is presented. These same substances are then treated as working fluid gases, and a survey of the dissociation equilibria that occur in them at various elevated temperatures is presented. Among the reactants treated separately are hydrides and organic fuels, peroxides, oxyfluorides, oxychlorides, fluoramines, and nitro compounds. Various combinations of these, together with polymeric binding materials, hydrogen, oxygen, fluorine, and several metals are taken up in the real propellant systems.

These four chapters provide a very good survey of current propellant chemistry. The authors are knowledgeable and full of enthusiasm. They present their material in the easy colloquial style of successful practioners of the art they are describing. They are fully aware of both standard formulations and unproved but promising propellant candidates. What their presentation may lack in precision of statement, it more than makes up in the drive and enthusiasm with which it is written. A picture of the factors that must be taken into account and of the current mode of thinking about them emerges which fairly represents the complicated, unsettled, and highly competitive field of propellant chemistry.

The authors have decided to treat products and ingredients separately, and certainly a case can be made for this approach in terms of the different energetic attributes, molecular weight requirements, and phase stabilities desirable in the two categories. Nevertheless they repeatedly acknowledge the fact that products cannot be treated as completely independent of the reactants because the same elements must be present in each, and because the energy change that occurs is more important than are the high energy level of reactants or the low energy level of products separately. The BN concept, to which they are partial, is a typical case in which they find such cross connection necessary.

The opening chapter of the book is on the calculation of propellant performance, and gives a brief introduction to rocket propulsion parameters. The relationships of the thermal parameters, temperature, pressure, heat capacity, and heat of reaction, to the performance parameters, thrust, specific impulse, exhaust velocity, and weight are given in this chapter. A brief outline of general methods of calculating combustion-product temperature and composition is also given here.

This chapter is the least polished of the book and gives evidences of lack of editorial care in proofreading and lack of attention to detail in the formulation of equations and the structure of sentences. Examples, which probably would cause no difficulty for the student in the class of a competent instructor, but might somewhat frustrate a person working through the text alone, are the lack of dimensional balance of equation 1-1, and the units applied to the mechanical equivalent of heat, J, used throughout Chapter 1. This type of loose construction has the unfortunate effect of making the reader skeptical about the validity of these and hence of other constructions which are not readily understood on first reading. A sentence such as the following from the top of page 24 is enough to cause the uninitiated to ponder for some time: "Additionally it can be seen the presence of condensed phases is undesirable since the enthalpies of condensed phases are generally higher than for the ideal gas as well as lowering the average molecular weight of the working fluid." Here we have an unfortunate editorial error in the use of *lowering* when *raising* is intended, and a statement about enthalpy that can only be true if enthalpy of vaporization is ignored. These are by no means all of the examples of poor construction that could be listed in the first chapter, in addition to which numerous typographical errors are present.

The reviewer was somewhat misled by the discussion leading up to equations 1-39 to 1-46, in which specific impulse and exhaust velocity are related to molecular weight, temperature, and pressure in terms of an adiabatic coefficient γ. In the discussion phrases such as, "approximate equations," "outdated computation concepts," "lead to erroneous conclusions when improperly applied," are used. The reviewer was then somewhat surprised to discover that these equations which had been so disparaged were the only bases referred to throughout the remainder of the text for the part played by molecular weight and temperature of the combustion gases.

The book is replete with tables and diagrams, which comprise about 40% of the book's 240 pages and add considerably to its interest. The diagrams illustrate comparative thermodynamic information for particular substances in several classes of combustion product gases, and equilibrium dissociation behavior of selected gaseous product species as functions of temperature. Of interest in the chapter on real propellant systems are extensive tables of the compositions of combustion product gases for various oxidizer–propellant combinations.

A list of symbols and their units of measurement is included and is essential because few symbols are defined in the text. The units of measurement listed illustrate a dilemma of the propellant chemist, who is pulled on the one hand by the prevalence in the chemical literature of thermodynamic data, heats of formation, binding energies, and so on, given in the c.g.s. system, and on the other hand by the propulsion engineer who demands his parameters in English units. Thus, we find densities in g. cc.$^{-1}$, and mass of propellant in lb.; energies in kcal. mole^{-1}, and velocities in ft. sec.$^{-1}$. Perhaps the most curious use of units in the table is erg cal.$^{-1}$ for the mechanical equivalent of heat. These units are quite irreconcilable with the usage of J in equations throughout Chapter 1.

Despite the shortcomings of the first chapter, on the whole the book is to be recommended. The chemist entering the field of propellant chemistry or wishing to increase his awareness of it will find it a worthwhile introduction to the subject. It will give him the principal commonly used or seriously considered major propellant components, factors (aside from kinetics) that must be taken into account in considering potential propellant ingredients, qualitative discussions of how these factors apply to particular components, and qualitative theoretical consideration of the properties of these compounds in terms of molecular binding concepts. It will also provide him with some tables of thermodynamic data and instructions in their use for the illustrative calculation of equilibrium compositions and propellant performance characteristics. The book is not a definitive study of the best methods of calculating these parameters, nor should it be considered a replacement for the massive and reliable tables of thermal properties which now exist in the field of propellant engineering and chemistry.

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Positronium Chemistry. By JAMES GREEN, The University of New South Wales, Sydney, Australia, and JOHN LEE, New England Institute for Medical Research, Ridgefield, Conn. Academic Press Inc., 111 Fifth Ave., New York, N. Y. 1964. xii + 105 pp. 16 × 24 cm. $5.50.

A great many fundamental and extremely interesting problems in chemical structure and the nature of chemical reactions are not amenable to study with conventional chemical techniques. The subtle problems involving the electronic structure of molecules, the nature of atomic wave functions, electron-transfer mechanisms, etc., require a knowledge of several disciplines and probes of high resolution for their elucidation. When such a probe is discovered, and its potential realized, a rash of new activity in the field is to be expected. Such discoveries as electron and nuclear magnetic resonance, the hydrated electron, and the Mössbauer effect are obvious examples.

Too often, however, the literature in which such discoveries and the progress in the development of the techniques are reported is not regularly read by scientists who could apply them in their own areas of research. Moreover, experimental difficulties and the lack of an adequate background in physics and electronics may dampen the enthusiasm some chemists and biologists might otherwise express.

Positronium, the transient bound system of a positron and an electron, may be considered an isotope of hydrogen. It has essentially half the reduced mass of the normal hydrogen atom and hence, twice the Bohr radius and half the ionization potential. It was discovered by physicists through observation of the longer annihilation lifetime of the triplet state. The rate of conversion of triplet to singlet states ("quenching") gives information on the chemical nature of the medium in which positronium is formed.

The authors of "Positronium Chemistry" are to be commended for supplying a well-organized, very readable account of the present status of a potentially important chemical species and for choosing a title that will attract the nonphysicist.

After a very brief, but clear and adequate description of the basic physics of the positron and the bound states of positronium, the authors describe the experimental techniques involved in making measurements with positronium. Block diagrams and a few electronic circuits are presented, but the descriptions of the coincidence counting technique and the functions of the various components are so simply and clearly described as to be intelligible even to a novice in the use of such equipment. (As the authors point out in the Pref-

ace, the increasing availability of commercial equipment to carry out measurements with positronium means that an expert knowledge of electronics is no longer a prerequisite for work in the field.)

The next two chapters of the monograph are devoted to a description of the behavior of positrons in gases and in solids and present the theoretical background for interpreting the "chemistry" of positronium in these media.

The last half of the book reviews the techniques and the often-conflicting observations of positronium chemistry in gases, organic liquids, and aqueous solutions. The many gaps in knowledge of the behavior of this species and suggestions for future work are clearly indicated.

It is refreshing to read a book so carefully edited and proofread in its printing. I am aware of only one typographical error.

This little monograph will probably be most interesting to radiation chemists, who will find many parallels to their own field in the chemistry of positronium, and to nuclear chemists. However, it should also be understandable and of interest to physicists, chemists, and biologists who want to keep abreast of challenging and potentially important new areas of research.

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Chemistry and Technology of Explosives. Volume I. By TADEUSZ URBANSKI, Department of Organic Technology, Politechnika, Warsaw. The Macmillan Co., 60 Fifth Ave., New York, N. Y. 1964. xv + 653 pp. 18 × 25 cm. $15.00.

This volume, presumably the first of three, is devoted almost exclusively to C-nitro aromatic compounds. Aliphatic and heterocyclic nitro compounds receive briefer treatment, reflecting their lesser interest in technology. Nitric acid esters and nitramines do not appear in this volume.

The book is a masterly treatise, reflecting the author's intimate knowledge of his subject. The manufacture and chemical, physical, and physiological properties of nitro compounds of interest in the technology of explosives are given detailed treatment. The first five chapters cover the art and knowledge of aliphatic and aromatic nitration and general information on the physical and chemical properties of the nitro group. A chapter on the general properties of aromatic compounds is followed by detailed exposition of essentially everything in the available literature on the mono- and polynitro derivatives of benzene, toluene, other aromatic hydrocarbons, naphthalene, halogen derivatives of benzene, phenols, aniline, and azo- and hydrazobenzene. Chapter XIX describes mono- and polynitro aliphatic compounds and the final one, dinitrodinitroso- and hexanitrosobenzene. Separate chapters are given to TNT and picric acid manufacture.

Although the author admits that these may not represent current practice, his diligence in searching out available information is illustrated by the inclusion of German and Japanese methods from BIOS, CIOS, FIAT, HEC, and PB sources.

Each chapter is followed by a bibliography covering the available literature through 1959, with a few references as late as 1962. Only a few patents are cited.

The book is surprisingly free of misprints, almost all of which are trivial. The only really deceiving one noted was the melting point of tetranitromethane: actually +14.1° but given as +3°C. The translation sets a high standard, with so few "Europeanisms" that it gives the impression of an English original. The printing, done in Poland, is excellent and the binding adequate. The book is well worth its relatively modest price and is recommended to all with interest in this interesting and actually little known area.

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Ion Exchange Separations in Analytical Chemistry. By OLOF SAMUELSON, Professor of Engineering Chemistry, Chalmers University of Technology, Goteborg, Sweden. John Wiley and Sons, Inc., 605 Third Ave., New York 16, N. Y. 1963. 474 pp. 15.5 × 23.5 cm. $9.50.

In his "Ion Exchange Separations in Analytical Chemistry" Olof Samuelson has revised and expanded the content of his earlier book "Ion Exchangers in Analytical Chemistry." In the preface of the earlier edition he stated, "Only the principles of chromatographic separations by means of ion exchange resins and some applications will be briefly mentioned in this monograph. It is not intended to be a complete reference book in this field, but rather a sketch of the possibilities revealed." In contrast, the later edition appears to have considered all of the important publications in the field and is a good general reference book.

The over-all organization of the book was not changed in the new edition. As in the previous version the Introduction is followed by (1) a General Part, (2) a Practical Part, and (3) Applications. However, the organization of the parts have been changed considerably with the newer edition covering considerably more material and having some new sections not found in the earlier edition but omitting detailed descriptions of specific analyses included previously. The Introduction was changed only slightly; the section on ion-exchange chromatography was lengthened to reflect its increased importance in analytical procedures.

In the General Part two new chapters, "Applications of the Plate Theory" and "Non-aqueous Solutions," were added. The first three of the other four chapters (Chapters 2–4) were reorganized to give a more logical presentation than previously and expanded to cover publications in the past decade and others before 1952 not considered in the earlier edition. Chapter 5, "Column Operation," has been changed the least. This is understandable because it describes procedures which have not changed much in the past decade. Chapter 6 on the plate theory is an important addition to the text. It should be valuable to analytical chemists for calculating the separation to be expected in solutions of low ionic concentrations.

In the Practical Part of the book a chapter has been added on "Choice of Resin." This is an expansion of a section of another chapter in the previous edition and reflects the increase in the variety of resins available. A short description of the preparation and purification of resins for analytical use is also given in this chapter.

Of the other two chapters in the Practical Part, the first (Chapter 9 in the new edition) considers "Technique of Simple Ion Exchange Separations," and the second, "Technique of Ion Exchange Chromatography." The former has been reorganized in a more logical manner and partially rewritten but contains much of the same material used previously. The latter has been almost completely rewritten and greatly expanded. It considers the effects of the important variables on the separation of similar substances. It also describes fraction collectors and a number of methods for continuously assaying the eluate. It should prove very valuable as a guide to analytical chemists in the important technique of ion-exchange chromatography.

The Applications part is the largest section of the book. In the original edition it was more than half of the text. Because of the expansion of the first two parts in the new edition, it represents a somewhat smaller portion. The material in this section has been reorganized and applications restricted to separations of inorganic and simple organic ions. Whereas in the original edition the applications were largely those of concern to industrial chemists, the recent edition considers the separations in a more academic manner. The 1952 edition had 19 chapters in this section; in the new edition the number has been reduced to 7, although the length of the text has been increased slightly.

Chapter 11 in the new edition has the same title as before, "Determination of Total Salt Concentration." However, the text has been rewritten to describe several general methods, and applications and specific examples with references are tabulated.

In Chapter 12, "Removal of Interfering Ions of Opposite Charge," the content has also been reorganized with some revisions and rearrangements of the examples.

In Chapters 13 and 14, "Inorganic Colloids and High Polymer Electrolytes" and "Isolation of Trace Constituents," there have been fewer revisions. However, again the text in the new version is more general in its orientation and gives less attention to specific examples. In the latter chapter a description of methods for concentrating radioactive elements has been added.

Chapter 15 in the 1963 edition, "Metal Separations," is entirely new. It has been organized to follow the groups of elements in the periodic table in so far as possible and methods have been given for separating groups of elements and individual members of the groups. In the past decade a large number of investigations have been performed on such separations. All of the important group and elemental separations described in the literature are well summarized in this chapter.

The Introduction summarizes the separation methods and tabu-