here also relatively large amounts of Cl_2O_6 are formed.

Chlorine dioxide solutions were insolated for some time and then forced into water and shaken. A heavy mist was observed similar to that which forms when Cl_2O_6 reacts with water. Chlorine dioxide and chlorine were removed from the water extract by aspirating air through it for three hours. The resulting solution was neutralized with potassium hydroxide and evaporated. Microscopic examination of the crystals obtained indicated potassium chlorate and potassium perchlorate. The presence of ClO_4^- was also demonstrated by characteristic crystals formed when a drop of 2% brucine solution was added to a drop of the test solution on a microscope slide. The outside of the spot was surrounded by a brown ring which is also characteristic of ClO_3^-. The tests were compared with similar tests on pure substances. The chloric acid and perchloric acid can be explained by the formation of Cl_2O_6 which reacts with water according to

$$Cl_2O_6 + H_2O \longrightarrow HClO_3 + HClO_4$$

Qualitative tests on the water extract also indicated small amounts of hypochlorous acid, presumably due to Cl_2O.

$$Cl_2O + H_2O \longrightarrow 2HClO$$

Methods for the quantitative estimation of chlorine dioxide, chlorine, hypochlorous acid, chloric acid and perchloric acid in the water extract have been developed and checked. The relative amounts of the different components depend in a rather complicated way upon such factors as concentrations, light intensity and time of insolation. This is to be expected since Cl_2O_6 and Cl_2O are themselves photosensitive.

The point which we wish to stress in this note is that relatively large amounts of Cl_2O_6 are formed (corresponding in some experiments to as much as 20% of the chlorine dioxide decomposed). This is in contradiction to the findings of previous workers [E. J. Bowen, *Trans. Faraday Soc.*, **27**, 513, (1931); Y. Nagai and C. F. Goodeve, *ibid.*, **27**, 508, (1931)], who report only chlorine and oxygen. The formation of Cl_2O_6 indicates that the above reactions in solution probably have mechanisms similar in many respects to those for the corresponding gaseous reactions [THIS JOURNAL, **56,** 269 (1934)].

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RECEIVED APRIL 22, 1937

NEW BOOKS

The Chemistry of Natural Products Related to Phenanthrene. By L. F. FIESER, Associate Professor of Chemistry, Harvard University. Second edition, with an appendix. Reinhold Publishing Corporation, 330 West 42d Street, New York, N. Y., 1937. xiv + 456 pp. 15.5 × 23.5 cm. Price, $7.00.

The increased activity and interest in the field of phenanthrene and related compounds have led the authors of this useful and widely accepted book to supplement the second edition with an appendix. This consists of about 90 pages devoted to a description and discussion of the published investigations during 1936.

The topics are grouped in individual chapters which correspond to those in the main portion of the book. They are too numerous to review here but they include the important contributions to the structure of Vitamin D and the stereochemical nomenclature of the sterols, androsterone and analogous compounds. This additional part has been written with the same clarity and completeness as characterized the original work.

The second edition of this book will be of inestimable value to the investigator or scholar in this general field, as it offers a comprehensive résumé of the literature up to January 1, 1937.

ROGER ADAMS

Reagent Chemicals and Standards, with Methods of Assaying and Testing them; also the Preparation and Standardization of Volumetric Solutions and Extensive Tables of Equivalents. By JOSEPH ROSIN, Chief Chemist and Chemical Director, Merck & Company, Inc. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y., 1937. x + 530 pp. 16 × 23.5 cm. Price, $6.00.

This volume is a thoroughly modern and carefully edited treatment of approved methods for testing the commoner chemical reagents, and the standards of purity to be sought. The author, working from the Merck-Krauch book originally published in 1888, the Murray treatise of 1919, reprinted in 1927, and the reports of the American Chemical Society Committee on analytical reagents. has organized into a single accessible source the most recent information regarding reliable methods and tests.

The greater part of the volume is composed of monographs on reagents and their tests, arranged alphabetically. The substances treated include many new organic reagents. Preceding this section several pages are devoted to describing test solutions, and following it are some fifty pages of stoichiometric data including sections on the determination of the hydrogen-ion concentration. on buffer solutions, indicators and related data. A particularly valuable feature is the inclusion of assay tests for many of the reagents discussed.

In his preface the author calls attention to two interesting facts. First, the purity of commercial reagent chemicals has been greatly increased since the earlier books were issued. Second. the methods of testing quantitatively for impurities have been so improved that often tenths or hundredths of a milligram may now be determined instead of milligrams as was formerly the case.

The author is well equipped to issue such a book, for it was due chiefly to his careful and persistent work that the reagent chemicals issued by the Powers–Weightman–Rosengarten Company during the last years of that firm's independent existence, came in general to be recognized as the purest commercially available.

This book will of necessity become a part of the library of every testing. research and educational laboratory.

WILLIS A. BOUGHTON

An Introduction to Nuclear Physics. By N. FEATHER, Ph.D., University Lecturer in Physics and Fellow of Trinity College, Cambridge. Cambridge University Press; The Macmillan Company, 60 Fifth Avenue, New York, N. Y., 1936. x + 212 pp. 21 figs. 14.5 × 22.5 cm. Price, $3.00.

As a result of a vast activity in physical research laboratories in the past decade a definite science of "nuclear physics" has come into being. It has all happened so rapidly that it is now impossible to get a grasp of these developments directly from the journal literature. Dr. Feather has provided an admirable summary of the subject which will be read with profit and pleasure by many whose principal interests lie in other directions as well as by those who are actively engaged in nuclear research.

An outstanding quality of the book is its careful emphasis on the logical sequence of the ideas leading up to current theoretical views. The way in which this has been accomplished in a wholly non-mathematical way is truly marvellous. In general this is the outstanding feature of the presentation which makes it so valuable an introduction, for the account is not burdened with technical details of experiments or of mathematical calculations.

The book is divided into four parts: I. *Introductory* reviews the experimental methods of the older studies of radioactivity and the newer methods with artificially accelerated particles, the growth of the understanding of the nuclear atom model as affected by wave mechanics and the picture of the nucleus as a structure composed of elementary particles; II. *Concerning Stable Nuclei* deals with measurements of mass charge, spin, and magnetic moment of the nuclei of naturally occurring atoms; III. *Concerning Unstable Nuclei* deals with the emission of alpha particles, positive and negative electrons. and gamma rays from radioactive nuclei; IV. *Transformations Produced by Fast-moving Particles and by Radiation* deals with effects produced by bombardment of alpha particles from natural radioactive materials, by neutron bombardment, by artificially accelerated protons and deuterons and photodisintegrations produced by radiation.

As the scope of a book is also indicated by mentioning omissions, it may be remarked that there is no discussion of the physics of cosmic rays and very little on the physics of positrons except as they are emitted from positron-active bodies. These omissions are natural enough as not belonging strictly to nuclear physics. A more serious omission is that of the question of relative abundance of the naturally occurring nuclei as studied by the mass spectrograph and by chemical analyses of the earth's crust.

E. U. CONDON

Diffusion. VI. Dans les Liquides. VII. Dans les Gels et les Solides. (Diffusion in Liquids, Gels and Solids.) (Traité de chimie physique appliqué à la biologie, Ch. VI et VII de Tome I.) By J. DUCLAUX, Professeur au Collège de France. Hermann et Cie., 6 Rue de la Sorbonne, Paris, France, 1936. VI: 90 pp. 35 figs. 16.5 × 25 cm. Price, 20 fr. VII: 50 pp. 8 figs. 16.5 × 25 cm. Price, 12 fr.

The physical chemist interested in diffusion will find these two books useful primarily on account of the extensive bibliographies included. They could also be used to advantage to supplement an advanced course in physical chemistry for either chemists, pre-medical students or biologists. The books contain a rather sketchy presentation of the theoretical side of diffusion, a discussion of experimental methods and a fairly detailed presentation of results for various typical cases. Of particular interest to the biochemist is of course the section on diffusion in gels on account of the obvious importance of membrane equilibria in biological processes.

R. M. FUOSS

Thermodynamic Properties of Steam, Including Data for the Liquid and Solid Phases. By JOSEPH K. KEENAN, Associate Professor of Mechanical Engineering, and FREDERICK G. KEYES, Director of Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology. John Wiley and Sons, 440 Fourth Ave., New York, N. Y., 1936. 89 pp. Illustrated. 19 × 26 cm. Price, $2.75.

This book contains the most extensive and the most accurate available tabulation of the thermodynamic properties of steam.

The specific volume, heat content and entropy along the saturation curve are given for liquid and vapor to the critical point, 705.40°F. and 3206.2 lb./sq. in. As is customary, these quantities are tabulated for integral values of both temperature and pressure.

TABLE I

CORRECTIONS FOR THE ROTATIONAL DISTORTION OF THE WATER MOLECULE

Saturation

Temp., °F. t	Enthalpy Sat. liq. h_f	Evap. h_{fg}	Sat. vap. h_g	Sat. liq. S_f	Entropy Evap. S_{fg}	Sat. vap. S_g	$\frac{h_{fg}}{T}$
32	0.00	1075.8	1075.8	0.0000	2.1877	2.1877	2.1880
32 corr.	(0.00)	1075.5	1075.5	(0.0000)	2.1873	2.1873	2.1874
212	180.07	970.3	1150.4	0.3120	1.4446	1.7566	....
212 corr.	(180.07)	(970.3)	(1150.4)	(0.3120)	(1.4446)	(1.7566)	....
500	487.8	713.9	1201.7	0.6887	0.7438	1.4325	....
500 corr.	488.4	(713.9)	1202.3	.6894	(0.7438)	1.4332	....
705.4	902.7	0	902.7	1.0580	0	1.0580	....
705.4 corr.	903.8	(0)	903.8	1.0592	(0)	1.0592	....

Superheated Vapor

Abs. press., lb./sq. in.		Temperature, degrees Fahrenheit 400	800	1200	1600
14.696	h	1239.9	1432.3	1637.5	1857.3
	h corr.	1240.3	1433.7	1640.4	1862.0
	S	1.8743	2.0576	2.1989	2.3174
	S corr.	1.8748	2.0591	2.2014	2.3209
5500	h	....	985.0	1518.2	1788.1
	h corr.	....	986.4	1521.1	1792.8
	S	....	1.1093	1.4908	1.6369
	S corr.	....	1.1108	1.4933	1.6404

For superheated steam the tabulation extends to 1600°F. and 5500 lb./sq. in.

The properties of the gas have been obtained principally by an analytical treatment based on an equation of state. It is necessary to have a very accurate equation of state in order to make a reliable calculation of the changes in entropy and heat content with pressure, since the procedure requires that first derivatives be accurate. However, one of the most exacting tests of an equation of state is its use in evaluating such a quantity as the change in heat capacity with pressure since this requires reliable second derivatives. The authors apply this test and find excellent agreement with the available experimental data, which extend to a pressure of 3000 lb./sq. in. and a temperature of 900°F. This significant comparison is appropriately presented as Fig. 1 of the book and it says much for the reliability of the heat content (enthalpy), entropy and volume relationships.

The heat capacity of the gas at zero pressure was taken from the computations of A. R. Gordon. These are based on band spectrum data and are more reliable than values which have been obtained in any other way. Nevertheless, there exists a small inaccuracy in the spectroscopic computations of Gordon [*J. Chem. Phys.*, **2**, 65 (1934)]. While the amount of the inaccuracy is too small to be of importance in engineering calculations, it proves to be of some interest.

Gordon based his calculations of various thermodynamic quantities of steam on the assumption that the water molecule could be treated as a rigid rotator; however, he recognized that molecular vibration and rotation are not independent, by using equations which expressed the moments of inertia as a function of the amount and type of vibration. He did not consider the deformation produced by the rotation of the water molecule. This not only changes the kinetic energy due to the alteration of the moments of inertia but also introduces potential energy changes.

The effect of rotational distortion has been considered by E. B. Wilson, Jr., [*ibid.*, **4**, 526 (1936)] and on page 16, Keenan and Keyes mention a personal communication from Wilson. Presumably because they were not available in time, the simple corrections of Wilson were not included in the tables. In any case, it seems worth while to consider their consequences.

The authors selected the data at the normal boiling point of water in order to evaluate the relationship between the liquid and gas states. Applying Wilson's equations it may be shown that a correction of $2.50 \times 10^{-6} (t_F - 212)$ B. t. u. per deg. Fahr. per lb. should be added to the entropy and the quantity $1.25 \times 10^{-6} (T_F^2 - 671.69^2)$ B. t. u. per lb., where $T_F = 459.69 + t_F$, should be added to the heat content of the gas. As will be seen below the above corrections remove a small discrepancy noted by the authors who state on page 19, "The result . . . (heat of vaporization/T) . . . differs by 3 in the last figure given in the tables or about one part in 7000 of the entropy of the vapor at 32°F. Though this difference is negligible for all uses of the tables it signifies certain defects in our knowledge of water vapor at low temperatures."

The application of Wilson's equations in the region near the critical point shows that the heat content and entropy are changed only by about 0.1%. In Table I a few comparisons are given to show the order of magnitude of the above corrections. In order to preserve the self-consistency of the tables, the above corrections for entropy and heat content have been added to the values for the saturated liquid between 212°F. and the critical temperature. This is certainly within the limit of accuracy with which the properties of the liquid are known at these temperatures. For example, the values of entropy and heat content at the critical point given in the present tables are about 2% lower than those given by Keenan in his 1930 tables. It will be evident from the comparisons in Table I that application of the rotational deformation correction of the water molecule is unnecessary for engineering purposes.

By comparing the 32° values of S_{fg} with h_{fg}/T_F in Table I, it is seen that the corrected values are in agreement within the limits of calculation error whereas the uncorrected values show the 0.0003 discrepancy which the authors have pointed out.

The book contains a table giving the properties of liquid water under pressures to 6000 lb./sq. in. and extending to the critical temperature. The properties of ice and water vapor, along the saturation curve, are given to −40°F. Tables of viscosity, heat conductivity, 8 graphs, a Mollier chart, approximately 2 by 3 ft., and a small temperature entropy chart are included.

W. F. GIAUQUE

Solutions of Electrolytes, with Particular Application to Qualitative Analysis. Second edition. By LOUIS P. HAMMETT, Ph.D., Professor of Chemistry in Columbia University. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York, N. Y., 1936. ix + 238 pp. Illustrated. 14.5 × 21 cm. Price, $2.25.

In this second edition of Professor Hammett's text-book the material of the first edition has been rearranged and increased. The book is divided into two parts, the first being a modern and thorough treatment of the theory of solutions of electrolytes, and the second part a sketchy laboratory manual for qualitative analysis. Exercises and suggestions for reading are given at the ends of the chapters and lecture experiments are described in an appendix.

The most important change in the new edition comes in the introduction. The Brönsted concept of acids and bases is introduced and employed consistently through the book. The ionization of an acid is treated as the transfer of a proton from the acid to a solvent molecule rather than as a simple dissociation. The writer cannot agree with the author's statement that the newer theory is at least as simple and teachable as the older one: certainly not for students who have had the misfortune to learn the older theory in elementary chemistry. However, there can be no doubt of the value of the newer theory. Professor Hammett is to be congratulated as heartily upon its introduction as upon his modern and simple treatment of the complete ionization of salts, which is common to both editions.

In Chapter II the solubility product principle is discussed, and in Chapter III the law of chemical equilibrium for weak electrolytes. After as thorough a theoretical treatment of both subjects as is possible without the aid of thermodynamics, application of the principles to analytical chemistry is discussed. In Chapter IV, on the ionization of water, the subject of hydrolysis is taken up. It may be noted in passing that the treatment of the hydrolysis of acid salts is not correct. In sodium bicarbonate, the example chosen to illustrate the topic, the amount of ionization of the bicarbonate ion is approximately equal to the amount of hydrolysis. As a result the true concentration of hydroxyl is only one twenty-fifth of that found on page 90. The ionization constants employed here and some of the others given in Table IV on page 60 have not been brought up to date with the new edition.

These are the only flaws which have been noted in this excellent work. Chapter V, on complex compounds, and Chapter VI, on oxidation-reduction reactions, are rich mines of chemical information into which candidates for the doctorate have been seen to delve. Chapter VII, at the end of the theoretical part, deals with oxidation potentials. It is so clearly put and valuable that the writer usually skips to it immediately after Chapter I in a course employing this text.

This is not an easy text. It demands careful study and close attention from the student. It is far superior in its scope and modern viewpoint, however, to any other text in the field.

CHARLES H. GREENE

Structure and Molecular Forces in Pure Liquids and Solutions. A General Discussion. Reprinted from the "Transactions of the Faraday Society." Published for the Faraday Society by Gurney and Jackson, 33 Paternoster Row, London, England, 1937. ii + 282 pp. Illustrated. 16 × 25 cm. Price, 12s./6d., postage 8d.

This volume is a collection of papers presented at the Sixty-fifth General Discussion of the Faraday Society, held in Edinburgh in September, 1936. The papers provide a very comprehensive survey of present knowledge concerning the structure of pure liquids and of non-electrolyte solutions.

The first part of the Discussion, introduced by James Kendall, is devoted to the properties of pure liquids. The heat capacity and viscosity of liquids, their infrared and Raman spectra, and the propagation of ultrasonic waves through them receive considerable attention. The problem of fusion is considered by several authors. There is a noteworthy theoretical discussion of molecular distribution in liquids by J. D. Bernal.

The second part of the Discussion, introduced by J. H. Hildebrand, is concerned with the properties of liquid solutions. The influence of various types of intermolecular force on deviations from ideal behavior in non-electrolyte solutions is the chief topic of discussion.

Those interested in the theory of solutions and in the nature of the liquid state will find the book a valuable source of information.

J. G. KIRKWOOD

Magnetochemie. (Magnetochemistry.) By Dr. WILHELM KLEMM, Professor in the Technical Institute of Danzig-Langfuhr. Akademische Verlagsgesellschaft m. b. H., Leipzig C 1, Germany, 1936. xv + 262 pp. 99 figs. 16 × 23.5 cm. RM. 16; bound, RM. 18.

As a result of the development of the theory of the relation between the magnetic properties and electronic structure of substances, there has occurred during the last decade great progress in the application of magnetic methods to the solution of chemical problems. Klemm's small book on magnetochemistry contains the most extensive and detailed discussion of this field which exists, one hundred pages being devoted to general magnetochemistry, including topics such as Pascal's rules, free radicals and biradicals, the determination of valence states in anomalous compounds [$(NH_4)_2SbBr_6$, perchromates, KO_2, etc.], bond types in coördination complexes, the diamagnetic anisotropy of aromatic crystals, chemical analysis by magnetic methods, etc. A compilation of existent magnetic data is not given; as the author mentions, a complete compilation of these data is badly needed.

This part of Klemm's book is preceded by a well-written elementary discussion of experimental methods, the theory of magnetism and atomic structure, and the diamagnetism, paramagnetism, and ferromagnetism of substances.

Because of its emphasis on chemical applications of magnetic methods, the book provides a useful supplement to the larger treatises of Stoner and Van Vleck.

LINUS PAULING

Enzyme Chemistry. By HENRY TAUBER, Ph.D., Consulting Chemist. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y., 1937. xii + 243 pp. 28 figs. 15.5 × 23.5 cm. Price, $3.00.

Dr. Tauber has rewritten and expanded into book form the material of his earlier "Experimental Enzyme Chemistry."[1] The current edition retains all the merits of the former edition and includes, in addition, an excellent discussion of such recent work as the relationship between the yellow enzyme and lactoflavin, and the enzyme "destroying" vitamin A and ascorbic acid. The author has presented an excellent summary of recent advances in enzyme chemistry and the book is highly recommended.

W. M. SANDSTROM

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(1) Reviewed in THIS JOURNAL, **58**, 2657 (1936).

BOOKS RECEIVED

April 15, 1937–May 15, 1937

HAMILTON FISH ARMSTRONG. "'We or They.' Two Worlds in Conflict." The Macmillan Company. 60 Fifth Ave., New York, N. Y. 106 pp.

WALTER H. EDDY AND GILBERT DALLDORF. "The Avitaminoses. The Chemical, Clinical and Pathological Aspects of the Vitamin Deficiency Diseases." The Williams and Wilkins Company, Mt. Royal and Guilford Aves., Baltimore, Md. 338 pp. $4.50.

ERICH EINECKE. "Das Gallium. Eine kritische Würdigung der Erkenntnisse mit experimentellen Beiträgen." Verlag Johann Ambrosius Barth, Salomonstrasse 18B, Leipzig C 1, Germany. 155 pp. RM. 12.

ULICK R. EVANS. "Metallic Corrosion, Passivity and Protection." Longmans, Green and Co., 114 Fifth Ave., New York, N. Y. 720 pp. $15.00.

G. GAMOW. "Structure of Atomic Nuclei and Nuclear Transformations." Second edition. Oxford University Press, 114 Fifth Ave., New York, N. Y. 270 pp. $6.00.

WALTER HÜCKEL. "Lehrbuch der Chemie. II. Organische Chemie." Akademische Verlagsgesellschaft m. b. H., Markgrafenstrasse 6, Leipzig C 1, Germany. 602 pp. RM. 16; bound, RM. 18.

J. E. NYROP. "The Catalytic Action of Surfaces." Second edition. Levin and Munksgaard, Nörregade 6. Copenhagen, Denmark. 101 pp. 10 kroner.

A. R. UBBELOHDE. "An Introduction to Modern Thermodynamic Principles." Oxford University Press, 114 Fifth Ave., New York, N. Y. 131 pp. $3.00.

"Abeggs Handbuch der anorganischen Chemie. Elemente der achter Gruppe der periodischen Systems." Vierter Teil. "Nickel und seine Verbindungen." Lieferung 1. Verlag von S. Hirzel, Königstrasse 2, Leipzig C 1, Germany. 827 pp. RM. 78.

"Bulletin Scientifique. Recueil Chimique. No. 2." (In Russian.) Université d'État de Kiev. Ukrainian S. S. R. 158 pp.

"Gmelins Handbuch der anorganischen Chemie. System-Number 22: Kalium." Lieferung 2. Verlag Chemie G. m. b. H., Corneliusstrasse 3, Berlin W 35, Germany. 268 pp. RM. 31.50.

"Memoirs of the Institute of Chemistry." Vol. III, Issue 4. (In Russian.) Academy of Sciences of the Ukrainian S. S. R., Kiev, Ukraine. 164 pp.