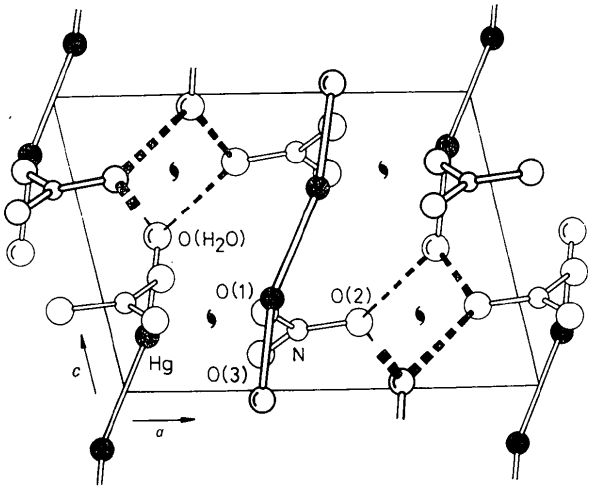

Fig. 1. Projection of the crystal structure on the *ac* plane.

$O(2^{iii})$ and O(2), which are linked to the water molecule by the hydrogen bonds, is defined by a polar angle of 94·2° from [001] and an azimuthal angle of ±34·7° from [010]. This is in good agreement with the values of 98° and ±42°, respectively, determined by El Saffar (1973) for the proton–proton direction if it is assumed parallel to the $O(2^{iii})$–O(2) direction. All atoms apart from the mercury atom at a distance less than the sum of the van der Waals radii are considered to belong to the effective coordination about mercury (Grdenić, 1965). There are three nitrate oxygen atoms at the distances of 2·68, 2·75 and 2·81 Å in addition to one mercury and one water oxygen atom at 2·508 and 2·13 Å, respectively, in an irregular square pyramid.

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Table 2. *Interatomic distances* (Å) *and bond angles* (°) *with their estimated standard deviations in the last figure* (*in parentheses*)

$Hg–Hg^{i}$	2·508 (2)	$O(2^{ii})\cdots O(H_2O^{iii})$	2·70 (3)
$Hg–O(H_2O)$	2·13 (2)	$Hg\cdots O(3)$	2·68 (2)
N—O(1)	1·26 (3)	$Hg\cdots O(1)$	2·75 (2)
N—O(2)	1·26 (3)	$Hg\cdots O(1^{v})$	3·03 (2)
N—O(3)	1·24 (3)	$Hg\cdots O(3^{v})$	2·81 (2)
$O(2^{ii})\cdots O(H_2O)$	2·68 (3)	$O(1)\cdots O(3^{v})$	3·00 (3)

$Hg^{i}–Hg–O(H_2O)$	167·5 (7)
O(1)–N—O(2)	119·8 (20)
O(2)–N—O(3)	123·0 (21)
O(3)–N—O(1)	116·9 (21)
$O(H_2O)\cdots O(2^{ii})\cdots\cdots O(H_2O^{iii})$	122·1 (15)
$O(2^{ii})\cdots\cdots O(H_2O^{iii})\cdots O(2^{iv})$	115·0 (15)

The positions without a label are given by x,y,z, as in Table 1. The labels are as follows: (i) $-x,-y,-z$; (ii) $1-x,-y,1-z$; (iii) $\frac{1}{2}-x,\frac{1}{2}+y,\frac{3}{2}-z$; (iv) $-\frac{1}{2}+x,\frac{1}{2}-y,\frac{1}{2}+z$; (v) $\frac{1}{2}-x,\frac{1}{2}+y,\frac{1}{2}-z$.

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Book Review

Works intended for notice in this column should be sent direct to the Book-Review Editor (M. M. Woolfson, Physics Department, University of York, Heslington, York YO1 5DD, England). As far as practicable books will be reviewed in a country different from that of publication.

The chemistry of imperfect crystals. By F. A. KRÖGER. Vol. 1: pp.xiii+313, Figs. 58, Tables 10. Price *f* 70.00 (about U.S. $25.50). Vol. 2: pp. 1000. Price *f* 275.00 (about U.S. $105.75). Vol. 3: pp.xiv+306, Figs. 42, Tables 15. Price *f* 100.00 (about U.S. $38.50). Amsterdam: North Holland, 1974.

This is a book primarily for research workers already in, or about to enter, the field of solid-state physics, chemistry or materials science; it is a book for the working specialist rather than the amateur. It concedes little to a user unfamiliar with crystal structures or to one who does not already know the context and priorities of the subject.

The first edition was published in 1964; the second is a thoroughly up-dated and somewhat expanded version. The book has the characteristics both of a textbook, with its detailed didactic presentation of theory, and of a review with its numerous references to the literature. This dual objective is the main difficulty of the book, for with so large a subject the material has become so bulky that its practical usefulness is jeopardized. The author is aware of the size of the field and of the existence of many smaller works dealing with specialized areas, but he is also aware of the value of a coherent presentation of a subject by a single author. He consciously offers his book, therefore, as giving, 'as before, a one-man view of solid-state chemistry'.

The new edition has essentially the same structure as the first but the three parts of the original book have become three separately bound volumes. The first volume (which appeared ahead of the other two, about six months ago)

deals with preparative procedures and the theory of crystal growth. A good deal of basic thermodynamics is included. The second volume, the largest of the three, deals with imperfections (including impurities) in crystalline materials, and their physico-chemical consequences. The first three chapters of this volume are particularly useful – and readable – as a survey of the nature of crystal imperfections in general. Subsequent chapters develop the detailed physical chemistry and mathematics of equilibria involving imperfections of all possible kinds, and then examine the application of such analysis to increasingly complex substances, from elements through a substantial range of binary compounds to the more important tertiary compounds. The third volume is a study of all situations which are specifically not in equilibrium, *i.e.* relaxation effects, chemical changes or reactions in or on solids. This includes sections on the diffusion of crystal imperfections, precipitation of impurities, the mechanisms of sintering and tarnishing, the electrochemistry of imperfect solids, the photographic process and charge-transfer catalysis. This third volume is perhaps the most useful to the active research worker. Through the three volumes, the numbering of the chapters runs sequentially but the page numbering does not, which seems inconsistent; also, the three indexes are quite separate. Cross-referencing within the three volumes is frequent but between them rather rare.

The thoroughness with which the literature citations have been updated is impressive, and reflects also the expansion of the subject during the past decade. A useful table in Vol. 1 lists all substances which have been grown as single crystals, with the methods used and the literature references. In the first edition, this contained about 200 entries and 230 references; it now extends over 38 pages, has 700 entries and 1100 references. Only molecular solids (*e.g.* organic crystals) are conspicuous by their absence from these compilations. Mammoth tables are a feature of this book: a table in Vol. 2, listing binary compounds for which any work has been carried out on the influences of impurities on crystal properties, runs to 86 pages and has 3400 references. There are many such enormous tabulations. They do not make for smooth reading of the book but they certainly contain a wealth of information, allowing the reader instant access to the original literature at whatever point he likes.

A vital contribution that Kröger has made to the subject (in addition to his own research work in this field) is the symbolism he has devised for crystal imperfections. This is presented at the beginning of Vol. 2 and is used continuously throughout the book. There is a useful summary on p. 275, at the end of Vol. 3. Characteristically it is rather elaborate, so as to allow for all possible situations. Perhaps it is because it has appeared cumbersome that it has not been widely adopted, but it is in fact an elegant and practical scheme, worth knowing and using.

Misprints are remarkably few, considering the size and complexity of this book (although there is a bad typographical displacement on p. 469 of Vol. 2). There is one serious infelicity in the occasional use of the term 'free enthalpy' for the Gibbs free energy, G. Free energy relationships play an important part in this book, so it is a pity that this invitation to confusion is presented. 'Free enthalpy' is neither defined nor explained as such; indeed, the impression that it is being used interchangeably with the normal term is fortified by duplicated index entries. If 'free enthalpy' had been merely a verbal indiscretion, then it would have been curious that this was not corrected during re-editing, when linguistic slips such as 'specie' were removed. As it stands it is misleading, for G is emphatically not a sort of enthalpy.

Taken as a whole the book is excellent in terms of clarity, coherence and internal consistency. Its width of coverage is masterly, even encyclopaedic; its accurate presentation of detail is remarkable. As a reference text, giving both the broad panoramic view and a meticulous literature survey, it must be unique in the field. Only its cost is unfortunate, for at £70 one can hardly expect the book to be purchased by ordinary individuals. Any of the three volumes can of course be bought separately but this is not really to be recommended, for the work is intended as a single treatise. However, many libraries must surely acquire this book and many working scientists and technologists will find invaluable its compendious stock of organized information.

J. H. ROBERTSON

School of Chemistry
University of Leeds
England