

After introductory chapters on elementary crystallography and crystal optics there follows a comprehensive account of the polarizing microscope and its use with both orthoscopic and conoscopic observation. Three later chapters describe the stereographic projection, the preparation and handling of specimens, and practical examples. Appendices follow that list a selected bibliography, tables and collections of optical crystallographic data, and sources of materials mentioned in the text.

The treatment of the optical chapters generally follows the authors' earlier work *Crystals and the Polarizing Microscope* and fully maintains their reputation for clarity. The long chapter on the microscope contains an admirable section on correct illumination and its variation to meet differing needs, a topic of prime importance, sadly overlooked by students, and by writers of optical textbooks in the past. The later chapters contain much valuable advice and give a clear account of the operation of a simple stage goniometer for changing the orientation of a crystal. This section describes and illustrates the universal stage but does not say how to use it, an omission which is the more surprising in view of the inclusion of a whole chapter on the stereographic projection whose relevance otherwise is not immediately obvious. The least satisfactory section is the opening chapter which requires to be greatly supplemented if it is to provide a really adequate crystallographic foundation for the optics that follow.

The book retains the good qualities of its predecessor in its clear exposition of elementary optics and at a price that makes it attractive as an undergraduate textbook. To this extent it is undoubtedly a success but one is left with the feeling that with the same approach its appeal could be greatly increased by a drastic shortening of the less relevant sections and such further development of the practical aspects of the later chapters as would leave its total size and price unchanged.

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**Statistics in physical science. Estimation, hypothesis testing and least squares.** BY WALTER CLARK HAMILTON. Pp. [xii]+230. New York: The Ronald Press Company, 1964. Price \$10.00.

This comparatively short book treats a wide range of subjects. The first chapter, which occupies about a quarter of the total volume, is devoted to basic concepts and mathematical preliminaries. The second chapter is concerned with estimation of a single variable, including goodness-of-fit tests. Further chapters deal with analysis of variance in a thorough fashion, with the method of least squares and tests of linear hypotheses, and miscellaneous topics. Each chapter ends with exercises for the reader. The book ends with sixteen pages of tables, a bibliography, and a subject index. A bibliography cannot contain everything, but I missed my own favourite reference book, Cramér's *Mathematical Methods of Statistics*.

An unusual feature of the book is the space devoted to crystallographic problems, in which the author became interested while working with Dr Verner Schomaker. The longest crystallographic section is a discussion of significance of the value of the agreement factor  $R$ , a matter not

often mentioned in papers on structure determination. A seven-page table has been compiled by the author for use in such tests. There is, however, nothing on statistical methods for the determination of symmetry and structure (other than least-squares refinement).

A crystallographer seeking to increase his knowledge of statistical methods in general will find this book a good introduction because of the many examples drawn from his own field. There is rather extensive use of matrix methods, which some may find a disadvantage.

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**Applications of neutron diffraction in chemistry.** By G. E. BACON. The international encyclopedia of physical chemistry and chemical physics. Topic 11, Vol. 1. 141 pp. Oxford, London, New York, Paris: Pergamon Press, 1963. Price 42s.

Most crystallographers will by now be familiar with the ambitious project launched by Pergamon Press which envisages a hundred volumes devoted to 'a comprehensive and modern account of all aspects of the domain of science between chemistry and physics'. The present volume is the first devoted to topic 11, *The ideal crystalline state*. None of the volumes will be encyclopedic in the sense that the contents in them are arranged alphabetically; merely that the individual volumes of the project as a whole will be classified systematically.

Professor Bacon's book is somewhat shorter than the 200 pages which most of the volumes are expected to be. It is divided into eight chapters: principles and methods, hydrogen bonds in inorganic compounds, organic compounds, heavy-element compounds of carbon, nitrogen and oxygen, metal hydrides and ammonium compounds, compounds which include neighbouring elements, magnetic materials, liquids and gases. The author strikes a good balance throughout. He gives just sufficient background material to make the principles clear and his treatment of individual crystal structure is, on the whole, excellent. (The reader has to have a substantial grounding in the jargon of X-ray analysis. He is expected to know an  $F_0$  when he sees one. In this respect it is rather surprising to find Bragg's *The Crystalline State*, 1949, recommended as background reading rather than, say, Bunn's *Chemical Crystallography*, 2nd ed., 1961.)

The book is good and so eminently readable one hesitates to suggest improvements. On occasion, however, one feels the author might with advantage have used more of his ration of 200 pages to expand some of the topics he tackles. One gets this feeling on the very first page. Here the author illustrates diffraction by means of a one-dimensional simple-harmonic grating. Not only does this, as it stands, imply regions of negative scattering amplitude for light but it is a highly special case in which only the first order of diffraction is observed (correctly noted, but unexplained by the author). Similarly a sentence or two would have clarified why, in the projections of  $\text{KH}_2\text{PO}_4$  (pp. 25, 26), the applied electric field appears to cause the hydrogen atoms to move in such differing directions. It is only later (page 28) that we realize that we are looking along the applied field. A portion of the periodic table might have

helped those of us with bad memories to sort out (page 75) which of La, Y, Ce, Tb, Yb and Lu are rare earths and we could have been helped by not seeing  $\text{La}_2\text{C}_3$  (page 79) when it is more rationally written  $\text{La}_4(\text{C}_2)_3$ . (The word oxygen has been substituted for carbon on this page.)

In a short book such as this perhaps one has a right to expect few errors; it is gratifying nevertheless to find so few. Anyone (such as this reviewer) who has failed to keep abreast of advances in neutron diffraction will have his eyes opened to a fascinating field of research. The ideas of 'invisible' atoms will appeal to all X-ray crystallographers and there are few fields of scientific endeavour where one can so easily forgive a pun: crystals with invisible atoms are called 'null matrices'.

*Whether or not one is contemplating the daunting prospect of seeing all the hundred volumes on one's shelf, this particular volume, which stands independently of the others, will be a valuable addition to every crystallographer's library. It augurs well for the next two volumes we can expect under topic 11: lattice theory and the theory of metals.*

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**Atomic structure and chemical bonding.** By F. SEEL. 112 pp. (Translation and revision of 4th German edition by N. N. GREENWOOD and H. P. STADLER). London and New York: Methuen and John Wiley, 1963. Price 15s.

If one were required to compress an elementary non-mathematical account of atomic structure and chemical reactivity into a crown octavo booklet of 112 pages one would be hard put to it to better this book which is a translation of the 4th German edition.

The book will not be of special concern to crystallographers *qua* crystallographers and indeed, although the author gives good coverage to important structural types, he does not stress that crystal-structure analysis has been the basis of our revolution in thought concerning valency. His approach to this is often curious. He claims (p. 54) that it is erroneous ever to regard nitrogen as five-covalent, not as one might expect on crystal-structural grounds, but as 'is evident from Fig. 41 . . .'. This figure, needless to say, begs the question. There are several curious quirks of this kind. Examine the logic of the argument on pp. 66-69: (a) Li can use unhybridized *s* orbitals to form a metal; (b) atoms in general can involve hybridized orbitals to form metals; (c) one reason why hydrogen does not form a metal is because its electrons cannot hybridize.

Naturally the subject matter of the book is condensed and a student could hardly make much of it on his own. It would, however, be excellent collateral reading for a lecture course. The text is aided by a generous supply of ingenious diagrams. (Occasionally a bit too ingenious; examine Fig. 14 as an illustration of variable valency in the transition elements.) Here and there one felt the need for more illustrative information. Thus coordinate axes would have helped with *d* orbitals (Fig. 9), as they would when comparing COCIF with SOCIF (pp. 63-64). The author makes very

sensible use of energy data to explain chemical reactions and, although it is all chemically orthodox, it is well set out. Here again an energy-level diagram or two would have helped the discussion.

The sensible layout and good coverage have made this a popular book in Germany. This excellent translation should be equally popular in the English-speaking world.

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**Silicate science. Volume 1.** By W. EITEL. Pp. xii + 666, with 375 figs. New York and London: Academic Press, 1964. Price 171s. 6d. Subscription price 150s. to those who have placed orders for the complete set prior to publication of the last volume.

*The Physical Chemistry of the Silicates* by W. Eitel, published in 1954 was recognized as a *tour de force* summarizing the vast body of knowledge about silicates which had accumulated up to 1952. It is a measure of the enormous growth of this subject that the present large volume is the first of five being prepared, all by W. Eitel, which are now needed to cope with the progress made in the period 1952-62. It is important to realize that the five new volumes (1. *Silicate Structures*; 2. *Glasses, Enamels, Slags*; 3. *Dry Silicate Systems*; 4. *Hydrothermal Silicate Systems*; 5. *Ceramics and Hydraulic Binders*) are not a revision of the earlier work but are entirely supplementary to it. Volume 1 *Silicate Structures* is divided into three sections: *A*. Silicate crystal structures, 218 pages; *B*. Clay mineral structures, 67 pages; *C*. Silicate dispersoids, 327 pages. The arrangement within each section is by means of numbered paragraphs each dealing with a separate topic: the paragraphs are in effect extended abstracts (with illustrations) of one or more papers on a given theme, and related themes are usually found in neighbouring paragraphs.

The largest part of section *A* describes the important silicate structures determined in the ten year period, but this is preceded by chapters on general crystal chemical topics, infrared spectrometry and complex anions in alumin-, beryll- and boro-silicates. For the arrangement of material in the description of structures the Zoltai method of classification is used. The hitherto commonly adopted Bragg classification of silicate structures is ruled by the type of linkage of  $\text{SiO}_4$  tetrahedra (chains, sheets, *etc.*), but inconsistencies arise through the treatment given to aluminum and other atoms when they occur within oxygen tetrahedra. For example, in cordierite  $\text{AlO}_4$  groups are not regarded as in the 'silicate' arrangement, but in anorthite they are. The classification by Zoltai takes into account all tetrahedrally coordinated cations in describing tetrahedral arrangement. Thus beryl and cordierite, for example, are described as having framework rather than ring structures, and oakermanite containing linked  $\text{Si}_2\text{O}_7$  and  $\text{MgO}_4$  groups is treated under sheet structures. One result of the new classification is that it causes sillimanite ( $\text{Si}_2\text{O}_5$  chains) to be separated from its polymorphs, because aluminum is in fourfold coordination in sillimanite whereas in kyanite and andalusite it is in 5-fold and 6-fold positions respectively.

Although the coverage of recent structure determinations is fairly comprehensive, a number of important spheres of