graphic behavior of the synthetic and isolated substances were identical. Tests of the biological activity of synthetic kinetin are in progress.[11]

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[11] NOTE ADDED IN PROOF.—The biological activity of synthetic kinetin now has been found to be the same as that of the isolated substance in tests on tobacco tissues.

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RECEIVED MARCH 30, 1955

SELF-EXCHANGE OF BORON IN BORON HYDRIDES

Sir:

The considerable interest in the reaction kinetics[1-3] and in the structures of the boron hydrides[4] has prompted us to investigate the self-exchange of boron in various boron hydrides.

We have found that the exchange of boron between isotopically-normal diborane and B^{10}-enriched diborane is quite rapid at 25°, the rate being similar in magnitude to that observed for the deuterium exchange between diborane and hexadeuteriodiborane.[3] In contrast, we have found that no boron exchange occurs between isotopically-normal pentaborane and B^{10}-enriched pentaborane at temperatures up to 100° in the liquid phase or up to 250° in the gas phase. At the latter temperature the pentaborane undergoes considerable decomposition to give hydrogen and non-volatile solids (no volatile boron hydrides could be detected). It should be noted that hydrogen exchange between deuteropentaborane and pentaborane has been observed at 200°, but not at room temperature. The reactions have been followed by mass spectrometric analysis.[5] B^{10}-enriched diborane is prepared from $B^{10}F_3$[6] in the conventional manner[7] and B^{10}-enriched pentaborane is obtained by pyrolysis of the diborane.[8]

The rapid exchange of boron in diborane is consistent with the accepted diborane structure of two borines held together by two bridge hydrogens[9] and with the widely accepted reaction mechanism involving diborane dissociation.[1-3] It is interesting that pentaborane, with a pyramidal structure[10] involving direct B–B linkages, does not undergo boron exchange even under conditions which bring about copious decomposition. It is concluded that dissociation fragments do not exist in pentaborane under ambient conditions. However, the hydrogen atoms appear to be sufficiently labile at elevated temperatures for self-exchange.

This study of the self-exchange of boron, as well as that of hydrogen, is being extended to cover all known boron hydrides.

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(1) R. P. Clarke and R. N. Pease, THIS JOURNAL, **73**, 2132 (1951); J. K. Bragg, L. V. McCarty and F. J. Norton, *ibid.*, **73**, 2134 (1951).

(2) S. H. Bauer, A. Shepp and R. E. McCoy, *ibid.*, **75**, 1003 (1953); H. G. Weiss and I. Shapiro, *ibid.*, **75**, 1221 (1953); A. T. Whatley and R. N. Pease, *ibid.*, **76**, 1997 (1954).

(3) P. C. Maybury and W. S. Koski, *J. Chem. Phys.*, **21**, 742 (1953).

(4) W. H. Eberhardt, B. Crawford, Jr., and W. N. Lipscomb, *J. Chem. Phys.*, **22**, 989 (1954); J. R. Platt, *ibid.*, **22**, 1033 (1954).

(5) A Consolidated model 21-103 mass spectrometer operating at 70 volts was used in this study.

(6) The $CaF_2 \cdot B^{10}F_3$ complex, obtained by allocation from the Atomic Energy Commission, Oak Ridge, Tenn., is heated to 250° *in vacuo* to release $B^{10}F_3$, which is then condensed in anhydrous ethyl ether.

(7) I. Shapiro, H. G. Weiss, M. Schmich, S. Skolnik and G. B. L. Smith, THIS JOURNAL, **74**, 901 (1952).

(8) A. B. Burg and H. I. Schlesinger, *ibid.*, **55**, 4009 (1933).

(9) W. C. Price, *J. Chem. Phys.*, **16**, 894 (1948); **15** 614 (1947).

(10) W. J. Dulmage and W. N. Lipscomb, THIS JOURNAL, **73**, 3539 (1951); K. Hedberg, M. E. Jones and V. Schomaker, *ibid.*, **73**, 3538 (1951).

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RECEIVED APRIL 2, 1955

BOOK REVIEWS

Comprehensive Inorganic Chemistry. Volume Three. The Halogens. By ROBERT C. BRASTED, Associate Professor of Chemistry, School of Chemistry, University of Minnesota. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. 1954. x + 250 pp. 16 × 24 cm. Price, $5.00.

One who examines this book may wonder just what group of readers the author is addressing. The answer is to be found in the preface which says: "Comprehensive Inorganic Chemistry is an eleven-volume reference work on the chemical elements and their inorganic compounds. It is comprehensive in the extensiveness of the fields covered rather than in the fullness of their treatment; hence, the volumes are offered individually as a *vade mecum* for the advanced worker—whether industrial or academic—not as an encyclopedic work. Their purpose, therefore, is to serve as a ready reference to those engaged in chemical manufacture and development and to those in advanced studies in chemistry in institutions of higher learning. . . ."

An advanced worker in inorganic halogen chemistry will be particularly interested in those portions of the book dealing with his own areas of specialization, because the point of view of the writer probably will differ from his own. He may not always agree with the author, but he probably will see new problems for research.

The author has read extensively in the recent literature on the halogens and has organized the subject matter under headings indicated by the chapter titles: (1) Fluorine, (2) Chlorine, (3) Bromine, (4) Iodine, (5) Astatine, (6) The Hydrohalides, (7) Oxycompounds of the Halogens, (8) Positive Halogens, Interhalogens and Polyhalide Anionic Complexes, (9) The Pseudohalogens (Halogenoids) and Related Compounds. Chapters 1–5 inclusive deal largely with the preparation and properties of the free elements and include discussions of many compounds with particular emphasis upon fluorides. Only a little information is given about astatine. To this reviewer the most interesting chapter is that on the oxycompounds. This is an up-to-date summary with some emphasis upon mechanism of reactions.

The book is not a text and it is not a complete reference book to the literature; it is, instead, a book on certain aspects of halogen chemistry of active interest. Even on these topics it is not a complete survey of the literature.

On the whole the book is good; however, it is not perfect. Some parts of it are so brief that they are difficult to under-stand. In places it is not well organized and gives one the impression of being a patchwork quilt of bits of information. Errors are present but these are at least in part due to errors quoted from the literature. At times the author makes contradictory statements which may be traced to conflicts in the literature being reviewed. For example, recent studies of the dissociation energy of the F_2 molecule are discussed on p. 19 while on p. 22 the old value is used without comment as the bond strength in the molecule. The subject index is brief and there is no author index.

The policy of the author and the other editors to make this volume deal largely with topics which are being studied now seems good. It is hoped that it will be continued in the remaining eight volumes of the series.

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Geochemistry. By the late V. M. GOLDSCHMIDT, Professor of Geology, Frederiks University and Museum, Director of the Statens Rastofflaboratorium, Oslo, and edited by Alex Muir. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. 1954. xi + 730 pp. 16.5 × 24.5 cm. Price, $11.04.

More than any other man V. M. Goldschmidt was the father of modern geochemistry; during the years 1922–1940 his laboratories in Oslo and Göttingen developed the ideas, the techniques, and the basic data which established geochemistry as a quantitative science and provided the stimulus for the present intense activity in this field. He died in 1947 at 59, his health shattered by his experiences in German concentration camps. This book, written while he spent his last years in British hospitals, is incomplete, but it is characterized throughout by the technical excellence and first-hand familiarity with subject found only in books written by active researchers in a field. It has benefited very greatly from the capable and solicitous editing and annotation of Dr. Muir, and by the help of many other scientists; to these men we owe a debt of gratitude for making the work available at last.

The book is divided into two main sections of general geochemistry and the specific geochemistry of the elements. The first section, dealing with fundamental principles and processes, represents only a fragment which Goldschmidt intended to modernize and make much more extensive. It begins with a discussion of the distribution of the elements during the evolution of the earth, based on the familiar Goldschmidt classification of the elements as siderophil, lithophil, chalcophil, atmophil and biophil, and on the available thermodynamic data for the treatment of phase equilibria. Goldschmidt always accepted the classical picture of an earth condensing from a hot gas cloud and his discussion is necessarily biased along the lines of treating the primitive earth as a huge smelting furnace. Though he understood that the earth's atmosphere and hydrosphere must have evolved as a secondary phenomenon, his views led him to classify as atmophil such elements as Cl, Br, I, B, and even Si as SiO, postulating their presence in the earth's primitive atmosphere. He explained the extremely high concentration of the first four in sedimentary rocks and the ocean as compared to igneous rocks as the result of the residual primitive atmosphere plus later derivation from the earth's interior as volatile emanations from volcanoes and fumaroles.

There follows an excellent short discussion of the evolution of magmatic rocks with special reference to the pattern of distribution of major and minor elements in the early and late crystallizing fractions. Goldschmidt's classic presentation of the quantitative treatment of geochemical processes, based on his development of the concept of geochemical balancing between igneous and sedimentary rocks and the ocean and atmosphere, is taken verbatim from his 1933 article and included as a chapter. This section of the book also includes a brief unsatisfactory treatment of cosmic abundances, and a final extensive chapter on the principles of crystal chemistry which Goldschmidt did so much to help formulate during the first phase of his scientific career at Oslo.

Part II, on the geochemistry of the specific elements, makes up the major part of the book. The elements are arranged by the appropriate groups and their geochemical cycles discussed in detail. Special attention should be called to the chapters on carbon, the halogens, iron, cobalt and nickel, and silicon, probably the best in the book, in which Goldschmidt writes with superb clarity, organization, and understanding. Iodine actually is an atmophil element to some extent, occurring in concentrations up to 0.012 p.p.m. in air, and the discussion ranges from early theories relating the prevalence of goiter in the Alps to depletion of atmospheric iodine by settling of high molecular weight I_2 (not possible, of course), to the state of equilibrium between the surface of air-borne dust particles and gaseous molecules, and the relationship of regional distribution of iodine deficiency to the pattern of the differing iodine concentrations of air masses of different geographic origin. The chapter on iron contains an excellent treatment of the ferrous-ferric iron equilibrium in magmatic rocks and iron and sulfide ores, and ranges into a discussion of the chlorosis, due to iron deficiency, in Hawaiian pineapples growing on both iron-poor soils derived from coral, and iron-rich lava soils. These examples may suffice to show the extraordinarily wide range of Goldschmidt's interests and knowledge; one can almost sense, as one reads, the keen enthusiasm with which he followed the path of the geochemical cycle of each element.

Probably no other man ever knew as much about all of the geochemistry of his time as Goldschmidt, and with the characteristic tendency for increasing specialization in a progressing science, probably no man ever will. He was the first and last of his kind in his field, and his book, long awaited, will stand as a classic source of ideas, observations and inspiration to be drawn upon by all the sciences.

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Starch and its Derivatives. Volumes I and II. Third Edition (Revised). By J. A. RADLEY, M.Sc., F.R.I.C., Chemical Consultant. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. 1954. xi + 465 pp., xi + 510 pp. 15 × 22 cm. Price, $10.00, each volume.

Current appetite for technical books on starch chemistry and technology is reflected in the exhaustion of the first and second editions of Kerr, "Chemistry and Industry of Starch" (Academic Press, Inc., 1944, 1950), and Radley, "Starch and its Derivatives," the latter now appearing in a two-volume 3rd revised edition (hereafter referred to as the 3rd ed.). The editorial preface indicates the general purpose is to ". . . focus attention upon recent work, or upon new aspects of old work, and upon their theoretical implications. Such books are written by experts for other experts in related fields of science, or for the well educated layman.... It is the first duty of the monograph writer to estimate the value, either actual or potential, of recent work upon the subject of which he writes: he must pick out the plums to save others from the indigestion that follows eating the whole pie. . . ." These objectives are unevenly attained, sometimes quite well, but oftener not at all.

The strength of the 3rd ed. lies in a few good new chapters, written by outstanding workers. For example, the chapter by Dr. T. J. Schoch on starch fractions is critical, interestingly written, unquestionably authoritative, and provided with an excellent set of references to 1949, many with brief abstracts. Throughout, an abundance of references is supplied, though few are very recent.

The greatest single weakness of the 3rd ed. is the delay between the writing of the bulk of the text and its publication. The author's preface does not give any date (as it should) to indicate how recently the literature has been covered, but some idea can be obtained by looking through the most recent references for each of the first ten chapters: 1911, 1951, 1951, 1944, 1944, 1949, 1941, 1950, 1944, 1945. Some of the chapters have been taken from the previous editions (1940, 1943) without appreciable revision. For example, chapter 20 on β-amylase action could stand a bit of dusting off (the most recent reference is 1940). Most of the material on the starch industry is antiquated, with few references since 1944.

As regards digestibility, much of the book consists of statements relating to research findings with little or no attempt to interpret them: ". . .Haerz observed (1905)