NEW BOOKS

The Constitution of Matter. By MAX BORN, translated by E. W. BLAIR and T. S. Wheeler. E. P. Dutton and Co., New York, 1923. vii + 80 pages. 15 × 22.5 cm. Price $2.50.

This little pamphlet of 80 pages is a translation of the second edition of Born's "Der Aufbau der Materie." In this form it is a slightly revised rendering of three reviews which were originally published in "Die Naturwissenschaften" for 1919.

The first essay, entitled "The Atom," aims to give a brief survey of the field of atomic physics—as such it is already out of date. The third paper, called "The Fusion of Chemistry and Physics," is of decided interest to chemists. It is a short account of the results which have attended efforts to connect chemical reactivity with atomic structure through the use of modern thermodynamics and the "ion lattice" theory of crystals. Though the reality of many of their present results may be open to doubt, these efforts will be of the utmost value in outlining one approach to the fundamental problem of calculating the course of chemical reactions from a knowledge of the physical properties of the reacting atoms. As far as the reviewer is aware the essay under discussion is the best existing survey of this field. It has certain limitations, however, as a popular treatise. It cannot be read without study; and a point of view which finds that the Nernst heat theorem has effected a "fusion of chemistry with physics which apparently leaves nothing to be desired," or considers that powder diffraction data prove that the atoms of lithium fluoride crystals are electrically charged, is liable to produce a false sense of progress in the minds of the uninitiated. The second essay—"From Mechanical Ether to Electrical Matter"—is mainly a discussion of the "ion lattice theory" of crystals.

The translation of the third essay is to be welcomed as an authoritative if perhaps over-enthusiastic statement of a subject which has not yet received attention from English-speaking scientists. It is not so easy to understand the justification for a translation of the rest of the book. The subject of atomic structure has been often presented in quite as able a fashion in English and for the general scientific public.

The book, especially the first essay, is extensively illustrated by drawings and photographs. The reproductions of the latter are not always impressive and the descriptions of many are so scanty that their meaning will not be clear to the persons who would profit by reading the paper.

RALPH W. G. WYCKOFF

The Atom and the Bohr Theory of its Structure. An Elementary Presentation. By H. A. KRAMERS, Lecturer at the Institute of Theoretical Physics in the University of Copenhagen, and HELGE HOLST, Librarian at the Royal Technical College of Copenhagen. Translated from the Danish by R. B. LINDSAY, Fellow of the American-Scandinavian Foundation, 1923, and Mrs. RACHEL T. LINDSAY. With a foreword by Sir Ernest Rutherford, F. R. S. Alfred A. Knopf, Inc., 220 West Forty-Second Street, New York, 1923. xiii + 210 pp. 34 figs. 22 × 14 cm. Price $4.00 net.

Evidently it has become somewhat of a popular pastime to write books on various phases of atomic structure and the Bohr theory, for they have been multiplying so rapidly during the past two years that a newcomer must indeed confront a serious task in winning attention and favor. It is not difficult to recall the names of Sommerfeld, Andrade, Stock, Born, Campbell, Russell, Valentiner, Fajans, Ladenburg, Reiche, Rinne, Langevin and deBroglie, Foote and Mohler and others, as authors of such books. Most of these have chosen to appeal in a more or less popular vein to the layman and the teacher rather than to the trained mathematical physicist. The result is that the man in the street may, if he will, speak familiarly and intelligently of the Bohr atom, and he may visualize in a most satisfactory and accurate manner conceptions which have their foundations also in intricate mathematical theory. Latest among the elementary treatises on atoms and the Bohr theory is that written by the two Danes, Kramers and Holst, and translated into English by the Lindsays.

The authors are exceptionally well qualified to present the subject matter authoritatively, inasmuch as both are closely associated with Professor Bohr and his new School of Physics. The book fulfils every expectation, for it is at once clear, accurate (which cannot be said for some of the other books on the subject) and logical. An enthusiastic sense of the dramatic characterizes it, for more than half of the 210 pages are devoted to skilfully setting the stage, as it were, for the advent of the immeasurably great contribution of Niels Bohr. Beginning with the conceptions of the ancient philosophers the advance in knowledge of the structure of matter proceeds step by step until finally in 1913 there stand four separate fundamental contributions, largely unrelated—indeed to some extent antagonistic: the Lorentz-Larmor classical electrodynamics, the empirical spectroscopy of Balmer, Ritz and Rydberg, the Planck quantum theory, and the Rutherford nuclear atom. Then the Bohr theory of the hydrogen spectrum began to clear up a seemingly hopeless muddle. Even with the late masterful work on the electronic structures of the entire periodic system, the theory is yet incomplete. But its triumph is unassailable.

Kramers and Holst have every excuse for being enthusiastic to the point of exuberance, and yet their presentation is rationally tempered by consideration of all the difficulties, uncertainties and shortcomings of the theory. There is created almost the impression that Professor Bohr has

had to parry the thrusts of a hostile world; critical, it is true, at first, but not hostile, and now unanimously approving. The authors have no desire to astonish the reader or to shout from the housetop. Rather do they present facts and speculations in an orderly and dignified manner, with the hinted caution not to expect too much. It is almost as if the very modest Bohr himself were speaking—as no doubt he is. Recently newspapers and pseudo-scientific popular publications have attempted to stir up great excitement by pointing out that Rutherford's success in obtaining hydrogen by bombarding nitrogen atoms with α particles will lead to the easy production of gold from mercury, and that the enormous energy bound in atoms, enough in one gram to be equivalent to 3000 tons of coal, may be utilized to practical advantage. In no uncertain terms this book disillusions the gullible reader of such sensational perversions. It is popular and elementary, but it is also idealizing the truth and it is therefore rigorously scientific. It is never patronizing, but seeks to convince by excellent analogies.

Little can be said in adverse criticism. The style at times seems almost on the verge of monotony, perhaps because the book is a translation. The mechanical features of the book are only fairly satisfactory, though errors are few in number. "Harmonics" is rather amusingly replaced by "harmonies" on p. 106. Some readers might object to the classification on p. 24, of chemistry as a branch of physics. Brevity also sometimes unfortunately obscures the line which should be clearly drawn between experimental fact and speculation, entirely rational though it may be. One also has the feeling that contributions of X-ray researches, for example, are considerably neglected (particularly since the very latest triumph of the theory is Professor Bohr's explanation, in a current paper, of the selective reflection of characteristic X-rays by crystals).

This is a book for folks who would satisfy curiosity and know and think honestly. It can be understood by anyone with average intelligence; in fact, it should prove fascinating to all ages from twelve or fourteen up. It stimulates the imagination and leads to an infinitely greater appreciation of the great works of men whose lives are spent in pure science. It is a book for the home library table, for the college lecture room, for the scientist's reference shelf, for the minister who would preach truth and faith. It is the kind of book which may be read appreciatively at a single sitting in two or three hours, or in bits, even on a street car (the reviewer has observed this in three instances). Kramers and Holst open the door of a new knowledge to all who have the intellectual ambition to be abreast of man's achievements. For the Bohr theory, even yet in its very beginnings, is already the worthy culmination of centuries of keen speculation and beautiful researches, and one of the great achievements of all time.

GEORGE L. CLARK

The Electron in Chemistry, being five lectures delivered at the Franklin Institute, Philadelphia. By Sir J. J. THOMSON, O.M., F.R.S., Master of Trinity College and Professor of Experimental Physics in the University of Cambridge. The Franklin Institute, Press of J. B. Lippincott Company, Philadelphia, 1923. 3 + 144 pp. 41 figs. 24.5 × 16.5 cm. Price $1.75 (carriage extra).

Through his epoch-making investigations upon cathode rays, and later upon positive rays, Sir J. J. Thomson has contributed more than any other one man to our knowledge of the fundamental nature of matter. A book from his pen upon "The Electron in Chemistry" commands, therefore, our profound attention. We are not surprised to find a very thorough treatment of this subject, which is of the greatest significance to chemistry, and in connection with which, also, chemistry doubtless has as much to say as physics. In this connection, the author states in the preface:

"From many points of view the chemical side seems to be the one on which the most striking developments of the newer physics may be expected. In the first place the problems are of the greatest intrinsic importance, and secondly, in the vast mass of information accumulated by chemists with regard to the combination of atoms we have unrivalled means of testing the truth of any conclusion to which the theory may lead us."

Chapter I deals with the arrangement of electrons in the atom. He adopts a static model of the atom, stating,

"When there are several electrons in the atom the orbits described by the electrons would be of great complexity, and the mental picture conveyed by this multitude of orbits would be too blurred and complicated to be of much assistance in helping us to get readily a clear idea of what is going on in chemical processes.

"I have therefore adopted the plan of supposing that the law of force between the positive part and the electrons is, at the distances with which we have to deal in the atom, not strictly that of the inverse square, but a more complex one which changes from attraction to repulsion as the distance between the positive charge and the electron diminishes. This hypothesis leads to a simple mental picture of the structure of the atom and its consequences are in close agreement with the facts of chemistry. I suppose that the repulsive force between two electrons is always inversely proportional to the square of the distance."

He then proceeds, upon the basis of the law of force adopted, to deduce the stable arrangements of electrons in atoms of increasing complexity, which becomes, for example, a tetrahedron for four electrons, an octahedron for six, a twisted cube instead of a tetrahedron, for eight. He is able furthermore to compute the sizes of atoms and their ionizing potentials.

In Chapter II is discussed the arrangement of electrons in compounds. The chemical bond usually consists of a pair of electrons, although not infrequently a pair of atoms may be linked by a single electron, as in H_2^+ detected in positive-ray photographs. A three-electron bond is regarded as a possibility. The double bond consists of four electrons. In general the ideas presented concerning the arrangement of electrons in compounds are very similar to those presented by Lewis, with which most readers are already familiar.

The octet is regarded as the maximum number of electrons that can exist in any zone, and hence an unsymmetrical structure is assigned to compounds such as sulfur hexafluoride. This seems to be inconsistent with the properties of this substance. A chemist might object that several of the conclusions reached in this chapter are too entirely deductive, such as the statement that "methyl alcohol is a substance without any tinge of acid properties; in fact, it is basic, if anything."

The polarity of molecules, as indicated by their dielectric constant in the gaseous state, receives considerable attention as a means of determining their symmetry, and hence of distinguishing between possible electron structures. The author was probably the first to emphasize the significance of the dielectric constant of gases, and his discussion of it in this book is exceedingly suggestive.

Chapter III treats of residual affinity, molecular compounds and coördination numbers. His insistence upon a maximum of eight electrons in a zone makes it necessary to assume an unsymmetrical structure when six atoms surround central atom. As with sulfur hexafluoride, he assumes that two of the atoms are held to the central atom by single electron bonds. An error occurs on p. 73 where antimony pentachloride is referred to as a gas.

Chapter IV deals with the mechanism of chemical combination, where much stress is laid upon the effect of polarity in "opening up" the reacting molecules. Double layers, active molecules, partial valences, the ketol-enol change, the production of light by chemical change, homologous elements, variable valence and magnetism are all discussed at some length.

Chapter V contains a discussion of the electron theory of solids. The author's law of force is used to calculate vibration frequency, photo-electric effect, compressibility and surface tension.

The fact that the book was written for a series of lectures may account for the omission of references that might have been made to the work of others in this same field. For example, we find but one casual reference each to Bohr and to Lewis, and none to Kossel. It is evident that the book should be regarded as a monograph upon the author's personal views rather than as a presentation of the present general status of the subject. It is exceedingly suggestive to those who are familiar with the field, but would be rather misleading if relied upon alone by a beginner.

The brilliant achievements of the Bohr theory of atomic structure in the realm of spectroscopy and ionizing potentials have been practically ignored, which will be rather disappointing to many readers who might have hoped, from a physicist of the eminence of Sir J. J. Thomson, for an illuminating treatment of the rival claims of the static and dynamic models of the atom.

J. H. HILDEBRAND

Metals and Metallic Compounds. By ULICK R. EVANS, M.A., King's College, Cambridge. Longmans, Green and Company, 55 Fifth Avenue, New York; Edward Arnold and Company, London; 1923. 22.5 × 14.5 cm. Vol. I. Introduction, Metallography, Electrochemistry. xii + 468 pp. 91 figs. Price $7.00 net. Vol. II. Metals of the "A" Groups. xi + 396 pp. 19 figs. Price $6.00 net. Vol. III. The Transition Elements. xii + 270 pp. 44 figs. Price $4.75 net. Vol. IV. Metals of the "B" Groups. xiii + 350 pp. 38 figs. Price $6.00 net.

This book is unique. It is a treatise on the metals and their compounds which is much more detailed than a short text like Mellor's "Modern Inorganic Chemistry," but it contains no such wealth of uncritically assembled data as the encyclopedic reference works. Moreover, it is as nearly up-to-date as any such book can possibly be and displays an unusual degree of unity of point of view and method. The author shows a thorough acquaintance with technical processes and a predominating interest in problems of industrial importance, but the purely scientific part of his task has been excellently well done. The book is intended for continuous reading and holds the reader's interest remarkably well considering how much detailed information it contains. Like several of the other English works of somewhat similar scope, this is intended to form the mind of the student of metals as well as to impart information and, consequently, the first volume contains a review of such parts of general chemistry, physics and geology as such a student needs to keep in mind. This volume includes excellent chapters on metallography, electrochemistry and geochemistry.

The author says concerning the other volumes:

"In Volumes II, III and IV, I deal one by one with the individual metals. The order observed is based upon the Periodic Table in a form similar to that made popular by Sir James Walker. The old form of the Periodic Table which classes sodium along with copper has now—it is to be hoped—few active supporters, although it still ornaments the walls of our lecture theatres, and appears to find favor with the authors of chemical treatises based upon the classical model. In the new table, which accords well with the chemical and electrochemical properties of the elements and is in harmony with modern ideas of the structure of the atom, the elements can be divided into three main classes, and I have allocated a different volume to each class. Volume II deals with the metals of the "A Groups," Volume III with the "Transition Elements" ("Group VIII" of the old table), while Volume IV deals with the metals of the "B Groups."

"The space devoted to each metal is divided into three main sections. The first deals with the metal and its compounds from the point of view of the academical laboratory. The pure chemistry of the metal and its compounds is here discussed; no reference to ores, technical processes and industrial application is made in this section, which is therefore fairly concise. The section ends with a summary of the methods of analysis of the metal in question, although the book is not intended as a practical analytical handbook.

"The second section deals shortly with the terrestrial occurrence of the metal in question, starting with its origin in the rock-magma, and discussing the probable mode of formation of the important ores and minerals, both primary and secondary.

"The third section—which is often the longest—is of a technical character. We

start with the ore or mineral, and follow the metal through the processes of concentration and smelting, and finally consider the practical uses of the element, and of compounds containing it; I have tried to show why the properties of the individual metal—as stated in the theoretical section—render it suitable for the various uses to which it is put, and to make the technical section a correct survey of industry carried on at the present time; I have only referred to obsolete methods of procedure in a few places where such a reference is thought to be instructive.

"Stress has been laid on the important points, which have been illustrated by a few chosen examples in order to avoid burdening the reader with a mass of names and numbers, which he will not retain, and which can be looked up when required in a table of physical constants or in a detailed book of reference. Proper names have largely been concentrated in the footnotes, and thus kept out of the text; I have written a book about chemistry—not about chemists. Likewise the figures are frankly diagrammatic, drawn to emphasize the salient points; in the diagrams of technical plants much that is of merely structural importance is omitted. I have only employed the historical order of description where it happens also to be the logical order.

"Throughout the book numerous references are given, in footnotes, to scientific and technical literature; these should be consulted by the reader who wishes to study any given part of the subject in greater detail. In selecting these references, I have not given preference to the work of the actual originators of the various theories or processes, but have sought rather to provide the reader with the most recent information regarding the matter under discussion. The recent papers themselves will include references to the earlier ones, whilst the converse is clearly not true."

. . . . . ."The book is intended for the advanced student of inorganic and metallurgical chemistry, and for those engaged in research in these subjects. The industrial chemist will, I hope, also find it of assistance, whilst certain portions (*e. g.*, those dealing with work-hardening, recrystallization, the effect of impurities on metals, and corrosion) should prove useful to the engineer."

The work as a whole can be cordially recommended to all serious students of inorganic chemistry. There seem to be a few errors of diction, spelling, etc., of which a partial list is appended.

Vol. I, p. 169, l. 25; p. 170, l. 12–13; p. 274, l. 11; p. 342, note 1; p. 355, l. 26.

Vol. II, p. 264, footnote.

Vol. III, p. 156, l. 9; p. 169, l. 19.

NORRIS F. HALL

Conférences sur les Métaux. By MARCEL GUICHARD, Professor at the Sorbonne. Third edition. Gauthier-Villars et Cie., Quai des Grands-Augustins, 55, Paris, 1924. xxix + 355 pp. 105 figs. 22.5 × 17 cm.

Professor Guichard's "Lectures on the Inorganic Chemistry of the Metals" were published with the encouragement and aid of the "Alumni Association" of the Faculty of Sciences of Paris, and represent about thirty hours of lectures addressed to first-year university students. The author makes no claim of completeness, but strives judiciously to select the essential facts and general ideas germane to the subject. Preparative directions and analytical methods are omitted, as well as descriptions of industrial installations. Less important groups of compounds

have also received scant mention. The importance of alloys, sulfides, oxides and chlorides has been intentionally exaggerated, as the author feels that it is these compounds which give each metal its peculiar and interesting aspect.

The book is frankly and consistently descriptive, but it does not force all the rich variety of the different elements into a single rigorous *order of presentation*—a procedure which tends to make one think of the metals as exhibiting more or less annoying deviations from orthodox behavior. Instead, the individual character of the chemistry of each metal is thrown into clear relief. The various compounds of a given metal are regarded as "derived" in order from some particular common natural compound—but the compound chosen varies from element to element. The author arranges the elements according to a classification of his own, based on resemblances, which he regards as more valid and useful than Mendeleef's classification.

A long introductory essay "On Chemistry and Chemists" in this edition affords him an opportunity to review the present day status of his profession in France and to offer words of guidance to budding chemists.

The laconic staccato of spoken lectures characterizes the style throughout and there are no numerical calculations, no problems, and none of the usual signs of a feverish struggle to be up-to-date.

Perhaps the most striking features of the book are the consistent use of phase diagrams and metallographic data in the description of the metals, and the extreme conciseness of the treatment of the whole subject.

There seem to be many typographical and other errors. The value of the faraday is given as 96,600 coulombs on p. 19. On p. 23 "réactif" is misspelled. An antiquated notation is used throughout. The diagram on p. 37 brings the state of the alkali industry up to 1908. On p. 95, calcium sulfate is written SO_2Ca, and the atomic weight of radium is given as 226.4 while that of lead is 207 in one place and 207.1 in another. The habit of giving references by name only has certain advantages, as no reader's time is wasted in looking them up, but the discoverers of "Celtium" may well protest if posterity is to give credit for their work to "G. Urbin" and "Dauvillers" (pp. 104–5).

NORRIS F. HALL