Acad. Sci.*
AOC	*Adv. Organomet. Chem. (book)*
AOM	*Appl. Organomet. Chem.*
AP	*Arch. Pharm. (Weinheim, Ger.)*
APF	*Ann. Pharm. Francaises*
APH	*Acta Polon. Pharm., Drug Res.*
APL	*Acta Polym.*
APO	*Adv. Phys. Org.Chem.*
APR	*Arch. Pharm. Res.*
APS	*Adv. Polym. Sci.*
APY	*Applied Physics*
AQ	*An. Quim.*
AR	*Ann. Rep. Prog. Chem.*
ARA	*Ann. Rep. Prog. Chem., Sect. A*
ARB	*Annu. Rep. Prog. Chem., Sect. B*
ARK	*ARKIVOC (Archive for Organic Chemistry)*
ARM	*Annual Review of Microbiology*
ARP	*Annu. Rev. Phys. Chem.*
ARS	*Antiviral Res.*
ASC	*Adv. Synth. Catal.*
ASJ	*Asian. J. Chem.*
ATA	*Austria, patent applied for*
ATP	*Austria, patent granted*
AUA	*Australia, patent applied for*
AUP	*Australia, patent granted*
AX	*Acta Crystallogr.*
AXA	*Acta. Crystallogr., Sect. A*
AXB	*Acta. Crystallogr., Sect. B*
AXC	*Acta. Crystallogr., Sect. C*
AXD	*Acta Crystallogr., Sect. D*
AXE	*Acta Crystallogr., Sect. E*
B	*Biochemistry*
BAP	*Bull. Acad. Pol. Sci.*
BAU	*Bull. Acad. Sci. USSR, Div. Chem. Sci.*
BBA	*Biochim. Biophys. Acta*
BBB	*Biosci. Biotech. Biochem.*
BBG	*Berichte der Bunsen-Gesellschaft*
BBR	*Biochem. Biophys. Res. Commun.*
BCC	*Bioconjugate Chem.*
BCF	*Blood Coagulation & Fibrinolysis*
BCH	*Biomed. Chromatogr.*
BCJ	*Bull. Chem. Soc. Jpn.*
BEC	*Bull. Electrochem.*
BEA	*Belgium, patent applied for*
BEP	*Belgium, patent granted*
BF(2)	*Bull. Soc. Chim. Fr., Part 2*
BIJ	*Biophys. J.*
BJ	*Biochem. J.*
BJO	*Beilstein J. Org. Chem.*
BJP	*Br. J. Pharmacol.*
BKC	*Bull. Korean Chem. Soc.*
BKH	*Bioorganicheskaya Khimiya*
BMC	*Bioorg. Med. Chem.*
BML	*Bioorg. Med. Chem. Lett.*
BMM	*Biomacromolecules*
BMS	*Biomed. Mass. Spectrom.*
BOC	*Bioorg. Chem.*
BP	*Biochem. Biopharmacol.*
BPC	*Biophysical Chemistry*
BPJ	*Br. Polym. J.*
BPM	*Biopolymers*
BSB	*Bull. Soc. Chim. Belg.*
BSF	*Bull. Soc. Chim. Fr.*
BSM	*Best Synthetic Methods (book)*
BTL	*Biotechnol. Lett.*
C	*Chimia*
CA	*Chem. Abstr.*
CAC	*Comprehensive Asymmetric Catalysis (book)*
CAG	*Carcinogenesis*
CAL	*Catal. Lett.*
CAN	*Crit. Rev. Anal. Chem.*
CAR	*Carbohydr. Res.*
CAT	*Chim. Acta Turc.*
CB	*Chem. Ber.*
CBC	*ChemBioChem*
CBI	*Chem. Biodiver.*
CBL	*Carbohydrate Letter*
CBO	*Chemistry and Biology*
CBR	*Chem. Br.*
CC	*J. Chem. Soc., Chem. Commun.*
CCA	*Croat. Chem. Acta.*
CCC	*Collect. Czech. Chem. Commun.*
CCC-I	*Comp. Coord. Chem. (book)*
CCC-II	*Comp. Coord.Chem. II (book)*
CCL	*Chin. Chem. Lett.*
CCR	*Coord. Chem. Rev.*
CCT	*Comb. Chem. High T. Scr.*
CDC	*Cron. Chim.*
CEC	*Cent. Eur. J. Chem.*
CED	*J. Chem. Eng. Data*
CEG	*Crystal Engineering*
CEJ	*Chem. Eur. J.*
CEN	*Chem. Eng. News.*
CEO	*CrystEngComm*
CEX	*Chem. Express*
CGD	*Crystal Growth and Design*
CH	*Chirality*
CHA	*Switzerland, patent applied for*
CHC	*J. Carbohydr. Chem*
CHE	*Chem. Heterocycl. Compd. (Engl. Transl.)*
CHEC	*Comp. Heterocycl. Chem. (book)*
CHEC-II	*Comp. Heterocycl. Chem. II (book)*
CHJ	*Chin. J. Chem.*
CHP	*Switzerland, patent granted*
CHR	*Chromatographia*
CHS	*Chem. Senses*
CIL	*Chem. Ind. (London)*
CIM	*Chem. Ind. (Milan)*
CIS	*J. Colloid Interface Sci.*
CJA	*Can. J. Anal. Sci. Spectrom.*
CJB	*Can. J. Bot.*
CJC	*Can. J. Chem.*
CJS	*Can. J. Spectrosc.*
CL	*Chem. Lett.*
CLA	*Clin. Chim. Acta*
CLC	*Clinical Cancer Research*
CLI	*Chem. Phys. Lipids*
CLY	*Chem. Listy*
CM	*Chem. Mater.*
CMC	*Comp. Med. Chem. (book)*
CMD	*J. Comput.-Aid. Mol. Des.*
CME	*Curr. Med. Chem.*
CMS	*Comp. Mater. Sci.*
CNC	*Cancer*

CNO	*Chem. Nat. Compd.*
CNR	*Cancer Research*
COB	*Curr. Opin. Chem. Biol.*
COC	*Comp. Org. Chem. (book)*
COFGT	*Comp. Org. Func. Group Transformations (book)*
COMC	*Comp. Organomet. Chem. (book)*
COMC-II	*Comp. Organomet. Chem. II (book)*
CONAP	*Comp. Natural Products Chem. (book)*
COR	*Curr. Org. Chem.*
COS	*Comp. Org. Synth. (book)*
COT	*Curr. Opin. Struct. Biol.*
CPA	*Chem. Pap.*
CPB	*Chem. Pharm. Bull.*
CPC	*J. Chim. Phys. Physico-Chim. Biol.*
CPE	*ChemPhysChem*
CPH	*Chem. Phys.*
CPL	*Chem. Phys. Lett.*
CR	*C. R. Hebd. Seances Acad. Sci.*
CRA	*C. R. Hebd. Seances Acad. Sci., Ser. A*
CRB	*C. R. Hebd. Seances Acad. Sci., Ser. B*
CRC	*C. R. Hebd. Seances Acad. Sci., Ser. C*
CRT	*Chem. Res. Toxicol.*
CRV	*Chem. Rev.*
CS	*Chem. Scr.*
CSA	*Czechoslovakia, patent applied for*
CSC	*Cryst. Struct. Commun.*
CSP	*Czechoslovakia, patent granted*
CSR	*Chem. Soc. Rev.*
CSY	*Curr. Org. Synth.*
CT	*Chem. Tech.*
CTC	*Contemp. Org. Synth.*
CTM	*Curr. Top. Med. Chem.*
CTO	*Catalysis Today*
CYA	*Cytometry, Part A*
CYR	*Cryst. Res. Tech.*
CZ	*Chem. Ztg.*
DDA	*German Democratic Republic, patent applied for*
DDP	*German Democratic Republic, patent granted*
DDR	*Drug Data Report*
DEA	*Germany, patent applied for*
DEP	*Germany, patent granted*
DIA	*Diabetes*
DIB	*Diss. Abstr. Int. B*
DIS	*Diss. Abstr.*
DMD	*Drug Metab. Dispos.*
DMR	*Drug Metab. Rev.*
DOC	*Dokl. Chem. (Engl. Transl.)*
DOK	*Dokl. Akad. Nauk SSSR*
DP	*Dyes Pigments*
DPC	*Dokl. Phys. Chem.*
E	*Experientia*
EAC	*Electrochim. Acta*
EC	*Educ. Chem.*
ECL	*Environ. Chem. Lett.*
EF	*Energy Fuels*
EFT	*Eur. Food Res. Tech.*
EJB	*European Journal of Biochemistry*
EJC	*Egypt. J. Chem.*
EJI	*Eur. J. Inorg. Chem.*
EJM	*Eur. J. Med. Chem.*
EJO	*Eur. J. Org. Chem.*
EJP	*Eur. J. Pharm. Sci.*
EJS	*Eur. J. Mass Spectrom.*
ELA	*Electroanalysis*
ELP	*Electrophoresis*
EMJ	*EMBO J.*
ENA	*Enatiomer*
EPA	*European Patent Office (EPO), patent applied for*
EPH	*Eur. J. Pharmacol.*
EPJ	*European Polymer Journal*
EPP	*European Patent Office (EPO), patent granted*
EROS	*Encyclopedia of Reagents for Organic Synthesis (book)*
ESA	*Spain, patent applied for*
ESO	*Electrochemical Society Proceedings*
ESP	*Spain, patent granted*
EST	*Environ. Sci. Technol.*
ETC	*Environ. Toxicol. Chem.*
FA	*Farmaco*
FAR	*Farmacia*
FCF	*Fortschr. Chem. Forsch.*
FEB	*Fresenius Environ. Bull.*
FES	*Farmaco, Ed. Sci.*
FFJ	*Flavor Fragr. J.*
FIT	*Fitoterapia*
FJA	*Fresenius J. Anal. Chem.*
FMA	*Func. Mater.*
FML	*FEMS Microbiol. Lett.*
FOC	*Food Chem.*
FOR	*Fortschr. Chem. Org. Naturst.*
FRA	*France, patent applied for*
FRP	*France, patent granted*
FST	*Food Sci. Technol.*
FZA	*Fresenius Z. Anal. Chem.*
G	*Gazz. Chim. Ital.*
GAK	*Gummi Asbest Kunstst.*
GBA	*United Kingdom, patent applied for*
GBP	*United Kingdom, patent granted*
GC	*Green Chem.*
GRA	*Greece, patent applied for*
GRP	*Greece, patent granted*
GSM	*Gen. Synth. Methods*
H(vol)	*Heterocycles*
HAC	*Heteroatom Chem.*
HC	*Chem. Heterocycl. Compd. (book)*
HCA	*Helv. Chim. Acta*
HCO	*Heterocycl. Commun.*
HOU	*Houben-Weyl Methoden Org. Chem. (book)*
HP	*Hydrocarbon Process*
HPR	*High Pressure Res.*
HUA	*Hungary, patent applied for*
HUP	*Hungary, patent granted*
IAA	*Proc. Indian Acad. Sci., Sect. A*
IAS	*Proc. Indian Acad. Sci.*
IC	*Inorg. Chem.*
ICA	*Inorg. Chim. Acta*
ICC	*Inorg. Chem. Commun.*
ICL	*Inorg. Nucl. Chem. Lett.*
IDA	*Indonesia, patent applied for*
IDP	*Indonesia, patent granted*
IEA	*Ireland, patent applied for*
IEC	*Ind. Eng. Chem. Res.*
IEP	*Ireland, patent granted*
IJA	*Indian J. Chem., Sect. A*
IJB	*Indian J. Chem., Sect. B*
IJC	*Indian J. Chem.*
IJH	*Indian J. Heterocycl. Chem.*
IJK	*Int. J. Chem. Kinet.*
IJM	*Int. J. Mass Spectrom. Ion Proc.*
IJP	*International Journal of Pharmaceutics*
IJQ	*Int. J. Quantum Chem.*
IJR	*Int. J. Pept. Prot. Res.*
IJS	*Int. J. Sulfur Chem.*
IJY	*Indian J. Phys.*
ILA	*Israel, patent applied for*
ILP	*Israel, patent granted*
IMS	*Int. J. Mol. Sci.*
INA	*India, patent applied for*
INP	*India, patent granted*
IR	*Invest. Radiol.*
IS	*Inorg. Synth.*
ISA	*Int. J. Sulfur Chem., Part A*
ISB	*Int. J. Sulfur Chem., Part B*
ISJ	*Isr. J. Chem.*
ITA	*Italy, patent applied for*
ITP	*Italy, patent granted*
IZK	*Izv. Akad. Nauk Resp. Kazak. Ser. Khim.*
IZV	*Izv. Akad. Nauk SSSR, Ser. Khim.*
JA	*J. Am. Chem. Soc.*
JAA	*Int. J. Antimicrob. Agents*
JAK	*Jpn. Kokai Tokyo Koho*
JAM	*J. Am. Soc. Mass Spectrom.*
JAN	*J. Antibiot.*
JAP	*J. Appl. Polym. Sci.*
JAVMA	*Journal of the American Veterinary Medical Association*
JBA	*J. Bacteriol*
JBB	*J. Biochem. Biophys. Methods*
JBC	*J. Biol. Chem.*
JBS	*J. Braz. Chem. Soc.*
JC	*J. Chem. Soc (C)*
JCA	*J. Chem. Soc (A)*
JCB	*J. Chem. Soc (B)*
JCC	*J. Comput. Chem.*
JCCS	*J. Chin. Chem. Soc.*
JCD	*J. Chem. Soc., Dalton Trans.*
JCE	*J. Chem. Educ.*
JCF	*J. Chem. Soc., Faraday Trans*
JCH	*J. Chromatogr.*
JCI	*J. Chem. Inf. Comput. Sci.*
JCI	*J. Chem. Inf. Model.*
JCJ	*J. Comput. Chem., Jpn*
JCL	*J. Chin. Chem. Soc. Lett.*
JCM	*J. Chem. Res. (S)*

JCN	*Journal of Clinical Neuroscience*
JCO	*J. Comb. Chem.*
JCP	*J. Chem. Phys.*
JCR	*J. Coord. Chem.*
JCS	*J. Chem. Soc.*
JCS2	*J. Chem. Soc. (Suppl. 2)*
JCT	*J. Catal.*
JCX	*J. Chem. Crystallogr.*
JDC	*J. Soc. Dyers Colourists*
JEC	*J. Electroanal. Chem*
JEI	*J. Electroanal. Chem. Interfacial Electrochem.*
JEL	*J. Chem. Ecol.*
JEM	*J. Energet. Mat.*
JEO	*J. Electron Spectrosc. Relat. Phenom.*
JEP	*J. Pharmacol. Exp. Ther.*
JES	*J. Electrochem. Soc.*
JEZ	*J. Enzyme Inhib. Med. Chem.*
J(F1)	*J. Chem. Soc., Faraday Trans. 1*
J(F2)	*J. Chem. Soc., Faraday Trans. 2*
JFA	*J. Agric. Food Chem.*
JFC	*J. Fluorine Chem.*
JFE	*J. Food Agr. Environ.*
JFL	*J. Fluorescenc.*
JGM	*J. Mol. Graphics. Modell.*
JGU	*J. Gen. Chem. USSR (Engl. Transl.)*
JHC	*J. Heterocycl. Chem.*
JHS	*J. Health Sci.*
JIB	*J. Inorg. Biochem.*
JIC	*J. Indian Chem. Soc.*
JIM	*J. Immun. Methods*
JIS	*J. Biol. Inorg. Chem.*
JJP	*Jpn. J. Pharmacol.*
JKC	*J. Korean Chem. Soc*
JLC	*J. Liq. Chromatogr.*
JLR	*J. Labelled Compd. Radiopharm.*
JLU	*J. Luminesc.*
JMA	*J. Mater. Sci.*
JMB	*J. Mol. Biol.*
JMC	*J. Mater. Chem.*
JME	*J. Med. Chem.*
JML	*J. Mol. Liq.*
JMM	*J. Mol. Model.*
JMO	*J. Mol. Catal.*
JMP	*J. Mass Spectrom.*
JMR	*J. Mater. Res.*
JMS	*J. Mol. Sci.*
JMT	*J. Mol. Struct. Theochem*
JNC	*J. Inorg. Nucl. Chem.*
JNP	*J. Nat. Prod.*
JOC	*J. Org. Chem.*
JOM	*J. Organomet. Chem.*
JON	*Journal of Clinical Oncology*
JOU	*J. Org. Chem. USSR (Engl. Transl.)*
J(P1)	*J. Chem. Soc., Perkin Trans. 1*
J(P2)	*J. Chem. Soc., Perkin Trans. 2*
JPA	*Japan, patent applied for*
JPB	*J. Pharm. Biomed. Anal.*
JPC	*J. Phys. Chem.*
JPE	*J. Pest Sci.*
JPH	*J. Photochem. Photobiol., A*
JPJ	*J. Pharm. Soc. Jpn.*
JPL	*J. Pharm Pharmacol.*
JPM	*J. Incl. Phenom. Macrocycl. Chem.*
JPO	*J. Phys. Org. Chem.*
JPP	*Japan, patent granted*
JPR	*J. Prakt. Chem.*
JPS	*J. Pharm. Sci.*
JPT	*J. Protein Chem.*
JPU	*J. Phys. Chem. USSR (Engl. Transl.)*
JPY	*J. Anal. Appl. Pyrolysis*
JRE	*J. Pept. Res.*
JRM	*J. Chem. Res. (M)*
JRN	*J. Radioanal. Nucl. Chem.*
JRS	*J. Raman Spectrosc.*
JSC	*J. Serb. Chem. Soc.*
JSF	*J. Sulfur Chem.*
JSH	*J. Environ. Sci. Health, Part A*
JSI	*J. Phys. Chem. Solids*
JSL	*J. Solut. Chem.*
JSO	*J. Synth. Org. Chem. Jpn.*
JSP	*J. Mol. Spectrosc.*
JSS	*J. Sep. Sci.*
JST	*J. Mol. Struct.*
JSU	*J. Supramol. Chem.*
JTC	*J. Struct. Chem.*
JTH	*J. Theor. Comput. Chem*
JTY	*J. Chem. Theory Comput.*
JWS	*J. Wood Sci.*
JYR	*J. Polym. Res.*
K	*Kristallografiya*
KFZ	*Khim. Farm. Zh.*
KGS	*Khim. Geterotsikl. Soedin.*
KJM	*Kor. J. Med. Chem.*
KK	*Koord. Khim.*
KKZ	*Kogyo Kagaku Zasshi*
KO	*Kirk-Othmer Encyc. (book)*
KPS	*Khim. Prir. Soedin.*
KPU	*Khimichna Promislovist Ukraini*
L	*Langmuir*
LA	*Liebigs Ann. Chem.*
LC	*Liq. Cryst.*
LOC	*Lett. Org. Chem*
LS	*Life. Sci.*
M	*Monatsh. Chem.*
MAC	*Macromol. Chem. Phys.*
MAL	*Material Lett.*
MAR	*Macromol. Rapid Commun.*
MB	*Mol. Biol.*
MBD	*Metal-based Drugs*
MBI	*Marine Biol.*
MC	*Mendeleev Commun.*
MCH	*Mater. Chem. Phys.*
MCL	*Mol. Cryst. Liq. Cryst.*
MCO	*Mol. Cell. Probes*
MCR	*Medicinal Chemistry Research*
MDV	*Molecular Diversity*
MGC	*Main Group Chem.*
MGM	*Main Group Met. Chem.*
MIJ	*Microchem. J.*
MIM	*Mol. Imag.*
MIP	*Miscellaneous Pat.*
MKA	*Mikrochim. Acta*
MM	*Macromolecules*
MMC	*Makromol. Chem.*
MMR	*Magn. Reson. Mater. Phys., Biol. Med.*
MOL	*Molecules*
MP	*Mol. Phys.*
MPH	*Mol. Pharmacol.*
MR	*J. Magn. Reson.*
MRC	*Magn. Reson. Chem.*
MRM	*Magn. Reson. Med.*
MRO	*Mini Reviews in Organic Chemistry*
MSE	*Materials Science and Engineering*
MSI	*Mol. Simulat.*
N	*Naturwissenschaften*
NA	*Nucleic Acids*
NAR	*Nucleic Acids Res.*
NAS	*Nucelc Acids Symp. Ser.*
NAT	*Nature*
NCS	*Z. Kristallogr. – New Cryst. Struct.*
NJC	*Nouv. J. Chim. [New J. Chem.*
NKK	*Nippon Kagaku Kaishi*
NKZ	*Nippon Kagaku Zasshi*
NLA	*Netherlands, patent applied for*
NLP	*Netherlands, patent granted*
NMA	*Nature Materials*
NMB	*Nucl. Med. Biol.*
NN	*Nucleosides, Nucleotides Nucleic Acids*
NPR	*Nat. Prod. Rep.*
NZJ	*N. Z. J. Sci. Technol.*
OBC	*Org. Biomol. Chem.*
OCS	*Organomet. Synth.*
OJC	*Orient. J. Chem*
OL	*Org. Lett.*
OM	*Organometallics*
OMR	*Org. Magn. Reson.*
OMS	*Org. Mass Spectrom.*
OPD	*Org. Process Res. Dev.*
OPP	*Org. Prep. Proced. Int.*
OPS	*Opt. Spectrosc.*
OQE	*Opt. Quantum Electron.*
OR	*Org. React.*
ORV	*Opt. Rev.*
OS	*Org. Synth.*
OSC	*Org. Synth., Coll. Vol.*
P	*Phytochemistry*
PA	*Polym. Age*
PAC	*Pure Appl. Chem.*
PAS	*Bull. Pol. Acad. Sci.*
PB	*Polym. Bull.*
PC	*Personal Communication*
PCA	*J. Phys. Chem. A*
PCB	*J. Phys. Chem. B*
PCC	*J. Phys. Chem. C*
PCJ	*Pharm. Chem. J. (Engl. Transl.)*
PCP	*Phys. Chem. Chem. Phys.*
PCS	*Proc. Chem. Soc.*
PE	*Plast. Eng.*
PEN	*Protein Engineering*

PES	*J. Pept. Sci.*
PHA	*Pharmazie*
PHB	*Photochemistry and Photobiology*
PHC	*Prog. Heterocycl. Chem. (book)*
PIC	*Prog. Inorg. Chem. (book)*
PIN	*Polym. Int.*
PJC	*Pol. J. Chem.*
PJP	*Russ. J. Phys. Chem.*
PJS	*Pak. J. Sci. Ind. Res.*
PLA	*Poland, patent applied for*
PLC	*Polym. Commun.*
PLE	*Phys. Lett*
PLM	*Polymer*
PLP	*Poland, patent granted*
PMH	*Phys. Methods Heterocycl. Chem.*
PMR	*Platinum Metals Review*
PNA	*Proc. Natl. Acad. Sci. U.S.A.*
PNB	*Pflanzenschutz-Nachrichten Bayer*
POJ	*Polym. J.*
POL	*Polyhedron*
PP	*Polym. Prepr.*
PPB	*Plant Physiology and Biochemistry*
PPL	*Protein and Peptide Letters*
PPO	*Prog. Polym. Sci.*
PPS	*Photochem. Photobiol. Sci.*
PRB	*Phys. Rev. B*
PRC	*Plastics Rubber and Composites*
PRS	*Proc. R. Soc.*
PS	*Phosphorus, Sulfur Silicon Relat. Elem.*
PSA	*J. Polym. Sci., Part A: Polym. Chem.*
PSB	*J. Polym. Sci., Part B: Polym. Phys.*
PSC	*Protein Science*
PSI	*Pesticide Science*
PTA	*Portugal, patent applied for*
PTC	*Photochemistry*
PTP	*Portugal, patent granted*
PTR	*Pteridines*
QNO	*Quim. Nova*
QR	*Q. Rev.*
QRS	*Quart. Rep. Sulfur Chem.*
QSA	*Quant. Struct. Act. Relat. Pharmacol. Chem. Biol.*
QSAR	*Quantitative Structure-Activity Relationships*
RC	*Rubber Chem. Technol.*
RCB	*Russ. Chem. Bull.*
RCC	*Rodd's Chemistry of Carbon Compounds (book)*
RCM	*Rapid Commun. Mass Spectrom.*
RCP	*Rec. Chem. Progr.*
RCR	*Russ. Chem. Rev. (Engl. Transl.)*
RFP	*React. Funct. Polymers*
RHA	*Rev. Heteroatom Chem.*
RJ	*Rubber J.*
RJA	*Russ. J. Appl. Chem. (Engl. Transl.)*
RJC	*Russ. J. Gen. Chem. (Engl. Transl.)*
RJD	*Russ. J. Coord. Chem.*
RJE	*Russ. J. Electrochem.*
RJO	*Russ. J. Org. Chem. (Engl. Transl.)*
RMC	*Mini-Rev. Med. Chem.*
ROA	*Romania, patent applied for*
ROP	*Romania, patent granted*
RP	*Rev. Polarogr.*
RPC	*Radiat. Phys. Chem.*
RQM	*Revista de la Sociedad Química de Mexico*
RRC	*Rev. Roum. Chim.*
RS	*Ric. Sci.*
RTC	*Recl. Trav. Chim. Pays-Bas*
RUA	*Russian Federation, patent applied for*
RUP	*Russian Federation, patent granted*
RZC	*Roczn. Chem.*
S	*Synthesis*
SA	*Spectrochim. Acta*
SAA	*Spectrochim. Acta, Part A*
SC	*Synth. Commun.*
SCI	*Science*
SCM	*Speciality Chemicals Magazine*
SEA	*Sweden, patent applied for*
SEP	*Sweden, patent granted*
SFM	*Soft Matter*
SIA	*Surf. Interface Anal.*
SL	*Synlett*
SM	*Synth. Met.*
SMC	*Supramol. Chem.*
SNB	*Sens. Actuat. B*
SOS	*Science of Synthesis (book)*
SPE	*Spectroscopy*
SPH	*Scientia Pharmaceutica*
SPJ	*Saudi Pharm. J.*
SPL	*Spectrosc. Lett.*
SR	*Sulfur Rep.*
SRC	*Supplements to Rodd's Chemistry of Carbon Compounds (book)*
SRI	*Synth. React. Inorg. Metal-Org. Chem., Nano-Met. Chem.*
SS	*Sch. Sci. Rev.*
SSI	*Solid State Ionics*
SSR	*Second Supplements to Rodd's Chemistry of Carbon Compounds (book)*
SST	*Org. Compd. Sulphur, Selenium, Tellurium R. Soc. Chem. Ser.*
STC	*Struct. Chem.*
STE	*Steroids*
SUA	*Soviet Union, patent applied for*
SUL	*Sulfur Lett.*
SUP	*Soviet Union, patent granted*
SUS	*Surface Science*
T	*Tetrahedron*
TA	*Tetrahedron Asymmetry*
TAL	*Talanta*
TAP	*Toxicol. Appl. Pharmacol.*
TCA	*Theor. Chim. Acta*
TCC	*Top. Curr. Chem.*
TCM	*Tetrahedron, Comp. Method*
TCR	*The Chemical Record*
TES	*Tetrahedron, Suppl.*
TFS	*Trans. Faraday Soc.*
TH	*Thesis*
THA	*Theor. Chem. Acc.*
THC	*Topics in Heterocycl. Chem.*
THE	*Thermochim. ACTA*
THS	*Targets Heterocycl. Systems*
TL	*Tetrahedron Lett.*
TMC	*Transition Met. Chem. (Weinheim, Ger.)*
TMI	*Trends Microbiol.*
TML	*Transition Met. Chem (London)*
TRH	*Trends in Heterocyclic Chemistry*
TS	*Top. Stereochem.*
TSF	*Thin Solid Films*
UAA	*Ukraine, patent applied for*
UAP	*Ukraine, patent granted*
UK	*Usp. Khim.*
UKZ	*Ukr. Khim. Zh. (Russ. Ed.)*
UP	*Unpublished results*
USA	*Unted States of America, patent applied for*
USO	*Ultrason. Sonochem.*
USP	*United States of America, patent granted*
VSP	*Vibrational Spectroscopy*
WCH	*Wiadom. Chem.*
WOA	*World Intellectual Property Organization (WIPO), patent applied for*
WOP	*World Intellectual Property Organization (WIPO), patent granted*
WRE	*Water Res.*
WSC	*Weed Sci.*
XSA	*X-Ray Struct. Anal. Online*
YGK	*Yuki Gosei Kagaku Kyokaishi*
YUA	*Yugoslavia, patent applied for*
YUP	*Yugoslavia, patent granted*
YZ	*Yakugaku Zasshi*
ZAA	*South Africa, patent applied for*
ZAK	*Zh. Anal. Khim.*
ZAP	*South Africa, patent granted*
ZC	*Z. Chem.*
ZFA	*Z. Anorg. Allg. Chem.*
ZFK	*Zh. Fiz. Khim.*
ZK	*Z. Kristallogr.*
ZN	*Z. Naturforsch.*
ZNA	*Z. Naturforsch., A*
ZNB	*Z. Naturforsch., B*
ZNC	*Z. Naturforsch., C*
ZOB	*Zh. Obshch. Khim.*
ZOR	*Zh. Org. Khim.*
ZPC	*Hoppe-Seyler's Z. Physiol. Chemie.*
ZPK	*Zh. Prikl. Khim.*
ZSK	*Zh. Strukt. Khim.*

A note on the Ring Index

The CHEC-III Ring Index was not available in time for print publication or for this online upload. It can be accessed through the following link:

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