

cellent chapter on methylenes, an area in which Dr. Hine has made major research contributions.

Inevitably, anyone covering such a broad field will slight some important subjects, and give a somewhat distorted emphasis on others. Along this line, I regret the impression given by Dr. Hine that the steric effect of the leaving group is a generally accepted explanation of Hofmann-rule orientation in elimination reactions. Certainly many workers in the field, probably a majority, ascribe the major role to electronic effects. Some subjects that seem to me to deserve more emphasis than they get are Winstein's work on ion pairs, Cram's work on the stereochemistry of electrophilic replacements, and studies on the stereochemistry of free-radical additions. Some important advances in these fields may have come after the deadline for the manuscript, however. By way of minor quibbles, the stereo formulas for the bicycloheptane system (p. 324) are such complex jumbles of lines and circles that they are more likely to confuse the student than help him.

These are all minor faults, and I am sure Dr. Hine himself is not laboring under the illusion that he has written a perfect book. He has written a very good one that will be useful both as a textbook to the student and as a source of ideas and leads to the practicing organic chemist.

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WILLIAM H. SAUNDERS, JR.

**Inorganic Isotopic Syntheses.** ROLFE H. HERBER, Editor  
W. F. Benjamin, Inc., 2465 Broadway, New York 25, N. Y.  
1962. vii + 249 pp. 16 × 23.5 cm. Price, \$7.50.

In accordance with the stated intention of its editor, this volume is an excellent guide to the preparation of isotopically labeled inorganic compounds. A brief introductory chapter reviews radiochemical technique in general and radiochemical terminology. Each of the following eight chapters is devoted to a particular nuclide and is written by a separate author whom the editor considers to be an authority for that nuclide. The isotopes discussed are: H<sup>2</sup>, H<sup>3</sup>, N<sup>15</sup>, O<sup>18</sup>, P<sup>32</sup>, S<sup>35</sup>, Cl<sup>36</sup> and I<sup>131</sup>.

Over 300 syntheses are described. Some preparations are given in great detail, sufficient to enable the reader to proceed without further recourse to the literature. For other cases, when sophisticated equipment is required or the preparation is quite involved, the discussion is intended only as a guide and the reader must resort to the original publication. References to the original publications and related material are given for almost all but the most trivial syntheses. In all, almost 1000 references are listed.

This reviewer believes that this book would be a valuable edition in any laboratory, since today every laboratory is interested in isotopic syntheses to some extent.

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**Introduction to Ligand Field Theory.** By CARL J. BALLHAUSEN, Professor of Chemistry, University of Copenhagen, Denmark. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. 1962. ix + 298 pp. 16 × 23.5 cm. Price \$11.75.

In the borderland between physics and chemistry, one of the most fruitful applications of quantum mechanics is found in crystalline or ligand field theory, which is the key to understanding the magnetism, optical properties and coordination chemistry of solids containing ions of the transition groups. A review article written by the late Professor W. Moffitt and Dr. Ballhausen aptly concludes: "It will be a long time before a method is developed to surpass in simplicity, elegance and power that of crystalline field theory. Within its extensive domain, it has provided at least a deep qualitative insight into the behavior of a many-electron system. No other molecular theory, to our knowledge, has provided so many useful members which are so nearly correct. And none has a better immediate prospect of extending its chemical applications."

The broad outlines of crystal field theory were developed in the 1930's, but the subject has come into its own only in the last decade or so. New experimental techniques, such as microwave spectroscopy and better facilities for preparing single crystals of exotic compounds, have made it possible to put the theory on a more quantitative footing. In addition, the advent of the maser and laser has given it important technological repercussions.

In view of the current wave of interest in crystalline or ligand field theory, it is to be expected that a number of books would be written recently on the subject. In addition to numerous review articles, there are four such volumes of which the writer is aware. One of them is by a physicist (Low's "Paramagnetic Resonance in

Solids"), and the other three by chemists. All three of the latter omit the rare earths almost entirely. In size, price and amount of mathematical analysis, Professor Ballhausen's volume is intermediate between Orgel's "Transition Metal Chemistry," which contains not a single equation, and Griffith's "The Theory of Transition Metal Ions," which develops such mathematical refinements as fractional parentage and parity in half-filled shells. Ballhausen's book is, however, more complete than the other two in giving historical perspective and especially in references to the literature. For example, proper credit is given to the often overlooked pioneer work of Penney in 1940 on the stabilization of binding energies in the solid state by crystalline Stark splittings. Almost a thousand papers are cited, the bulk of them within the last few years, an indication of the rapidity with which the field is growing.

By ligands are meant the cluster of atoms about a central ion. Ballhausen and other modern writers use the term crystal field theory for mathematical analysis in which one treats the transition ion as a one-atom problem with the effect of the surrounding ligands represented by a static potential field of some particular symmetry type. The term ligand field theory is then employed for a more general treatment based on the method of molecular orbitals in which electrons can wander from the central ion to the ligands and *vice versa*, and various degrees of covalence thus are obtained. The reviewer was shocked recently to learn that one aptitude test question given to pupils in a suburban New York school was to distinguish between physicists and chemists by whether they are interested in atoms or molecules. If such outmoded compartmentalization is employed, crystal field theory is physics and ligand field theory is chemistry! Actually the two fuse together closely. Ballhausen's book combines both the basic central core of crystal field theory, roughly the first half of the book, and the modern ligand field ramifications. Recent work in paramagnetic and nuclear resonance has shown that even in the most ionic cases, except in the rare earths, the wandering or incipient covalence tendency is larger than was supposed in the early work.

As the pages unfold, the character of the book properly changes considerably. After a brief historical introduction, there are chapters on the theory of atomic spectra and on symmetry, which serve substantially as digests of Condon and Shortley type of material, and the results of group theory. Then two chapters give the mathematical development appropriate to crystalline fields of different symmetry types. The next chapter is on spin-orbit interaction, and the comparison with experiment becomes more frequent. The following one on molecular orbitals introduces the more general ligand field theory. Chapter 8 treats vibronic interactions and the Jahn-Teller effect, a subject to which the author naturally gives particular attention because of his original contributions in this field. After a short chapter dealing mostly with rotary dispersion, there is a long final one, almost devoid of equations and replete with references to the literature, on "electronic structures of selected inorganic complexes."

Professor Ballhausen has struck a good compromise between readers who would like to see everything proved mathematically and those who want merely the results of analysis. In a book of its dimensions, it is impossible to derive everything, and occasionally he could delineate a little more sharply between what he has and has not proved.

The English and literary style are excellent, though the author is not writing in his native tongue.

In summary, Professor Ballhausen is to be congratulated in writing a valuable, comprehensive and authoritative volume on a timely subject.

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**The Opium Alkaloids. Selected Topics.** By DAVID GINSBURG, Israel Institute of Technology, Haifa, Israel. Interscience Division, John Wiley and Sons, Inc., 440 Park Avenue South, New York 16, N. Y. 1962. 111 pp. 16 × 23.5 cm. Price, \$6.50.

This is a pleasant, personal little book written by an author who is indeed expert in the field about which he writes. It is the child born of the author's research interest, developed from a series of lectures, and intended as a teaching tool to assist organic chemistry graduate students. It cannot serve as an alternative to the various compendia on the opium alkaloids (Small, Bentley, Manske and Holmes), and, of course, Ginsburg does not purpose to do so. The chief, and considerable, value of this book is that it reflects the author's personal interest both in research and teaching.

"Selected Topics," is part of the title and this is indeed the case. Selection is the book's virtue from the pedagogic standpoint. A tasty mixture of classical and recent topics in opium alkaloid chemistry is presented, flavored by the author's own