and its practical importance. Chapter 10 develops the theory of estimation, following mainly the approach of R. A. Fisher. Chapter 11 is devoted primarily to the theory of errors, as applied to physical measurements, but includes a somewhat sketchy discussion of the theory of tests of hypotheses. Chapter 12 takes up the application of the theory of probability to the adjustment of physical measurements subject to one or more constraints. For example, measurements may have been made of all the three angles of a triangle, and it is desired to arrive at a set of adjusted values which will add up to 180 degrees. Appendices deal with the gamma function and elementary matrix theory, and tables of certain important distributions are included, followed by a list of 90 problems and a list of 44 bibliographic references.

The authors' statement of their philosophy of statistics is most refreshing and valuable. A highly commendable and unusual feature is the distinction clearly and consistently made throughout the book between the "mathematical model" and the "real world." Also noteworthy is the axiomatic approach to the theory of probability and the careful statement of the assumptions underlying various statistical procedures.

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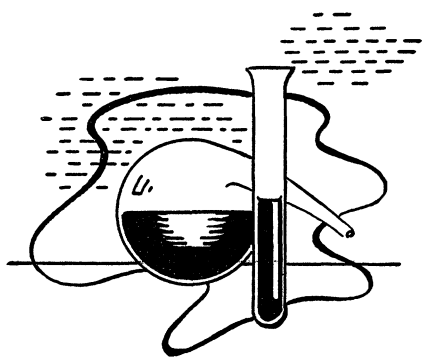

Infrared Determination of Organic Structures. H. M. Randall, R. G. Fowler, N. Fuson and J. R. Dangl. New York: D. Van Nostrand, 1949. 239 pp. $10.00.

The use of infrared spectra to identify organic compounds and characterize certain structural groupings in these molecules is not new, but recent developments in the technique of infrared spectroscopy (which make the recording of such spectra a routine matter) have caused such rapid development, that the appearance of a book on the method must be very welcome to many chemists and biochemists. To write such a book is no easy task; the method is still so new that, although certain principles can be very easily stated and exemplified, their detailed application to individual molecules presents many pitfalls for the unwary.

The fact that certain common chemical bonds and groupings have characteristic vibration frequencies which, to a first approximation, are independent of the rest of the molecule and so are always observed in approximately the same position in the infrared, makes the method, at first sight, a very attractive and powerful one. The difficulties lie in the degree of constancy of each characteristic frequency and in achieving a clear understanding of the reasons for the small but very important variations. Thus C=O frequencies are generally lower than C=C and C=N frequencies, but in most amides the C=O frequency is in the position normally occupied by C=C or C=N frequencies. It follows that it is just in those cases where the chemist most needs help from the spectroscopist (i.e., when he is on unfamiliar ground) that the spectroscopist is sometimes least sure of his characterizations.

In order to establish a new structure by infrared methods, it is generally necessary to have the spectra of series of model compounds in which the key groupings used in the spectroscopic analysis of the unknown structure have environments closely resembling those of the key groups in the various structures under consideration. This was very well exemplified in the use of infrared spectroscopy to establish the structure of penicillin. The present book derives directly from the work done by the authors on penicillin. The state of the method at that time was such that an extensive investigation had to be made of the frequencies characterizing many chemical bonds, especially those of the C=O, C=C, C=N, and NH bonds in a wide variety of compounds.

The authors make it very clear that their treatment of the subject must in no sense be regarded as definitive or even comprehensive. This is very wise, for it will be several years before the chemist can be given his handbook for the use of this structural tool. As a first step in the right direction, this book can be highly recommended. After a general discussion of the underlying principles, a most useful catalogue is given of frequencies occurring in the range 5 μ–7 μ, commonly known as the "double bond" region, since the key frequencies of the C=O, C=C, C=N, and N=O bonds occur here. A more general catalogue of characteristic infrared and Raman frequencies between 2.6 μ and 70 μ follows, preceded by a short discussion of the methods of assignment and how these are based on complete analyses of the infrared spectra of very simple molecules. A very valuable chapter is then devoted to illustrative examples of the method drawn from the authors' own experience. The experimental techniques employed by the authors are next described in detail and, finally, reproductions are given of the actual tracings of the spectra of over 350 compounds.

The only serious slip noticed is that in the final catalogue of spectra (p. 195) the spectrum of morpholine is wrong and this vitiates the discussion concerning morpholine on page 7. (The spectrum given for morpholine appears to be that of nitromethane.) It is not possible to agree with every one of the assignments proposed but detailed discussion of these cases is not practicable here, and in general only further work would show which view was correct. It might have been advisable, however, to indicate by special marks that certain assignments are beyond question, others are fairly certain, and a few are still open to question. The treatment of the theoretical interpretation has some omissions. In particular, the

very important effects of hydrogen bonding and, more generally, of interactions and variations in charge distribution in altering characteristic frequencies receive inadequate attention. In all other respects, the book is an extremely valuable contribution which forms an excellent introduction to the subject for chemists and those more interested in the practical applications of infrared spectra. For the chemical spectroscopist, it is a storehouse of interesting information, which should prove very stimulating in the fascinating problem of correlating the spectroscopic and chemical properties of molecules.

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Titanium: Its Occurrence, Chemistry, and Technology. Jelks Barksdale. New York: Ronald Press, 1949. 591 pp. $10.00.

Growing interest in titanium chemistry and applications of elemental titanium and its compounds in recent years has demonstrated an urgent need for a comprehensive and concise summary of information pertaining to the chemistry of the element. Such a summary is presented in the present monograph.

Although written largely in terms of the titanium pigments industry, and thus reflecting the author's major experiences and interests, the volume nevertheless strikes a comparatively good balance among the technical developments involving titanium materials. Its wealth of information about pigments is supplemented by adequate discussions of uses of the element or its compounds in alloys, in the electrical and ceramic industries, in dyeing processes, and in catalysis. Recent developments involving the production of the pure metal and its applications are discussed, as are miscellaneous applications of compounds running the gamut from gem stones to water purification and sewage treatment.

Emphasis throughout the book is primarily upon technology. Considerable space is devoted to the mineralogy and technical treatment of useful ores for the recovery of compounds of the element. The chemistry of the free element and of its compounds is, however, treated in considerable detail in three chapters, and methods for analyzing titanium materials are considered in one chapter. This last chapter is very brief and appears to be somewhat sketchy in character. On the whole, however, the treatment seems excellent.

Throughout, the book is well documented. References to both technical and patent literature are indicated clearly in connection with statements of fact in the discussion. These references are then collected by chapters into a section of 77 pages, placed just before the index at the end of the volume. The author's statement that these references are complete up to the time when the book went to press appears correct. Indexing is equally comprehensive.

The book is written in a clear prose which is easy to follow and free from ambiguity. In general, the author has been sufficiently critical of conflicting literature reports to render his presentation authentic, although there are some instances where he has not been. One might wish that he had explored more searchingly the basic chemistry of some of the processes he described and had thereby offered more adequate explanations for these processes. In these and most other instances, however, the viewpoint has been more technical than theoretical or experimental. The volume has been given careful handling by the publishers and is thus clearly printed, attractively bound, and free from significant errors. In the opinion of the reviewer, however, the price is excessive.

Barksdale's *Titanium* should prove useful to both technologist and teacher. It contains a fund of information and should fill a vital need in the rapidly expanding field of titanium chemistry. Its use is to be recommended.

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The Alkaloids: Chemistry and Physiology, Vol. I. R. H. F. Manske and H. L. Holmes, Eds. New York: Academic Press, 1950. 525 pp. $10.00.

This volume is not for the casual reader who seeks a little information on the subject of vegetable bases, but rather for specialists in the alkaloid field, or those who intend to become so. It consists of seven sections, selected apparently on the basis of interests and availability of the authors.

The introductory chapter by Manske, "Sources of Alkaloids and their Isolation," is well described by its title, and offers many valuable generalizations of technique which are more specifically illustrated in the later chapters, where the isolation and separation of individual members is usually given.

The section by W. O. James, "Alkaloids in the Plant," is a scholarly treatment of the subject which assumes more botanical knowledge than is possessed by most chemists. The old and fascinating question of why plants produce alkaloids (and why many do not) is treated in some detail, and leaves us just where we started; we do not know, and perhaps there is no reason to speculate.

There are two excellent chapters by Léo Marion, "The Pyrrolidine Alkaloids," "The Pyridine Alkaloids," which deal with the simple cyclic plant bases, and the commercially and medically more important members of the pepper, areca, lobelia, and tobacco groups, as well as some minor types.

The relatively obscure subject of the *Senecio* alkaloids is considered in elegant detail by N. J. Leonard. Although the plants are of little importance except as a menace to cattle, the alkaloid group is nevertheless of interest as the first known example of the pyrrolizidine ring structure, and for the methodical way in which the nature of the individual members was elucidated.

"The Tropane Alkaloids," by H. L. Holmes, includes such medicinally important drugs as hyoscyamine, atropine, cocaine, and scopolamine. In addition to discussion of reactions and structure, there is an exhaustive table of derivatives and properties which may serve as an up-to-date Beilstein.

"The Strychnos Alkaloids," also by Holmes, makes difficult reading, but any account of strychnine will have