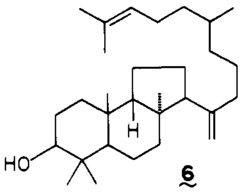
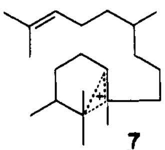
to the tricycle **5**, a reaction apparently involving hydrogen transfer from the side chain to the cationic C-ring intermediate. Since purely spontaneous hydrogen transfer between two distant carbons within a nonrigid acyclic framework, namely C-14 and (presumably) C-18 in **4**, is improbable, the two carbons involved must be held in close proximity by the enzyme; such constraints operating on the natural substrate require that C-14 and the Δ^{18} π bond be similarly juxtaposed (↔, **3**), thereby ensuring bond formation between these centers, *contrary to Markovnikov behavior*, as observed in the *nonenzymic* cyclization of squalene oxide.[9] With the enforcement of such behavior, bond formation between C-10 and C-15 must then necessarily occur, thus overriding, in effect, purely chemical behavior at the Δ^{14} site and providing the observed six- (rather than five-) membered C-ring. Moreover, in the biosynthesis of a host of other tetra- and pentacyclic triterpenoids, the generation of six-membered rings rather than the five-membered rings anticipated on a purely chemical basis may be ascribed to similar forces at work in related cyclase cases.

Indications of the transient involvement of a five-membered C ring in lanosterol biosynthesis have been presented,[10,11] in particular the enzymic formation of perhydrocyclopenta[*a*]naphthalene **6** from 18,19-dihydro-2,3-oxidosqualene, a result also expected on purely chemical grounds. In the 15′-nor-18,19-dihydro (**4** → **5**) case production of a perhydrocyclopentanaphthalene is *not* chemically preferred, and the formation of **5** indicates that the enzyme does not compel generation of a bona fide, if temporary, five-membered C ring. It appears that formation of **6** merely signifies that elimination of a proton from the parent carbocation, more stable than that from **4**, is a process of lower energy than some other reaction pathway (for example, hydrogen transfer of the type observed in the **4** → **5** conversion), not an uncommon result in organic chemistry. The tricyclic cations derived from these 18,19-dihydro epoxides are formulated as nonclassical species (e.g., **7**) because that structural type best explains the partitioning between five- and six-membered rings, is in keeping with the enzyme-enforced proximity of carbons involved in its genesis as well as the preservation of stereochemistry during cyclization, and most simply accommodates the closely linked chain of interactions C-10, C-14, C-15, and C-18. Accordingly, this interpretation has been extended to the squalene oxide cyclization itself (**9**, and for consistency, **8**; Scheme I).



6



7

The entirety of the above results thus permits for the first time a comprehensive view of substrate behavior during the bioconversion of oxidosqualene to lanosterol and presumably other polycyclic triterpenes. This view is shown, and the foregoing body of findings represented, in the sequence **3** → **8** → **9** → **10** → **2**.[12]

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[9] van Tamelen, E. E.; Willett, J.; Schwartz, M.; Nadeau, R. *J. Am. Chem. Soc.* **1966**, *88*, 5937.

[10] van Tamelen, E. E.; Willett, J. D.; Clayton, R. B. *J. Am. Chem. Soc.* **1967**, *89*, 3371.

[11] van Tamelen, E. E.; Sharpless, K. B.; Hanzlik, R.; Clayton, R. B.; Burlingame, A. L.; Wszolek, P. *J. Am. Chem. Soc.* **1967**, *89*, 7150.

[12] For early stereochemical portrayals of a hypothetical hydroxonium ion induced oxidative cyclization of squalene see: (a) Eschenmoser, A.; Ruzicka, L.; Jeger, O.; Arigoni, D. *Helv. Chim. Acta* **1955**, *38*, 1890. (b) Stork, G.; Burgstahler, A. W. *J. Am. Chem. Soc.* **1955**, *77*, 5068.

Book Reviews

Quantum Chemistry Symposium No. 14. 1980. Proceedings of the International Symposium on Atomic, Molecular, and Solid-State Theory, Collision Phenomena, Quantum Statistics, and Computational Methods. Edited by P.-O. Löwdin and Y. Öhrn. John Wiley & Sons, New York. 1980. xix + 732 pp. $40.00.

For two decades the Quantum Chemistry Project at the University of Florida, led by the indefatigable Per-Olov Löwdin, has been conducting (among many other meetings) annual international symposia on quantum chemistry at Sanibel Island and more recently at Flagler Beach. The present volume contains the invited and contributed papers at the 20th Symposium, held March 9–15, 1980, in honor of E. Bright Wilson. Featured are Wilson's personal reminiscences of quantum chemistry and quantum chemists (13 pages). Otherwise, there is the usual mix for symposium volumes, from trivial outlines of published works to significant original research papers, with the latter in the majority in this case. Altogether there are 72 contributions having 132 authors. A bibliography of Wilson's papers is included, as is a fine picture of him.

Robert G. Parr, *University of North Carolina at Chapel Hill*

Organic Compounds of Sulfur, Selenium, and Tellurium. Volume 6. By D. R. Hogg (University of Aberdeen). Royal Society of Chemistry, London, England. 1981. xviii + 331 pp. $127.00.

This is in the series of review volumes published by the Royal Society called Specialist Periodical Reports, this one covering the literature from April 1978 to March 1980 (except the literature for compounds with S=N functional groups goes through February 1980). The chemistry of these elements is under very active study, as examination of the topics and literature citations in this volume attests. These Reports are like a very good encyclopedia: you start to look up a topic you are interested in and find yourself reading with fascination at other pages that you happen to open.

For workers in the field, reading this Report is a must; it, of course, mainly covers the organic chemistry of these elements, with biochemistry and biology covered only in passing. This volume includes chapters on aliphatic compounds (by G. C. Barrett), ylides and related structures (by E. Block, D. L. J. Clive, N. Furukawa, and S. Oae), thiocarbonyl and selenocarbonyl compounds (by D. R. Hogg, J. K. Landquist, and A. Ohno), small ring compounds of S and Se (by G. C. Venier), saturated cyclic compounds (by P. K. Claus), and heteroaromatic compounds (by M. Davis).

William A. Pryor, *Louisiana State University, Baton Rouge*

An Introduction to Inorganic Chemistry. By Keith F. Purcell (Kansas State University) and John C. Kotz (State University of New York, College at Oneonta). Saunders, Philadelphia. 1980. xv + 637 pp. $30.95.

Professors Purcell and Kotz have amended, rewritten, and omitted parts of their earlier book (*Inorganic Chemistry*, reviewed *J. Am. Chem. Soc.* **1977**, *100*, 6797) to eliminate 480 pages and create a text more suitable for an advanced inorganic course. The level of presentation in this "Introduction" has not been lowered, however, and a challenging text has resulted.

The initial section (120 pp) deals with atomic orbitals, molecular structures (including ionic lattices), and an unusual and effective approach to molecular orbital theory. The second section (175 pp) is a novel analysis of nonmetal chemistry. After a chapter on acid/base (Donor/Acceptor) concepts, nonmetal chemistry is presented through a study of nonmetal functional groups (i.e., the B–O function, the Al–C function). Functional group description, reaction mechanism, and a systematic analysis of various functional group transformations are given in subsequent chapters. This is an effective and refreshing approach when contrasted with the more traditional, element-by-element, march across the periodic table.

The rest of the text covers transition-metal chemistry, with subsections on classical coordination chemistry (about 235 pp of bonding, structures, and reaction mechanisms) and organometallic reactions and catalysis (65 pp) and a brief section (25 pp) on biochemical applications.

The text is well-written, and clearly presented graphs and drawings abound. Numerous study questions, a double index (compound and subject), and a thorough set of references are included. The integration of theoretical and descriptive chemistry is excellent, and is a major asset of this text. The authors state that it is intended for junior and senior chemistry majors with "the background of a first year, college level course and some knowledge of organic chemistry". A strong physical chemistry course is also advised, as a working understanding of thermodynamics and electrochemistry is assumed, and the bonding sections require at least rudimentary calculus and linear algebra. Crystal field theory is not discussed, as the only model presented for metal–ligand bonding in transition-metal complexes is the Angular Overlap approximation to molecular orbital theory. This is an unfortunate omission, as CFT is still an active model among inorganic chemists; its omission also hinders the pedagogically useful contrast between the crystal and ligand field theories.

This is a challenging, modern, and thorough work, and should be an attractive text for advanced undergraduates and graduate students.

Peter S. Sheridan, *Colgate University*

Anodic Protection. By Olen L. Riggs, Jr. (Kerr-McGee Technical Center) and Carl E. Locke (University of Oklahoma). Plenum Press, New York. 1981. xiii + 284 pp. $39.50.

The stated objectives of this book are to give technical information about anodic protection, to explain its economic analysis, and to describe some of the applications and equipment. These objectives have been met only partially and at levels which vary considerably from chapter to chapter.

The first section contains a simple and rather simplistic overview of the purposes of anodic protection and gives examples of applications to industrial systems. Equipment currently available and in use and the design, operation, and maintenance of complete systems are discussed in subsequent chapters with some emphasis placed on available electrodes and reference electrodes. Up to this point, the text seems to have been written for the advanced undergraduate student in the natural sciences. The section on economic evaluation is brief and not very informative.

The book then discusses the principles of anodic protection and this part is backed by an appendix on electrochemical principles of corrosion. Readers will find this a good and concise refresher course on the topic. Laboratory tests and procedures and the requirements placed on testing laboratories are presented. A chapter on the design features of potentiostats with detailed circuit diagrams will be of little interest to the professional concerned with practical applications. The main part concludes with a discussion of selected applications.

The book is well referenced throughout. In addition, the last one-fifth of the book is made up of a glossary, a sketch of the historical development, a list of pertinent U.S. patents, and a bibliography which starts in 1790 and ends somewhere in 1979. This compilation will be difficult to find elsewhere, will be of particular interest to both the advanced reader and the beginner, and makes the book worth having.

G. M. Schmid, *University of Florida*

Trace-Organic Sample Handling. Edited by Eric Reid (University of Surrey). Ellis Horwood Ltd. Chichester, England. 1981. 383 pp. $101.95.

This book contains more than two dozen brief papers, mainly drawn from a symposium held in 1979, with editorial annotations aimed at bridging the rather diverse topics covered. The principal emphasis is on applied analytical techniques and the details of practical procedures along with a few, but very limited, papers of a more fundamental nature.

Garry A. Rechnitz, *University of Delaware*

Spectrochemical Analysis of Pure Substances. By KH. I. Zil'bershtein (Leningrad, USSR). Crane, Russak & Co., Inc., New York. 1977. XV + 435 pp. $49.50.

This advanced monograph deals with the spectrochemical analysis of high-purity inorganic solids or liquids. Specifically, it discusses the accurate determination of small amounts of nongaseous impurities in high-purity substances by optical emission spectroscopy.

The monograph contains 15 chapters in three parts. Part I discusses the principles and methods of optical emission spectrometry itself. Part II deals with the methods of preliminary concentration of impurities for purposes of spectrochemical analysis. Part III treats the practical methods of spectrochemical analysis of pure inorganic substances. Techniques are discussed for the *direct* spectrographic determination of impurities in the $(10^{-4}–10^{-6})\%$ range, as well as the $(10^{-6}–10^{-9})\%$ range, for impurities first isolated and concentrated from large amounts of substances to be analyzed.

There are nearly 1500 references, with emphasis on the Russian literature, mostly from the 1950's and 1960's. Hence literature coverage seems out of date. The monograph may still be of value as a reference work to specialists in the field and to scientists in general interested in the analysis of trace impurities in inorganic substances.

Peter J. Stang, *University of Utah*

Rock and Mineral Analysis. Second Edition. By W. M. Johnson (British Columbia Ministry of Energy, Mines, and Petroleum Resources) and J. A. Maxwell (Geological Survey of Canada). John Wiley and Sons, New York. 1981. xi + 489 pp. $52.50.

This monograph is Volume 27 of "Chemical Analysis", a series of monographs on analytical chemistry and its applications, edited by P. J. Elving, J. D. Winefordner, and I. M. Kolthoff. This revised edition places more emphasis on instrumental methods (principally atomic absorption and wavelength dispersive X-ray fluorescence) than did the previous edition (published in 1968), which emphasized classical wet methods of analysis.

This edition is organized into five parts. Part I (Chapters 1–4) considers the nature of geological samples, sampling procedures, and sample preparation and decomposition techniques. Part II (Chapters 5 and 6) discusses analyses requiring specialized methods of sample preparation or analyte detection (e.g., determinations of water, carbon, and the specific valence forms of iron and sulfur, to name a few). Parts III (Chapters 7–9) and IV (Chapters 10 and 11), devoted to atomic absorption spectroscopy and X-ray fluorescence spectroscopy, respectively, summarize sample preparation and preconcentration techniques, instrumentation, and specific procedures for determination of major, minor, and trace elements by each of these instrumental methods. Part 5 (Chapter 12) briefly surveys the application of optical emission spectroscopy, neutron activation analysis, fire assaying, and the electron microprobe to the analysis of geological materials. Three appendices include a compilation and discussion of data on international standard reference materials, a comparison table of international standard sieve sizes, and a table of source materials and instructions for preparation of standard stock solutions.

Except for a useful summary of sampling theory, this book is virtually devoid of theory underlying the analytical methodology applied to rock and mineral analysis. Rather, the emphasis is placed on the practical details of analysis, and consequently the book will be much more useful as a laboratory source book than as a textbook for a rigorous course in geochemical analysis. Indeed, as stated in the preface, this was the emphasis which the authors intended. Particularly useful are the discussions of the difficult problems of sample decomposition in the analysis of geological materials. Extensive references to the original literature (averaging approximately 85 references per chapter) and an index enhance the usefulness of the book. Only a brief discussion (ca. 4 pages) is allotted to the increasingly important technique of inductively coupled plasma atomic emission spectroscopy and no mention is made of the increasing use of X-ray diffraction in mineralogical analysis, e.g., for the determination of mineral phases. These shortcomings are minor, however, compared to the wealth of practical information contained in this book. If you are a practicing analyst involved with the analysis of geological materials, this book might well become one of the most frequently consulted books in your library.

Dennis E. Tallman, *North Dakota State University*

Photoacoustics and Photoacoustic Spectroscopy. By Allan Rosencwaig (UC Berkeley, Lawrence Livermore Laboratory). Wiley-Interscience, New York. 1980. xii + 309 pp. $35.00.

Photoacoustic spectroscopy is both a very old and a very new field. The original discovery of the photoacoustic effect was made just over 100 years ago, but as an important scientific tool, its history is less than 10 years old. This book does an admirable job in presenting the history, theoretical background, and experimental details of photoacoustic spectroscopy. There are a significant number of examples of the usefulness of photoacoustic spectroscopy in both gaseous and condensed media. Especially helpful are the sections devoted to the theoretical basis of photoacoustics as well as discussions on instrumentation. The theoretical and numerical sections are generally directed toward the advanced undergraduate and graduate school level. The author has done an excellent job of providing both a thorough and a very readable description of photoacoustic spectroscopy for the scientific community.

Harvey S. Trop, *Bell Laboratories*