

高 等 学 校 教 材



无机非金属材料 专业英语

大学英语专业阅读教材编委会组织编写

杜永娟 主编
郑昌琼 主审

NG
READ
I



化学工业出版社
教材出版中心

高等学校教材

无机非金属材料专业英语

大学英语专业阅读教材编委会组织编写

杜永娟 主编

郑昌琼 主审

化学工业出版社

教材出版中心

·北京·

(京)新登字 039 号

图书在版编目(CIP)数据

无机非金属材料专业英语/杜永娟主编. —北京: 化学工业出版社, 2001.12
高等学校教材
ISBN 7-5025-3355-9

I. 无… II. 杜… III. 无机材料: 非金属材料—英语—高等学校—教材 IV. H31

中国版本图书馆 CIP 数据核字 (2001) 第 092180 号

高等学校教材

无机非金属材料专业英语

大学英语专业阅读教材编委会组织编写

杜永娟 主编

郑昌琼 主审

责任编辑: 杨 菁 徐世峰

责任校对: 郑 捷

封面设计: 于 兵

*

化学工业出版社

教材出版中心 出版发行

(北京市朝阳区惠新里 3 号 邮政编码 100029)

发行电话: (010) 64918013

<http://www.cip.com.cn>

*

新华书店北京发行所经销

北京云浩印刷厂印刷

三河市前程装订厂装订

开本 787×1092 毫米 1/16 印张 14 1/4 字数 362 千字

2002 年 1 月第 1 版 2002 年 1 月北京第 1 次印刷

ISBN 7-5025-3355-9/G·908

定 价: 22.00 元

版权所有 违者必究

该书如有缺页、倒页、脱页者, 本社发行部负责退换

全国部分高校化工类及相关专业 大学英语专业阅读教材编审委员会

主任委员

朱炳辰 华东理工大学

副主任委员

吴祥芝 北京化工大学

钟 理 华南理工大学

欧阳庆 四川大学

贺高红 大连理工大学

委员

赵学明 天津大学

张宏建 浙江大学

王延儒 南京化工大学

徐以撒 江苏石油化工学院

魏新利 郑州工业大学

王 雷 抚顺石油学院

胡惟孝 浙江工业大学

吕廷海 北京石油化工学院

陈建义 石油大学（东营）

胡 鸣 华东理工大学

秘书

何仁龙 华东理工大学教务处

内 容 提 要

《无机非金属材料专业英语》是根据大学英语教学大纲（理工科本科用）的专业阅读部分的要求编写的。

全书共分7个部分，33个单元。每个单元包括精读课文，词汇表（附音标），课文注释，练习，阅读材料。内容涉及无机材料物理化学、陶瓷、玻璃、水泥与混凝土、耐火材料，宝石学和无机材料工程。

本教材供已通过大学英语四级的无机材料专业及相关专业学生，同等英语水平的科技人员使用。

前 言

组织编审出版系列的专业英语教材,是许多院校多年来共同的愿望。在高等教育面向21世纪的改革中,学生基本素质和实际工作能力的培养受到了空前的重视。对非英语专业的学生而言,英语水平和能力的培养不仅是文化素质的重要部分,在很大程度上也是能力的补充和延伸。在此背景下,教育部(原国家教委)几次组织会议研究加强外语教学问题,制订有关规范,使外语教学更加受到重视。教材是教学的基本因素之一,与基础英语相比,专业英语的教材问题显得更为突出。

国家的主管部门和广大院校的呼吁引起了化学工业出版社的关注。他们及时的与原化工部教育主管部门和全国化工类专业教学指导委员会请示协商后,根据学校需求,编委会优先从各院校教学(交流)讲义中确定选题,同时组织力量进行编审工作。本套教材涉及的专业主要包括化学工程与工艺、石油化工、机械工程、信息工程、生产工程自动化、应用化学和精细化工、生化工程、环境工程、制药工程、材料科学与工程和化工商贸等。

根据“全国部分高校化工类及相关专业大学英语专业阅读教材编委会”的要求和安排编写的《无机材料非金属材料专业英语》教材,可供材料类及相关专业本科使用,也可作为同等程度(通过大学英语四级)的专业技术人员的自学教材。

本书分为7个部分,33个单元,每个单元包括精读课文,词汇表(附音标),课文注释,练习,阅读材料等。各篇课文之间,课文与阅读材料既有一定联系,又可独立成章,教学时可以根据不同学时灵活选用。课文与阅读材料均来自英文原版教科书、专著、国际著名学术期刊和国际学术会议,绝大部分为20世纪80年代末和90年代以来的出版物。

本教材的内容涉及无机材料物理化学(Part1),陶瓷(Part2),玻璃(Part3),水泥与混凝土(Part4),耐火材料(Part5),宝石学(Part6)和无机材料工程(Part7)。基本覆盖了无机非金属材料专业的重要内容,从无机材料科学到工程,从主要无机材料的结构、组成、性质、应用到制备工艺;从传统的无机非金属工程材料,天然无机非金属材料到新型无机材料;材料的加工从高温到新技术。内容具有广泛性、基础性和新颖性。

本书由华东理工大学杜永娟主编,本书第一部分、第四部分与总词汇表由杜永娟编写,第二部分由陈奇编写,第三部分由王中俭编写,第五部分由陈国荣编写,第六部分由刘学良与郭守国编写,第七部分由郑金标编写。全书由杜永娟统稿,郑昌琼(四川大学)主审。华东理工大学博士研究生汪山、硕士研究生刘春玲、王萍、王海鹏、本科生郑爱萍等参加了部分文摘整理和文字处理工作。

本书在编写过程中得到化学工业出版社、全国部分高校化工类及相关专业大学英语专业阅读材料编委会、华东理工大学教务处和四川大学教务处的全力支持;博士生导师郑昌琼教授认真审阅了全书,提出宝贵意见,在此一并表示衷心感谢。

由于时间仓促和编者的水平有限,不足之处在所难免,希望广大读者提出宝贵意见。

编 者
2001年9月

Contents

PART I	PHYSICAL CHEMISTRY OF INORGANIC MATERIALS	1
Unit 1	Types of Bonds in Crystals	1
	Reading Material 1: Grouping of Ions and Pauling's Rules	5
Unit 2	Silicate Structures	9
	Reading Material 2: Structure of Carbides, Nitrides and Borides	12
Unit 3	Defect Crystal Chemistry	16
	Reading Material 3: Solid Solution	19
Unit 4	Surfaces and Colloids	23
	Reading Material 4: Surfaces and Interfaces	27
Unit 5	Diffusion	31
	Reading Material 5: Phase Transitions	35
PART II	CERAMICS	39
Unit 6	Ceramic Fabrication Process: Conventional Routes to Ceramics	39
	Reading Material 6: Ceramics Fabrication	43
Unit 7	Treatment after Firing: Grinding and Glazing	46
	Reading Material 7: Metallizing, Sealing, Sputter Deposition Process and Chemical Vapour Deposition	49
Unit 8	Electronic Ceramics: Electrical Insulators and Conductors	52
	Reading Material 8: Superconductors, Ferrites and Piezoelectric Ceramics	56
Unit 9	Optical Ceramics	59
	Reading Material 9: Ceramic Materials for Sensors	62
Unit 10	Bioceramics: Medical Applications of Ceramics	65
	Reading Material 10: Calcium Phosphate Ceramics	67
Unit 11	Advanced Structural Ceramics	70
	Reading Material 11: Research on Aerospace Ceramics	73
PART III	GLASS	76
Unit 12	Structure of Glass	76
	Reading Material 12: A Hierarchical Model of the Glass Structure	78
Unit 13	Glass Formation	82
	Reading Material 13: Atomistic Hypotheses of Glass Formation	85
Unit 14	Manufacture of Glass: Present Trend in Industrial Glass Melting	88
	Reading Material 14: Environmental Considerations in Glass Manufacturing	91

Unit 15	Glass Properties	95
	Reading Material 15: Glass Properties	97
Unit 16	Special Glass	101
	Reading Material 16: Glasses for Electronic Applications	103
Unit 17	Glass Ceramics	107
	Reading Material 17: US 5591682 Low Expansion Transparent Glass-ceramic	109
PART IV	CEMENT AND CONCRETE	112
Unit 18	Portland Cement	112
	Reading Material 18: Manufacture of Portland Cement	116
Unit 19	Hydration of Portland Cement	119
	Reading Material 19: Reactivities of Clinker Phases	122
* Unit 20	Oil Well Cementing	126
	Reading Material 20: Very High Strength Cement-based Materials	129
Unit 21	Concrete Chemistry	133
	Reading Material 21: Fibre Reinforced Concrete-myth and Reality	136
PART V	REFRACTORIES	140
Unit 22	Materials Development in Refractories during the 20 th Century	140
	Reading Material 22: Refractories Manufacturing Techniques	144
Unit 23	Refractory Bonds and Binders	148
	Reading Material 23: Mullite and Its Use as a Bonding Phase	151
Unit 24	Thermomechanical Properties of Refractories	155
	Reading Material 24: Corrosion Behavior of Refractories	158
Unit 25	Glassmaking Refractories	162
	Reading Material 25: Development of Refractories in Specific Applications	165
PART VI	GEMMOLOGY	169
Unit 26	An Introduction to the Geology of Gem Materials	169
	Reading Material 26: Red Tourmaline	172
Unit 27	Mechanical Properties of Gemstones	175
	Reading Material 27: Heat Treatment	178
Unit 28	Optical Properties of Cut Gemstones	182
	Reading Material 28: The Identification of Treated Gems	186
Unit 29	Diamond	189
	Reading Material 29: Amethyst	191
PART VII	INORGANIC MATERIALS ENGINEERING	194
Unit 30	Furnaces	194
	Reading Material 30: Stack Dimensions	197

Unit 31	Storage (Silo)	199
	Reading Material 31: Calculation of Static Powder Pressure	201
Unit 32	Raw Materials and Mixing	204
	Reading Material 32: <i>Weighing and Mixing</i>	207
Unit 33	Primary Forming Operations (I)	209
	Reading Material 33: Primary Forming Operations (II)	211
总词汇表	214

PART I PHYSICAL CHEMISTRY OF INORGANIC MATERIALS

Unit 1, Types of Bonds in Crystals

Ionic Bonds

In some crystals, the atoms are present in a state where their electron system is similar to that of a rare gas, so that their outer shell has either lost excess electrons or has been filled with a total of eight electrons, i.e., completed. Since the electric neutrality must be conserved, the crystal always simultaneously contains atoms that donate electrons and atoms that accept electrons. The former form positively charged cations, while the latter form negatively charged anions, and the electric charges of ions are integral multiples of the electron charges.

The cohesive forces in these crystals are electrostatic forces acting between the ions. This type of bond is called an ionic bond and the crystals are called ionic crystals. As the electric field of ions is spherically symmetrical, the ionic bonding is isotropic, i.e., the bonds do not have directional character and every ion attempts to be surrounded by the maximum possible number of ions of the opposite charge, so that the bonds are not saturated. Halide salts of alkali metals represent typical ionic crystals; this is so because alkali metals have only one electron in the outer shell, while halides lack exactly one electron for completion of their outer shell to eight electrons.

This idea is identical with the concept of valency except that the crystal is not considered as a compound of molecules, but rather as a unified structure for which the chemical formula has the meaning of the ratio of the elements and the geometric arrangement is an indispensable part of the description of the substance^①. The chemical formula, e.g., NaCl, does not denote a molecular structural unit here, because every ion in the crystal interacts with several closest neighbours with the opposite sign, so that, for example, each Na^+ ion in NaCl is surrounded by six equivalent nearest Cl⁻ ions, and vice versa.

Covalent Bonds

An exact quantum mechanical calculation for the hydrogen molecule model, carried out by Heitler and London (1927), revealed that there exist two possible lowest energy states of the hydrogen molecule, composed of the original single-atomic states, and that the lower energy corresponds to a singlet state in which orientations of the spins of electrons are antiparallel^②. The energy difference between the two states and the consequent forces, called ex-

change forces, depend on the overlap of the wave functions of the electrons, which become common for both atoms. Such a bonding is called homeopolar or atomic.

The pairing of electrons in states in which the electrons, according to Pauli principle, differ only in spin orientation is also characteristic for covalent bonds between atoms with more complex electron structures. The bond is again created by the overlap of the single-electron wave functions of atomic orbitals, which combine into the wave function of the common state. The main characteristics of covalent bonds are their saturation and mutual orientation of the bonds when there are several on the given atom; this is always the case except for atomic pairs. Saturation is a consequence of the Pauli principle; every bond contains exactly two electrons. Formally, the bond is similar to an ionic bond with the difference that the electrons are not transferred between atoms but become common property. For electrons in the p- and d- states, the degree of overlap, and thus also the covalent bond, depends not only on the interatomic distances but also on the mutual orientation of the directions of lines connecting the various atoms.

Bond hybridization. A future important property of covalent bonds is hybridization of the atomic orbitals, leading to variation of the valency of a given element in various compounds. The best example of this phenomenon is carbon, the ground state of which has the electron configuration $1s^2 2s^2 2p^2$ with only two p-electrons unpaired, which results in valency of two as, for example, in CO. However, it is known that carbon is usually present in compounds as a tetravalent element. Pauling (1931) explained this phenomenon through orbital hybridization, where carbon is present in the compound in the excited state $1s^2 2s^1 2p^3$, so that it has one unpaired s-electron and three unpaired p-electrons, i.e., a total of four electrons that can enter into covalent bonds^③. From a quantum mechanical point of view, these electrons cannot be considered separately but must be considered as equivalent particles in a single common state. From this also follows that the four bonds, available on carbon in this state, are completely equivalent. As a consequence, the atoms bonded to tetravalent carbon form a configuration of a regular tetrahedron. According to Kimball, the spatial orientations of the covalent bonds have the following shapes for various combinations of atomic orbitals:

atomic orbitals	shape of the hybrid orbitals	coordination number K	atomic orbitals	shape of the hybrid orbitals	coordination number K
a) sp, dp	linear	2	f) dsp^3, d^3sp	trigonal bipyramidal	5
b) sp^2, dp^2, d^2s	planar trigonal	3	g) d^4s	tetragonal pyramidal	5
c) d^2p	trigonal pyramidal	3	h) d^2sp^3	octahedral	6
d) sp^3, d^3s	tetrahedral	4	i) d^4sp	trigonal prismatic	6
e) dsp^2	planar tetragonal	4			

Metallic bonds

In metallic crystals, many of the valence electrons are present in states where they are not localized close to the atoms but can move freely over the crystal, which is reflected in a high conductivity^④. The structure of metals can thus be conceived of as being composed of positively charged ions immersed in an electron gas. The term "gas" is not used accidentally

here, as the free electrons actually behave statistically like a gas. The bonding between the positive ions occurs through these free electrons. Thus, an ionic bond can be described as containing an electron localized close to an acceptor atom, while the electron in a covalent bond is located between two atoms, and in a metallic bond the free electrons are completely delocalized. Metallic bonding, similarly to ionic, is characterized by isotropy and the consequent large coordination numbers. The ions in a metal tend to be surrounded by the maximum possible number of neighbours. In contrast to ionic bonds, metallic bonds do not require a balance of the electric charge between the elements; the electrostatic equilibrium is between metal ions and electron gas. This is why different metal elements can mix in crystals in practically arbitrary ratios to form alloys.

Van der Waals bonds

Van der Waals bonds are familiar from the kinetic theory of gases as the forces responsible for the deviation of the behaviour of a gas from that of an ideal gas. These are attractive forces between molecules with saturated bonds. Of all the forces in crystals, they are the weakest and mostly responsible for the formation of layered structures with weak cohesion between the layers. Van der Waals forces are present in molecular crystals, in which the molecules constitute the basic structural units. The forces which make the molecules stable are either of ionic or of covalent character while the molecules themselves are bound into crystal by van der Waals forces.

Selected from "Structure and Properties of Ceramics", A.Koller, Elsevier Publ., 1994

Words and Expressions

1. cation ['kætəɪən] *n.* 阳离子
2. anion ['ænaɪən] *n.* 阴离子
3. cohesive ['kəʊhɪ:sɪv] *a.* 内聚(力)的; 聚合在一起的
4. spherically ['sfærɪkəli] *ad.* 球的; 球形的
5. isotropic [aɪsə'trɒpɪk] *a.* 均质的; 各向同性的
6. halide ['hælaɪd] *a. n.* 卤化物(的); 卤族的
7. indispensable [ˌɪndɪs'pensəbl] *a.* 必不可少的
8. vice versa ['vaɪsɪ'vɜ:sə] 反之亦然
9. singlet ['sɪŋɡlɪt] *n.* 零自旋能级
10. antiparallel [ˌæntɪ'pærəleɪt] *a.* 逆平行的; 反(向)平的
11. overlap [ˌəʊvə'læp] *vt.* 与……重叠; 与……部分一致
12. wave function 波函数
13. homeopolar [həʊmiəpələ] *a.* 相似极化
14. mutual orientation 相互取向
15. hybridization [ˌhaɪbrɪdaɪ'zeɪʃən] *n.* 杂化
16. configuration [kən'fɪɡjʊ:'reɪʃən] *n.* 构形; (电子) 排布

17. tetravalent [ˌtetrəˈveɪlənt] *a.* 四价的
18. orbital hybridation 轨道杂化
19. tetrahedron [ˌtetrəˈhɪdrən] *n.* 四面体
20. spatial orientation 空间取向
21. trigonal [ˈtraɪɡənəl] *a.* 三方的
22. pyramidal [piˈræmɪdəl] *a.* 四方锥的
23. tetragonal [teˈtræɡənəl] *a.* 正方晶的
24. bipyramidal [baɪˈpɪrəmɪdəl] *a.* 四方双锥的
25. octahedral [ˈɒktəˈhedrəl] *a.* 八面体的
26. prismatic [prɪzˈmætɪk] *a.* 斜方晶系的
27. Van der Waals force 范德华力
28. coordination number [kəʊˈɒdɪneɪʃən] 配位数

Notes

- ① 本句的主语部分为 This idea is identical with the concept of valency, 其余部分为 except 引导的介词宾语。介词宾语中又包括一个由 for which 引导的定语从句, 修饰 unified structure。该定语从句包含两个由 and 连接的并列句。参考译文: 这种观念与化合价概念完全相同, 只是没有把晶体视为分子化合物, 而把它看作一种均一的结构, 对它而言, 化学式只表示元素之间的比值, 而元素的几何排布是描述该物质的必不可少的部分。
- ② 本句的主要结构为带有两个用 that 引导的宾语从句的主从复合句, 主语为 quantum mechanical calculation, 它有一个过去分词短语作定语。第一个宾语从句中也有一个过去分词结构 composed of 修饰 energy states, 第二个宾语从句中有一个用 in which 引导的定语从句修饰 singlet state。参考译文: 亥特勒和伦敦在 1927 年用量子力学精确地计算了氢分子模型, 得出氢分子存在由原先的单原子状态构成的两种可能的最低能量状态, 其中能量更低的这种对应于电子自旋反平行取向的单一态, 又称为零自旋能级。
- ③ 该句为带有定语从句的主从复合句, where 引导的定语从句说明 orbital hybridation, 定语从句中又有一个用 so that 引导的结果状语从句, 状语从句中又有一个 that 引导的定语从句, 修饰 electrons。参考译文: 鲍林 (1931) 用轨道杂化解释此现象, 在此化合物中碳以 $1s^2 2s^1 2p^3$ 的激发态存在, 于是它有一个未成对的 s 电子与三个未成对的 p 电子, 也就是说, 总共有四个电子能形成共价键。
- ④ 本句以 where 作为引导词引出定语从句, 说明 states, 在这个定语从句中, 又有一个 which 引导的非限制性定语从句, 它不是修饰某一个先行词, 而是补充说明。参考译文: 在金属晶体中许多价电子处于与原子非紧密结合且可以在整个晶体中自由移动的状态, 这反映在金属的高电导。

Exercises

1. Translate the following expressions into Chinese or English.
cohesive force, isotropic, vice versa, quantum mechanics, hybridization of the atomic orbitals, layered structure
阳离子, 阴离子, 离子键, 共价键, 碱金属卤化物, 波函数, 电子排布 (构型), 成对电

子, 电导, 配位数

2. Translate the following sentences into Chinese.

- ① The simple valence theory is based on the idea that atoms with a small number of electron in their last shell readily lose these electrons to atoms whose last shell is almost complete .
- ② The classification of bonds into types is not absolute and, in readily, bonds with mixed character occur, such as ionic-covalent, ionic-metallic and covalent-metallic bonds (in semiconductors) .

3. Fill in the blanks with suitable words.

- ① Atoms that give electrons form _____, while atoms that accept electrons form _____.
- ② Carbon atom has _____s-electron and three _____, owing to orbital hybridization these electrons are considered as _____ in a single common state. As a consequence, the atom bonded to tetravalent carbon form _____.

4. Answer following questions.

- ① Why is the ionic bond isotropic and unsaturated?
- ② What are the main characteristics of covalent bonds? Why have they such characteristics?

Reading Material 1

Grouping of Ions and Pauling's Rules

In crystals having a large measure of ionic bond character (halides, oxides, and silicates generally) the structure is in large part determined on the basis of how positive and negative ions can be packed to maximize electrostatic attractive forces and minimize electrostatic repulsion. The stable array of ions in a crystal structure is the one of lowest energy, but the difference in energy among alternative arrays is often very slight. Certain generalizations have been made, however, which successfully interpret the majority of ionic crystal structures, which are known. These generalizations have been compactly expressed in a set of five statements known as Pauling's rules.

Pauling's first rule states that a coordination polyhedron of anions is formed about each cation in the structure. The cation-anion distance is determined by the sum of their radii. The coordination number (i.e., the number of anions surrounding the cation), is determined by the ratio of the radii of the two ions. the notion that a "radius" may be ascribed to an ion, regardless of the nature of the other ion to which it is bonded, is strictly empirical. Its justification is the fact that self-consistent sets of radii may be devised which successfully predict the interionic separations in crystals to within a few percent. The reason why the radius ratio of two species of ions influences the coordination number is apparent from Fig1.1. A central cation of given size cannot remain in contact with all surrounding anions if the radius of the anion is larger than a certain critical value. A given coordination number is thus

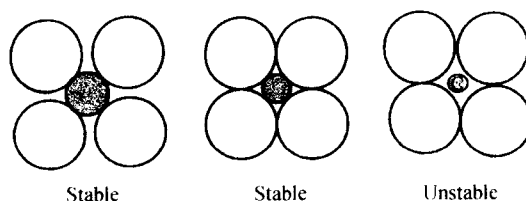


Fig.1.1 Stable and unstable coordination configurations

stable only when the ratio of cation to anion radius is greater than some critical value. In a crystal structure the anion is also surrounded by a coordination polyhedron of cations. Critical radius ratios also govern the coordination of cations about anions. Since anions are generally larger than cations, the critical radius ratio for a structure is almost always determined by the coordination of anions about the cations. This is why Pauling's first rule emphasizes the cation coordination polyhedron. For a given pair of ions, the radius ratio places an upper limit on the coordination number of the cation. In general, geometry would permit the structure to form with any one of a number of smaller coordination numbers. The stablest structure, however, always has the maximum permissible coordination number, since the electrostatic energy of an array is obviously decreased as progressively larger numbers of oppositely charged ions are brought into contact. The critical ratios are useful but are not always followed. The reason for this is that the packing considerations have considered the ions to be rigid spheres. A coordination number larger than that permitted by the radius ratio would be assumed if the electrostatic energy gained by increasing the coordination number exceeded any energy expended in deforming the surrounding ions. This consideration becomes especially important when the central cation has high charge or when the surrounding anions have a high atomic number and are large and easily deformed. Similarly, contributions of directional covalent bonding have an effect. Some experimentally observed coordination numbers are compared with predicted values in Table 1.1.

Table 1.1 Coordination Number and Bond Strength of Various Cations with Oxygen

Ion	Radius(CN = 6)	Predicted Coordination Number	Observed Coordination Number	Strength of Electrostatic Bond
B ³⁺	0.16	3	3,4	1or3/4
Be ²⁺	0.25	4	4	1/2
Li ⁺	0.53	6	4	1/4
Si ⁴⁺	0.29	4	4,6	1
Al ³⁺	0.38	4	4,5,6	3/4or1/2
Ge ⁴⁺	0.39	4	4,6	1or2/3
Mg ²⁺	0.51	6	6	1/3
Na ⁺	0.73	6	4,6,8	1/6
Ti ⁴⁺	0.44	6	6	2/3
Sc ³⁺	0.52	6	6	1/2
Ar ⁴⁺	0.51	6	6,8	2/3or1/2
Ca ²⁺	0.71	6,8	6,7,8,9	1/4
Ce ⁴⁺	0.57	6	8	1/2
K ⁺	0.99	8,12	6,7,8,9,10,12	1/9
Cs ⁺	1.21	12	12	1/12

The first rule focuses attention on the cation coordination polyhedron as the basic building block of an ionic structure. In a stable structure such units are arranged in a three-dimensional array to optimize second-nearest-neighbour interactions.

A stable structure must be electrically neutral not only on a microscopic scale but also at the atomic level. Pauling's second rule describes a basis for evaluating local electrical neutrality. We define the strength of an anion as the formal charge on the cation divided by its coordination number. For example, silicon, with valence 4 and tetrahedral coordination, has bond strength $4/4 = 1$; Al^{3+} with octahedral coordination has bond strength $3/6 = 1/2$. (The same considerations are applied regardless of whether all coordinating anions are the same chemical species; the bond strength of Al^{3+} is $1/2$ in both the structure of Al_2O_3 , where the six anion neighbors are O^{2-} , and that of kaolinite, where the anions surrounding Al^{3+} are 4OH^- and 2O^{2-} . The second rule states that in a stable structure the total strength of the bonds reaching an anion from all surrounding cations should be equal to the charge of the anion. For example, in the Si_2O_7 unit, two bonds of strength 1 reach the shared oxygen ion from the surrounding silicon ions; the sum of the bonds is thus 2, the valence of the oxygen ion. (Note that this implies that, in a silicate based on Si_2O_7 units, no additional cation may be bonded to this shared oxygen.) Similarly in the structure of spinal MgAl_2O_4 , each O^{2-} is surrounded by one Mg^{2+} which donates a bond of strength $2/4$ and three Al^{3+} which donate three bonds of strength $3/6$.

Pauling's third rule further concerns the linkage of the cation coordination polyhedra. In a stable structure the corners, rather than the edges and especially the faces, of the coordination polyhedra tend to be shared. If an edge is shared, it tends to be shortened. The basis of this rule is again geometrical. The separation of the cations within the polyhedron decreases as the polyhedra successively share corners, edges, and faces and the repulsive interaction between cations accordingly increases. Pauling's fourth rule states that polyhedra formed about cations of low coordination number and high charge tend especially to be linked by corner sharing. That this is true may be appreciated by recognizing that the repulsive interaction between a pair of cations increases as the square of their charge and that the separation of cations within a coordination polyhedron decreases as the coordination number becomes smaller. A fifth rule states that the number of different constituents in a structure tends to be small. This follows from the difficulty encountered in efficiently packing into a single structure ions and coordination polyhedra of different sizes.

Selected from "Introduction to Ceramics" 2nd Edition, W.D. Kingery, John Wiley & Sons, 1976

Words and Expressions

1. coordination polyhedron 配位多面体
2. empirical [em'pirikəl] a. 经验的
3. critical value 临界值
4. permissible [pə'misəbl] a. 容许的; 许可的

5. deform [di'fɔ:m] *vt.* 使变形；破坏……的外形
6. basic building block 基本组成部分
7. bond strength 键强
8. second-nearest-neighbour 次近邻
9. spinel [spi'nel] *n.* 尖晶石
10. linkage ['liŋkidʒ] *n.* 键合；联结