Structural Inorganic Chemistry

A. F. WELLS

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Preface

In the introduction to the first (1945) edition the author stated his conviction that the structural side of inorganic chemistry cannot be put on a sound basis until the knowledge gained from the study of the solid state has been incorporated into chemistry as an integral part of the subject, and that it is not sufficient merely to add information about the structures of solids to the descriptions of elements and compounds as usually presented in a systematic treatment of inorganic chemistry. Since the results of structural studies of crystals are described initially in crystallographic language, the first requirement is that these results be made available in a form intelligible to chemists. It was this challenge that first attracted the author, and it is hoped that this book will continue to provide teachers of chemistry with facts and ideas which can be incorporated into their teaching. However, while the incorporation of even the most meagre information about the structures of solids into the conventional teaching of chemistry is to be welcomed, a real understanding of the structures of crystals and of the relations between different structures is not possible without a knowledge of certain basic geometrical and topological facts and concepts. This essential background material includes the properties of polyhedra, the nature and symmetry of repeating patterns, and the ways in which spheres, of the same or different sizes, can be packed together. Because many students find difficulty in appreciating three-dimensional structures from two-dimensional illustrations (even stereoscopic photographs) the examination of, and preferably also the construction of, models should play a large part in the study of these subjects.

The general plan of the book is as follows. Part I deals with a number of general topics, including those mentioned above, and is intended as an introduction to the more detailed Part II, which forms the larger part of the book. In Part II the structural chemistry of the elements is described systematically, and the arrangement of material is based on the groups of the Periodic Table. The author believes that the numerous revisions and additions result in a reasonable picture of the subject at the end of the eighth decade of the twentieth century. It is evident that there are specialists who are better qualified than the author to write many of the chapters of a book which attempts to cover such a large field. Over the years, however, a number of good friends of the author have expressed the opinion that there is some virtue in having a book written by a single author, if only because this ensures a uniform style of writing. There may be readers who would like to see more thorough treatments of some topics which have become of great scientific or technological interest in recent years. For example, very careful and detailed studies have been made of the structures of certain groups of crystalline inorganic compounds with the object of correlating structure with physical properties. Also, there are certain types of crystal structure which are of crystallographic rather than

chemical interest (for example, shear structures and 'infinitely adaptive' structures). The author can do little more than mention structures of these types in a book which is addressed to chemists and attempts a survey, necessarily sketchy in parts, of the structures of elements and compounds not only in the solid state but also in the gaseous state and, to a very limited extent, in the liquid state.

References. The present volume has never been intended as a work of reference, though it may serve as a useful starting-point when information is required on a particular topic. As an essential part of the educational process the advanced student should be encouraged to adopt a critical attitude towards the written word (including the present text); he must learn where to find the original literature and to begin to form his own judgment of the validity of conclusions drawn from experimental data. The numerous references to the scientific literature included in Part II generally refer to the latest work; these usually include references to earlier work. To save space the names of scientific journals have been abbreviated to the forms listed on pp. xxix-xxxi.

Indexes. There are two indexes. The arrangement of entries in the formula index is not entirely systematic, for there is no wholly satisfactory way of indexing inorganic compounds which retains chemically acceptable groupings of atoms. The formulae have been arranged so as to emphasize the feature most likely to be of interest to the chemist. The subject index is largely restricted to names of minerals and organic compounds and to topics which are not readily located in the list of contents.

Acknowledgements. During the writing of this book, which of necessity owes much to the work and ideas of other workers in this and related fields, I have had the benefit of helpful discussions with a number of colleagues, of whom I would particularly mention Dr B. L. Chamberland. I wish to thank Dr B. G. Bagley and the editor of *Nature* (London) for permission to use Fig. 4.3, Dr H.T. Evans and John Wiley and Sons for Figs. 11.5(c), 11.7, 11.10, 11.11. and 11.13(b), Dr. H. G. von Schnering for Fig. 19.4(e), and Drs G. T. Kokotailo and W. M. Meier for Fig. 23.27. It gives me great pleasure to acknowledge the debt that I owe to my wife for her support and encouragement over a period of many years.

Storrs, Connecticut A.F.W.
1982

Abbreviations

The following abbreviations are used in references to Journals throughout this book.

AANL	Atti dell'Accademia nazional dei Lincei
AC	Acta crystallographica
AcM	Acta Metallurgica
ACSc	Acta Chemica Scandinavica
ACSi	Acta Chimica Sinica
AJC	Australian Journal of Chemistry
AJSR	Australian Journal of Scientific Research
AK	Arkiv för Kemi
AKMG	Arkiv för Kemi, Mineralogi och Geologi
AlC	Analytical Chemistry
AM	American Mineralogist
AnC(IE)	Angewandte Chemie (International Edition)
AP	Annalen der Physik
APURSS	Acta Physicochimica URSS
ARPC	Annual Review of Physical Chemistry
ASR	Applied Scientific Research
B	Berichte
BB	Berichte der Bunsengesellschaft für physikalische Chemie
BCSJ	Bulletin of the Chemical Society of Japan
BSCB	Bulletin des Sociétés chimiques Belges
BSCF	Bulletin de la Société chimique de France
BSFMC	Bulletin de la Société française de minéralogie et de cristallographie
C	Chimia (Switzerland)
CB	Chemische Berichte
CC	Chemical Communications (Journal of the Chemical Society, Chemical Communications)
CJC	Canadian Journal of Chemistry
CJP	Canadian Journal of Physics
CR	Comptes rendus hebdomadaires des Séances de l'Académie des Sciences (Paris)
CRURSS	Comptes rendus de l'Academie des Sciences de l'URSS
CSR	Chemical Society Reviews
DAN	Doklady Akademii Nauk SSSR
E	Experientia
FM	Fortschritte der Mineralogie
GCI	Gazzetta chimica italiana
HCA	Helvetica Chimica Acta
IC	Inorganic Chemistry
ICA	Inorganica Chimica Acta
IEC	Industrial and Engineering Chemistry
INCL	Inorganic and Nuclear Chemistry Letters
JACS	Journal of the American Chemical Society
JACeS	Journal of the American Ceramic Society

JACr	Journal of Applied Crystallography
JAP	Journal of Applied Physics
JCG	Journal of Crystal Growth
JCMS	Journal of Crystal and Molecular Structure
JCP	Journal of Chemical Physics
JCS	Journal of the Chemical Society (London)
JES	Journal of the Electrochemical Society
JINC	Journal of Inorganic and Nuclear Chemistry
JLCM	Journal of the Less-common Metals
JM	Journal of Metals
JMS	Journal of Molecular Spectroscopy
JMSt	Journal of Molecular Structure
JNM	Journal of Nuclear Materials
JOC	Journal of Organometallic Chemistry
JPC	Journal of Physical Chemistry
JPCS	Journal of the Physics and Chemistry of Solids
JPP	Journal de Physique (Paris)
JPSJ	Journal of the Physical Society of Japan
JSSC	Journal of Solid State Chemistry
K	Kristallografiya
KDV	Kongelige Danske Videnskabernes Selkab Matematisk-fysiske Meddeleser
MH	Monatshefte für Chemie und verwandte Teile anderer Wissenschaften
MJ	Mineralogical Journal of Japan
MM	Mineralogical Magazine (and Journal of the Mineralogical Society)
MMJ	Mineralogical Magazine (Japan)
MRB	Materials Research Bulletin
MSCE	Mémorial des Services chimiques de l'état (Paris)
N	Nature
NBS	Journal of Research of the National Bureau of Standards
NF	Naturforschung
NJB	Neues Jahrbuch für Mineralogie
NPS	Nature (Physical Sciences)
NW	Naturwissenschaften
PCS	Proceedings of the Chemical Society
PKNAW	Proceedings koninklijke nederlandse Akademic van Wetenschappen
PM	Philosophical Magazine
PNAS	Proceedings of the National Academy of Sciences of the U.S.A.
PR	Physical Review
PRL	Physical Review Letters
PRR	Philips Research Reports
PSS	Physica Status Solidi
QRCS	Quarterly Reviews of The Chemical Society
RCR	Revue de Chimie Minérale
RJIC	Russian Journal of Inorganic Chemistry
RMP	Reviews of Modern Physics
RPAC	Reviews of Pure and Applied Chemistry (Royal Australian Chemical Institute)
RS	Ricerca scientifica
RTC	Recueil des Travaux chimiques des Pays-Bas et de la Belgique
SA	Spectrochimica Acta
Sc	Science

SMPM	Schweizerische mineralogische und petrographische Mitteilungen
SPC	Soviet Physics: Crystallography
SR	Structure Reports
SSC	Solid State Communications
TAIME	Transactions of the American Institute of Mining and Metallurgical Engineers
TFS	Transactions of the Faraday Society
TKBM	Tidsskrift for Kjemi, Bergvesen og Metallurgi
ZaC	Zeitschrift für anorganische (und allgemeine) Chemie
ZE	Zeitschrift für Elektrochemie
ZFK	Zhurnal fizicheskoi Khimii
ZK	Zeitschrift für Kristallographie
ZN	Zeitschrift für Naturforschung
ZP	Zeitschrift für Physik
ZPC	Zeitschrift für physikalische Chemie
ZSK	Zhurnal strukturnoi Khimii

Contents