Acta Cryst. (1960). **13**, 61

Crystallographic studies on sodium uranyl-8-quinolinate, $Na.UO_2.(C_9H_6NO)_3$.

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(*Received* 20 *October* 1959)

Sodium uranyl-8-quinolinate was prepared by the action of uranyl nitrate on sodium carbonate and 8-quinolinol (Bullwinkel & Noble, 1958). The orange precipitate so obtained was repeatedly washed with sodium carbonate and dried. It crystallises as tiny and highly brittle orange-colour needles from water-alcohol mixture. The crystals belong to the monoclinic system, elongated parallel to *c*. The density of the compound was determined by using aqueous K_2HgI_4.

Rotation and Weissenberg layer-line photographs about the *b* and *c* axes were taken with Cu $K\alpha$ radiation and the cell dimensions were determined as

$$a = 22{\cdot}41,\ b = 14{\cdot}42,\ c = 13{\cdot}72\ \text{Å};\ \beta = 98°\ 30'.$$

There are eight molecules in the unit cell ($\varrho_c = 2{\cdot}23$ g.cm.$^{-3}$, $\varrho_o = 2{\cdot}20$ g.cm.$^{-3}$).

The systematic absences found were *h*0*l*, *h* odd and *l* odd; and *hk*1, $h+k$ odd; these fix the space group as C_{2h}^6–$C2/c$.

Intensity data for the *h*0*l* and *hk*0 reflections were collected by visual estimation. Patterson projections on (001) and (010) gave the uranium and sodium coordinates. The ambiguity in the coordinates was solved by packing considerations. A preliminary Fourier projection on (001), computed with the signs obtained from the uranium position, showed considerable overlapping of the lighter atoms around uranium and hence further work to locate these atoms was abandoned.

The coordinates of uranium and sodium are as follows:

	x	*y*	*z*
U	0·196	0	0·133
Na	0·400	0	0·350

I am grateful to Dr J. Shankar for his keen interest during the progress of the work.

Reference

Bullwinkel, E. P. & Noble, P., Jr. (1958). *J. Amer. Chem. Soc.* **12**, 2955.

Book Reviews

Works intended for notice in this column should be sent direct to the Editor (A. J. C. Wilson, Department of Physics, University College, Cathays Park, Cardiff, England). As far as practicable books will be reviewed in a country different from that of publication.

Application of Finite Groups.

By J. S. Lomont, Pp. xi + 346. New York: Academic Press, 1959. Price $11·00.

This book is a welcome addition to the growing collection of literature which explains the basic aspects of group theory to physicists and chemists, points out where these concepts can be usefully applied, and gives some examples of actual applications. The present book differs from most of the others in this category by the inclusion of considerably more advanced group theoretical concepts and techniques. This may take its study somewhat more difficult for people who are unfamiliar with mathematical reasoning, but the reviewer feels that the necessary effort would be well worthwhile.

The choice of the range of examples to illustrate physical applications of group theory is always a difficult one: too small a number does not do justice to the wide range of applicability of the discipline; too wide a choice creates the danger that the possibilities will be simply enumerated without detailed discussion. The author has found a felicitous middle ground which enables him to treat quite a variety of subjects in a rather thorough fashion. Most of the illustrations are well chosen in that they exhibit the power of group theory to simplify a wide range of problems although in at least one case (thermodynamics) results are obtained by the use of heavy group theoretical artillery that can be obtained rather simply without it.

Chapter I presents, in the form of definitions and theorems, all the necessary (and some unnecessary) matrix theoretical background for the later exposition of representation theory; a large amount of material is compressed here into 15 pages. This condensation is achieved in part by good organization and in part by the complete omission of all proofs, save one (Schur's Lemma) which is given in brief outline. This absence of proofs may be considered a drawback by many, while others may find that being forced to supply them constitutes a very worthwhile exercise; in any case, specific references to where the proofs of at least the most important theorems could be found would be helpful.

Chapter II (27 pages) gives the most important concepts of abstract group theory again mainly in the form of definitions and theorems (without proofs). An unusual and welcome feature is the inclusion of some more advanced and 'modern' concepts, e.g. that of the semi-direct product, as well as some 'classical' ones like composition series and group commutators. The quaternion group is used as a concrete example to illustrate various features, a welcome departure from the almost traditional use for these purposes of the symmetric group of degree 3. This chapter also contains applications to thermodynamics as well as the beginning of a discussion of

applications to the Dirac equation and fermion annihilation and creation operators.

The third chapter (43 pages) expounds the theory of group representations again mainly by stating definitions and theorems without proofs. Among the more unusual worthwhile sections of this chapter is a short but good discussion of inner and outer Kronecker products. As examples the character tables of some groups of interest in mathematical physics are discussed briefly. This material is continued in the fifth chapter (26 pages) which deals mainly with the relations between the representations of a group and its subgroups; part of this material is also presented in the language of 'little groups'. A section on projective representations is also included.

Chapter IV, by far the largest (114 pages), presents applications in the fields of molecular vibrations, wave guide theory, quantum mechanics, crystallography and crystal dynamics. The illustrations are presented in adequate detail. The chapter also includes a short discussion of the three-dimensional rotation group and double point groups. The applications are continued in chapter VI (22 pages) where the representations of space groups and the connection with energy band theory is discussed.

Chapters VII and VIII (42 pages) give the theory of symmetric groups and its application to molecular, atomic and nuclear structure. There is a brief mention of crystal field theory; it is also shown to what extent selection rules are derivable by group theoretic arguments.

One appendix gives the explicit form of the multidimensional irreducible representations of several point groups; another contains an excellent and rather extensive survey of the Lorentz groups.

The book contains 213 numbered references as well as extensive bibliographies at the end of most individual chapters; the latter are, however, of only limited usefulness since no specific reference to them is made in the text. This is a serious drawback since anybody who would like to know where additional discussion, especially of theory, can be found faces an almost insuperable task.

The terminology and notation is admirably clear, though on occasion a trifle over-elaborate. The index is excellent.

In spite of the title, a significant portion of the book deals—quite justifiably—with infinite groups. In view of this, it would have been helpful if the theoretical section would point out clearly which theorems have to be abandoned or at least modified when the transition from finite groups is made.

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Mineralogy. An Introduction to the Study of Minerals and Crystals. By E. H. KRAUS, W. F. HUNT and L. S. RAMSDELL. Pp. 686, with 736 figs. New York, Toronto, London: McGraw-Hill Book Co., Inc., 5th edition, 1959. Price 70*s*.

The previous edition of 'Mineralogy' appeared in 1951 and had 664 pages and 735 figures. The suitability of this book as a textbook for university courses in the U.S.A. has been demonstrated by its continuation into a fifth revised edition, and by evaluations of earlier editions by American reviewers: a reviewer in England can add little of value in this context. However, apart from an expected emphasis on American mineral localities, the book can be equally suitable outside of its home country as a basis of an introductory course with a bias towards practical and economic aspects of mineralogy. For the newcomer to mineralogy its wide perspective is admirable: there are chapters on crystal morphology, crystal optics, physical and chemical properties of minerals, crystal structure and X-ray diffraction, chemical crystallography, chemical analytical methods, gemstones, rock and mineral formation; and, as its *raison d'être*, about two thirds of the book is devoted to the description and tabular classification of minerals. With as wide a scope as this it is inevitable that some aspects are treated only cursorily, but a bibliography leads to more specialised texts.

Readers of this journal will look with particular interest at the crystallographic chapters and will perhaps wonder whether retention of the Weiss symbols, in addition to the universally used Miller indices (e.g. $na : b : \infty c$ and $hk0$), is really warranted by the claim that they are easier for beginners. The chapter on optics is remarkably good for such a condensed treatment, the only important omission being a statement or a graphical representation of the sequence in the Newton scale of interference colours. The crystal structure and X-ray section gives a reasonable selection of the relevant concepts and methods but in parts is a little too compressed to be clear to a beginner. In the main part of the book the principal crystallographic, physical and chemical features, the occurrence, associates, and industrial uses of the most common minerals, are described. In the section on silicates, considerable use is made of recent structural knowledge and coverage of the different minerals is well balanced except for chlorites and clay minerals. Chemical variation among the chlorites is barely mentioned, and the clay minerals illite and montmorillonite warrant but do not get, equal treatment with kaolinite. The chapter on gemstones is beautifully concise and informative, and the determinative tables (167 pages) are clearly set out.

The fifth edition is considerably revised. In the introductory chapters two new sections are on crystal chemistry (in chapter 13) and on magmatic processes (in chapter 14). More important, the descriptions and classification of minerals are revised in many places by being based on the most recent editions of 'Dana's System of Mineralogy' (1944, 1951), and Strunz's 'Mineralogische Tabellen' (1957). In the X-ray section there are better illustrations of rotation and Weissenberg photographs. Additional minerals and varieties mentioned in this edition are autunite, boehmite, borazon, Brazilian emerald and indicolite, gummite, illite, piedmontite and wad. Minor errors are practically non-existent, but something has gone wrong with the entries for nepheline (or nephelite) in the index; the index is, however, more comprehensive than in the previous edition.

This book is well produced, and it is well worth the price to anyone with a general interest in the Earth Sciences.

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