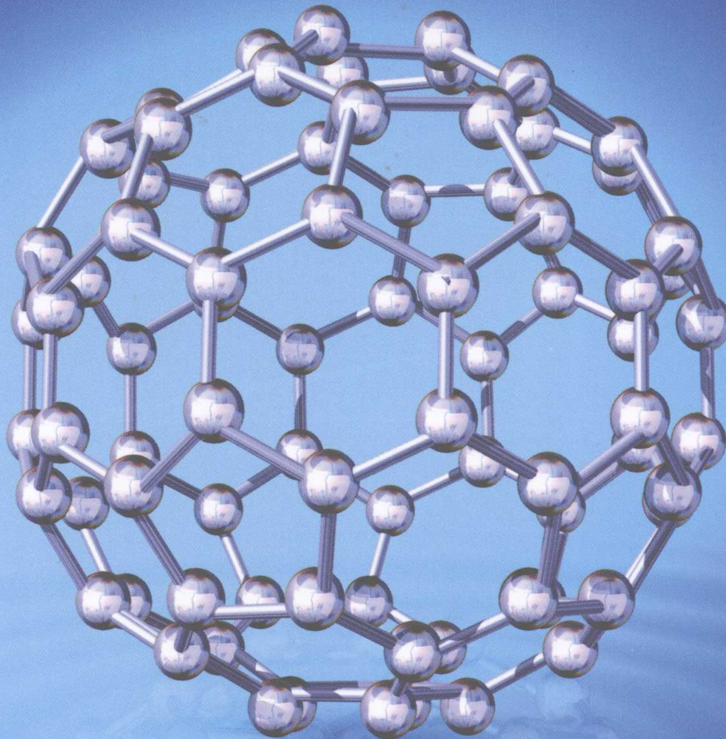

高等学校教材

化学化工专业英语

杨定乔　龙玉华　王升富　编

化学工业出版社

高等学校教材

化学化工专业英语

杨定乔　龙玉华　王升富　编

化学工业出版社

·北京·

本书内容选自近年来美国、英国最新出版的大学化学和化工专业教学用书、其它相关正规出版物及IUPAC（国际纯粹化学和应用化学联合会）化学命名法。选材范围广，词汇较全面。内容涉及无机化学、有机化学、分析化学、物理化学、金属有机化学、化学热力学、高分子化学、杂环化学、不对称合成及实验等。文章内容丰富，语言难度适中，编排深入浅出，循序渐进。每课除正文外，还附有词汇、词组和练习题。此外，书后还附有英语常用词头和词尾、化学化工常用英文缩写与符号、总词汇表，便于读者查阅和自学。

本书适于作高等院校化学、化工、药物化学、环境化学及相关专业高年级学生的专业英语教材，也可作为这些专业的研究生以及从事化学和化工领域的教学、科研和工程技术人员的参考书。

图书在版编目（CIP）数据

化学化工专业英语/杨定乔，龙玉华，王升富编．—北京：化学工业出版社，2008.1
高等学校教材
ISBN 978-7-122-01751-2

Ⅰ．化…　Ⅱ．①杨…②龙…③王…　Ⅲ．①化学-英语-高等学校-教材②化学工业-英语-高等学校-教材　Ⅳ．H31

中国版本图书馆CIP数据核字（2007）第202060号

责任编辑：成荣霞　　文字编辑：林　媛
责任校对：战河红　　装帧设计：韩　飞

出版发行：化学工业出版社（北京市东城区青年湖南街13号　邮政编码100011）
印　　刷：北京市振南印刷有限责任公司
装　　订：三河市前程装订厂
720mm×1000mm　1/16　印张$11\frac{1}{2}$　字数273千字　2008年2月北京第1版第1次印刷

购书咨询：010-64518888（传真：010-64519686）　售后服务：010-64518899
网　　址：http://www.cip.com.cn
凡购买本书，如有缺损质量问题，本社销售中心负责调换。

定　　价：21.00元

前　言

随着化学、化工领域的快速发展，全社会对化学、化工人才的素质尤其是通过英文文献获取和共享信息资源的能力，以及与国外同行进行口语交流的能力，要求也越来越高。为此，华南师范大学化学与环境学院组织相关教师，通过总结多年的专业英语教学经验，联合编写了这部教材。本教材内容选自近年来美国、英国最新出版的大学化学和化工专业教学用书、其它相关正规出版物及 IUPAC（国际纯粹化学和应用化学联合会）化学命名法，主要特点如下：

（1）选材丰富，具有时代感，学生通过学习可以了解到化学、化工专业的新发展和新理念。全书分两个部分，第一部分以无机化学为主，涵盖无机化学、分析化学、无机化学实验等方面的知识；第二部分以有机化学为主，涵盖有机化学、高分子化学、金属有机化学、化学热力学、杂环化学、绿色化学、不对称合成化学、离子液体化学、有机化学实验等方面的知识。

（2）专业词汇量大。书中涵盖专业英语词汇 3000 个左右，掌握这些词汇以后，可较熟练地阅读各类化学、化工英语期刊图书和其它文献，对于撰写英语论文也有很大帮助。

（3）专业英语单词配有相应音标。专业英语词汇特别是有机化学（化工）专业英语词汇，难发音，音标可以帮助词汇的记忆和掌握。

（4）每课除正文外，还附有词汇、词组和练习题，练习题设计恰当，实用易学。书后还附有英语常用词头和词尾、化学化工常用英文缩写与符号、总词汇表，便于读者查阅和自学。

本书由杨定乔、龙玉华、王升富合编。蓝葆春教授主审了全部稿件，有机合成课题组研究生王欢、张振明、罗人仕、胡萍、梁丽华、夏泽中、张刚对本书的编排做了大量工作，特此表示衷心的感谢。另外，本书的编写和出版得到了化学工业出版社的大力支持，同样表示衷心的感谢。由于编者水平有限，书中疏漏与不妥之处在所难免，恳请读者和同仁提出宝贵意见并批评指正。

编　者

2008 年 1 月于广州

CONTENTS

PART I

1 The Physical Properties of Substances

The study of the properties of substances constitutes an important part of chemistry, because their properties determine the uses to which they can be put.

The properties of substances are their characteristic qualities.

The physical properties are those properties of a substance that can be observed without changing the substance into other substances.

Let us again use sodium chloride, common salt, as an example of a substance. We have all seen this substance in what appear to be different forms—table salt, in fine grains; salt in the form of crystals a quarter of an inch or more across. Despite their obvious difference, all of these samples of salt have the same fundamental properties. In each case the crystals, small or large, are naturally bounded by square or rectangular crystal faces of different sizes, but with each face always at right angles to each adjacent face. The cleavage of the different crystals of salt is the same: when crushed, the crystals always break (cleave) along planes parallel to the original faces, producing smaller crystals similar to the larger ones. The different samples, dissolved in water, have the same salty taste. Their solubility is the same: at room temperature 36 g of salt can be dissolved in 100 g of water. The density of the salt is the same, $2.16 g \cdot cm^{-3}$. The density of a substance is the mass (weight) of a unit volume (1 cubic centimeter) of the substance.

There are other properties besides density and solubility that can be measured precisely and expressed in numbers. Such another property is the melting point, the temperature at which a solid substance melts to form a liquid. On the other hand, there are also interesting physical properties of a substance that are not so simple in nature. One such property is the malleability of a substance—the ease with which a substance can be hammered out into thin sheets. A related property is the ductility—the ease with which the substance can be drawn into a wire. Hardness is a similar property: we say that one substance is less hard than the second substance when it is scratched by the second substance. The color of a substance is an important physical property.

It is customary to say that under the same external conditions all specimens of a particular substance have the same physical properties (density, hardness, color, melting point, crystalline form, etc). Sometimes, however, the word substance is used in referring to a material without regard to its state. For example, ice, liquid water, and water vapor may be referred to as the same substance. Moreover, a specimen containing crystals of rock salt and crystals of table salt may be called a mixture, even though the specimen may consist entirely of one substance, sodium chloride. This lack of definiteness in usage seems to cause no confusion in practice.

Vocabulary

property [ˈprɔpəti] *n.* 性质；特性
cleave [kliːv] *vt.* 劈开；裂开
constitute [ˈkɔnstitjuːt] *vt.* 构成；组成
plane [plein] *n.* 平面
characteristic [ˈkæriktəˈristik] *a.* 特有的；*n.* 特性
parallel [ˈpærəlel] *a.* 平行的
original [əˈridʒənl] *a.* 原来的
quality [ˈkwɔliti] *n.* 质量；品质
dissolve [diˈzɔlv] *vt.* 溶解
observe [əbˈzəːv] *vt.* 观察
taste [teist] *vt.* 尝味道；*n.* 滋味
sodium [ˈsəudjəm] *n.* 钠
solubility [sɔljuˈbiliti] *n.* 溶解度
chloride [ˈklɔːraid] *n.* 氯化物
sodium chloride 氯化钠
density [ˈdensiti] *n.* 密度
volume [ˈvɔljum] *n.* 体积
salt [sɔːlt] *n.* 盐
cubic [ˈkjuːbik] *a.* 立方（体）的
appear [əˈpiə] *vt.* 出现；看来（好像）
precisely [priˈsaisli] *a.* 精确地
fine [fain] *a.* 细的
melt [melt] *vt.* & *vi.* 熔化，熔解
grain [grein] *n.* 颗粒
melting point 熔点
crystal [ˈkristl] *n.* 结晶；晶体
malleability [mæliəˈbiliti] *n.* 可锻性；展性
diameter [daiˈæmitə] *n.* 直径
freeze [friːz] (froze [frəuz], frozen [ˈfrəuzn]) *v.* 结冰；*n.* 凝固
sheet [ʃiːt] *n.* 薄片
related [riˈleitid] *a.* 有联系的；相关的
ductility [dʌkˈtiliti] *n.* 延性；延度
across [əˈkrɔs] *ad.* 横过；宽
draw [drɔː] (drew [druː], drawn [drɔːn]) *vt.* 拉
despite [disˈpait] *prep.* 不管；尽管
wire [waiə] *n.* 金属线
obvious [ˈɔbviəs] *a.* 明显的
scratch [skrætʃ] *vt.* 搔；抓；*n.* 刮痕
sample [ˈsæmpl] *n.* 样品；实例
customary [ˈkʌstəməri] *a.* 通常的；惯常的
fundamental [fʌndəˈmentl] *a.* 基本的
bound [baund] *vt.* 邻接；*n.* [常用复数] 界限
external [eksˈtəːnl] *a.* 外部的；外界的
square [skwɛə] *n.* 正方形
specimen [ˈspesimin] *n.* 样品；品种
rectangular [rekˈtæŋgjulə] *a.* 矩形的
particular [pəˈtikjulə] *a.* 特别的
size [saiz] *n.* 大小；尺寸
crystalline [ˈkristəlain] *a.* 结晶的
angle [æŋgl] *n.* 角；角度
right angle 直角
vapor [ˈveipə] *n.* （蒸）气
moreover [mɔːˈrəuvə] *ad.* 再者；此外
adjacent [əˈdʒeisənt] *a.* 临近的
contain [kənˈtein] *vt.* 含有；包括
cleavage [ˈkliːvidʒ] *n.* 分裂；分解、裂开
entirely [inˈtaiəli] *ad.* 完全地
crush [krʌʃ] *vt.* 压碎；压扁

definiteness ['definitnis] *n.* 明确
usage ['ju:zidʒ] *n.* 用法
substance ['sʌbstəns] *n.* 物质
mixture ['mikstʃə] *n.* 混合物

Phrases

(to) put to use 使用
parallel to 与……平行的
(to)change... into... 把……改变成……
similar to 与……相似的
in the form of 以……形式
on the other hand 另一方面
a quarter of 四分之一
without regard to 不考虑；不顾到
in each case 在每一种情况下
even though 即使
be bounded by 被……限制；与……相邻接

Exercises

1. Put the following into English.

a. 物理性质
b. 溶解度
c. 密度
d. 硬度
e. 展性
f. 熔点
g. 沸点

2. Translate the following into Chinese.

There are other properties besides density and solubility that can be measured precisely and expressed in numbers. Such another property is the melting point, the temperature at which a solid substance melts to form a liquid. On the other hand, there are also interesting physical properties of a substance that are not so simple in nature. One such property is the malleability of a substance—the ease with which a substance can be hammered out into thin sheets. A related property is the ductility—the case with which the substance can be drawn into a wire. Hardness is a similar property: we say that one substance is less hard than the second substance when it is scratched by the second substance. The color of a substance is an important physical property.

2 The Chemical Properties of Substances

2.1 The Chemical Properties of Substances

The chemical properties of a substance are those properties that relate to its participation in chemical reactions.

Chemical reactions are the processes that convert substances into other substances.

Thus sodium chloride has the property of changing into a soft metal, sodium, and a greenish-yellow gas, chlorine, when it is decomposed by passage of an electric current through it. It also has the property, when it is dissolved in water, of producing a white precipitate when a solution of silver nitrate is added to it, and it has many other chemical properties.

Iron has the property of combining readily with the oxygen in moist air to form iron rust; whereas an alloy of iron with chromium and nickel (stainless steel) is found to resist this process of rusting. It is evident from this example that the chemical properties of materials are important in engineering.

Many chemical reactions take place in the kitchen. When biscuits are made with use of sour milk and baking soda there is a chemical reaction between the baking soda and a substance in the sour milk, lactic acid, to produce the gas carbon dioxide, which leavens the dough by forming small bubbles in it. And, of course, a great many chemical reactions take place in the human body. Foods that we eat are digested in the stomach and intestines. Oxygen in the inhaled air combines with a substance, hemoglobin, in the red cells of the blood, and then is released in the tissues, where it takes part in many different reactions. Many biochemists and physiologists are engaged in the study of the chemical reactions that take place in the human body.

Most substances have the power to enter into many chemical reactions. The study of these reactions constitutes a large part of the study of chemistry. Chemistry may be defined as the science of substances-their structure, their properties, and the reactions that change them into other substances.

2.2 Chemical Changes and Physical Changes

Different kinds of matter have different physical and chemical properties. The properties of a substance are its characteristics. We know one substance from another by their physical and chemical properties. In a physical change the composition of a substance is not changed. Ice can be changed into water. This is a physical change because the composition of water is not changed. In a chemical change the composition of a substance is changed. One or more new substances are formed.

Iron rusts in moist air. When iron rusts, it unites with the oxygen from the air. A new substance is formed. It is iron oxide. It has other different properties. Wood will burn if it is heated in air. When wood burns, it reacts with the oxygen from the air. New substances are formed. They are carbon dioxide and water. Carbon dioxide and water have different properties. Heat is given off if the combustion of any fuel takes place.

The above two cases are chemical changes.

Chemical changes are very common. They are going on around us all the time. Whenever anything burns, there is a chemical change. When iron rusts, the change is a chemical change. A chemical change goes on when things decay.

Physical changes are very common, too. Tearing a piece of paper in two is a physical change. The paper is still paper.

We all know that this is not a chemical change. But we do not always know with ease whether a change is a chemical change or a physical change.

If you dissolve sugar in water, the sugar disappears. You may think that a new material has been formed. But really there is no new material. The sugar is still sugar. You can still taste it. Dissolving anything is a physical change.

When water freezes, the change is a physical change. The water changes from a liquid to a solid. Its chemical formula is still H_2O. The freezing of any liquid is a physical change.

In a word, any change in state is a physical change. When anything melts, it changes from a solid to a liquid. When it evaporates, it changes from a solid or a liquid to a gas. When it condenses, it changes from a gas to a liquid or a solid. But it is the same material still.

Now we see that a chemical change is different from a physical change in that the chemical change causes a change of matter in chemical composition, but the physical change does not.

Vocabulary

participation [paːtisiˈpeiʃən] *n.* 参与
silver [ˈsilvə] *n.* 银; *a.* 银（白）色的
reaction [riˈækʃən] *n.* 反应
nitrate [ˈnaitreit] *n.* 硝酸盐
silver nitrate 硝酸银
process [ˈprəuses] *n.* 过程
convert [kənˈvəːt] *vt.* 转换；转化
add [æd] *vt.* （添）加
greenish-yellow [ˈgriːniʃˈjeləu] *a.* 黄绿色的
iron [ˈaiən] *n.* 铁
chlorine [ˈklɔːriːn] *n.* 氯（气）
combine [kəmˈbain] *vt.* &*vi.* （使）结合
decompose [diːkəmˈpəuz] *vi.* 分解；分析
readily [ˈredili] *ad.* 容易地
passage [ˈpæsidʒ] *n.* 通过
oxygen [ˈɔksidʒən] *n.* 氧
current [ˈkʌrənt] *n.* 电流
moist [mɔist] *a.* 潮湿的
precipitate [priˈsipiteit] *vt.* &*vi.* （使）沉淀；*n.* 沉淀物
rust [rʌst] *n.* 铁（锈）
alloy [ˈælɔi] *n.* 合金
solution [səˈljuːʃən] *n.* 溶液
chromium [ˈkrəumiəm] *n.* 铬
nickel [ˈnikl] *n.* 镍
release [riːˈliːs] *vt.* 放出
stainless [ˈsteinlis] *a.* 不锈的
tissue [ˈtisjuː] *n.* 组织
resist [riˈzist] *vt.* 抵抗；阻挡
biochemist [baiəuˈkemist] *n.* 生物化学家
evident [ˈevidənt] *a.* 明显的
engineering [endʒiˈniəriŋ] *n.* 工程（学）
physiologist [fiziˈɔlədʒist] *n.* 生理学家
biscuit [ˈbiskit] *n.* 饼干
engage [inˈgeidʒ] *vt.* [in] 使从事
sour [ˈsauə] *a.* 酸的
define [diˈfain] *vt.* 规定；下定义
bake [beik] *vt.* 烘；烤
boil [bɔil] *vt.* 煮沸
soda [ˈsəudə] *n.* 苏打；碳酸水
burn [bəːn] *vt.* 燃烧
lactic [læktik] *a.* 乳汁的
lactic acid 乳酸
syrup [ˈsirəp] *n.* 糖浆
formation [fɔːˈmeiʃən] *n.* 形成
leaven [ˈlevən] *vt.* 使发酵

manufacture [mænju'fæktʃə] *n.* 制造
dough [dəu] *n.* 生面团
evaporation [ivæpə'reiʃən] *n.* 蒸发
bubble ['bʌbl] *n.* 气泡
human ['hju:mən] *a.* 人类的
unit [ju:'nait] *v.* 结合；化合；团结
digest [di'dʒest] *vt.* 消化
oxide ['ɔksaid] *n.* 氧化物
stomach ['stʌmək] *n.* 胃
iron oxide 氧化铁；三氧化二铁
intestine [in'stestin] *n.* （常用复）肠
carbon ['ka:bən] *n.* 碳
inhale [in'heil] *vt.* 吸入
dioxide [dai'ɔksaid] *n.* 二氧化物
hemoglobin [hi:məu'gləubin] *n.* 血红蛋白
carbon dioxide 二氧化碳
cell [sel] *n.* 细胞
combustion [kəm'bʌstʃən] *n.* 燃烧
blood [blʌd] *n.* 血液
formula ['fɔ:mjulə] *n.* 公式；分子式

Phrases

(to) convert...into... 把……转化成
unit...with... 使……同……化合
unit with... 与……化合（或结合、联合）
(to) add to 增加；加入
(to) combine with 与……化合（或联合）
react with... 与……起反应
(to) take place 发生
tear...in two 把……撕成两（块）
be engaged in 正做着；正忙于
in a word 总而言之；总之
(to) enter into 进入
(to) define... as 把……解释为；给……下定义为……
a large part of 大部分的

Exercises

1. Put the following into English.

a. 化学性质
b. 化学反应
c. 燃烧
d. 分子式
e. 乳酸
f. 硝酸银
g. 二氧化碳
h. 氧化铁

2. Which of the following processes would you class as chemical reactions?

a. The boiling of water.
b. The burning of paper.
c. The preparation of sugar syrup by adding sugar to hot water.
d. The formation of rust on iron.
e. The manufacture of salt by evaporation of sea water.

3. Translate the following into Chinese.

Thus sodium chloride has the property of changing into a soft metal, sodium, and a greenish-yellow gas, chlorine, when it is decomposed by passage of an electric current through it. It also has the property, when it is dissolved in water, of producing a white precipitate when a solution of silver nitrate is added to it, and it has many other chemical properties.

3 Oxidation Numbers of Atoms

The nomenclature of inorganic chemistry is based upon the assignment of numbers (positive or negative) to the atoms of the elements. These numbers, called oxidation numbers, are defined in the following way.

The oxidation number of an atom is a number that represents the electric charge that the atom would have if the electrons in a compound were assigned to the atoms in a certain conventional way.

The assignment of electrons is somewhat arbitrary, but the conventional procedure, described below, is useful because it permits a simple statement to be made about the valences of the elements in a compound without considering its electronic structure in detail and because it can be made the basis of a simple method of balancing equations for oxidation-reduction reactions.

An oxidation number may be assigned to each atom in a substance by the application of simple rules. These rules, though simple, are not completely unambiguous. Although their application is usually a straight-forward procedure, it sometimes requires considerable chemical insight and knowledge of molecular structure. The rules are given in the following statements.

(1) The oxidation number of a monatomic ion in an ionic substance is equal to its electric charge.

(2) The oxidation number of a atom in an elementary substance is zero.

(3) In a covalent compound of known structure the oxidation number of each atom is the charge remaining on the atom when each shared electron pair is assigned completely to the more electronegative of the two atoms sharing it. An electron pair shared by two atoms of the same element is usually split between them.

(4) The oxidation number of an element in a compound of uncertain structure may be calculated from a reasonable assignment of oxidation numbers to the other elements in the compound.

The application of the first three rules is illustrated by the following examples; the number by the symbol of each atom is the oxidation number of that atom:

$Na^{+1}Cl^{-1}$	$Mg^{+2}(Cl^{-1})_2$	$(B^{+3})_2(O^{-2})_3$
H_2^0	O_2^0	C^0 (diamond or graphite)
H^{+1} (hydrogen cation)		$(O^{-2}H^{+1})^-$ (hydroxide ion)
$N^{-3}(H^{+1})_3$	$Cl^{+1}F^{-1}$	$C^{+4}(O^{-2})_2$
$C^{+2}O^{-2}$	$C^{-4}(H^{+1})_4$	$K^{+1}Mn^{+7}(O^{-2})_4$

Fluorine, the most electronegative element, has the oxidation number -1 in all of its compounds with other elements.

Oxygen is second only to fluorine in electronegativity, and in its compounds it usually has oxidation number -2; examples are $Ca^{+2}O^{-2}$, $(Fe^{+3})_2(O^{-2})_3$, $C^{+4}(O^{-2})_2$. Oxygen fluoride, OF_2, is an exception; in this compound, in which oxygen is combined with the only element that is more electronegative than it is, oxygen has the oxidation number $+2$. Oxygen has oxidation number -1 in hydrogen peroxide, H_2O_2, and other peroxides.

Hydrogen when bonded to a nonmetal has oxidation number $+1$, as in $(H^{+1})_2O^{-2}$, $(H^{+1})_2S^{-2}$, $N^{-3}(H^{+1})_3$, $(P^{-2})_2(H^{+1})_4$. In compounds with metals, such as $Li^{+1}H^{-1}$ and $Ca^{+2}(H^{-1})_2$, its oxidation number is -1, corresponding to the electronic structure $H:^{-1}$ for a negative hydrogen ion with completed K shell (helium structure).

Vocabulary

oxidation [ɔksi'deiʃən] *n.* 氧化
oxidation number 氧化值
considerable [kən'sidərəbl] *a.* 相当的；不少的
nomenclature [nəu'menklətʃə] *n.* 命名法
insight ['insait] *n.* 见识；见解
monatomic [mɔnə'tɔmik] *a.* 单原子的
inorganic [inɔː'gænic] *a.* 无机的
ionic [ai'ɔnik] *a.* 离子的
assignment [ə'sainmənt] *n.* 指定；分配
elementary [eli'mentəri] *a.* 基本的；初等的
represent [riːpri'zent] *vt.* 说明；代表
compound ['kɔmpaund] *n.* 化合物
covalent [kəu'veilənt] *a.* 共价的
assign [ə'sain] *vt.* 指定；分配
share [ʃεə] *vt.* 共有；分担
conventional [kən'venʃənl] *a.* 常规的；惯例的
electron pair [i'lektrən'pεə] 电子对
electronegative [i'lektrəu'negətiv] *a.* 电负性的
somewhat ['sʌmwɔt] *ad.* 有点；稍微
arbitrary ['aː bitrəri] *a.* 任意的；武断的
split [split] *vt.* 割裂；分裂
procedure [prə'siːdʒə] *n.* 程序
reasonable ['riːznəbl] *a.* 合理的
describe [dis'kraib] *vt.* 描述；叙述
illustrate ['iləstreit] *vt.* 说明
permit [pə'mit] *vt.* 准许
symbol ['simbəl] *n.* 记号；符号
valence ['veiləns] *n.* 价（如原子价，化合价，效价）
fluorine ['flu(ː)əriːn] *n.* 氟
peroxide [pə'rɔksaid] *n.* 过氧化物
detail ['diːteil] *n.* 详情；细节
bond [bənd] *n.* 链；*v.* 连接；结合
application [æpli'keiʃən] *n.* 应用
nonmetal ['nɔn'metl] *n.* 非金属
unambiguous ['ʌnæm'bigjuəs] *a.* 清楚的；明确的
shell [ʃel] *n.* 壳；层
straightforward [streit'fɔːwəd] *a.* 直截了当的；简单的；容易的

Phrases

(be) based (up)on 以……为根据
in detail 详细地
corresponding to 符合；与……一致

Exercises

1. Write the oxidation number of each atom in the following compounds.

a. KCl
b. $CaCl_2$
c. Al_2O_3
d. N_2
e. Fe
f. Na_2O_2
g. $K_2Cr_2O_7$
h. CaF_2
i. Fe_3O_4
j. $LiAlH_4$

2. Translate the following into Chinese.

Oxygen is second only to fluorine in electronegativity, and in its compounds it usually has oxidation number -2; examples are $Ca^{+2}O^{-2}$, $(Fe^{+3})_2(O^{-2})_3$, $C^{+4}(O^{-2})_2$. Oxygen fluoride, OF_2, is an exception; in this compound, in which oxygen is combined with the only element that is more electronegative than it is, oxygen has the oxidation number $+2$. Oxygen has oxidation number -1 in hydrogen peroxide, H_2O_2, and other peroxides.

4 Chemical Calculations

Importance to industry of chemical calculation. To the industrial chemist the chemical equation is of the greatest importance. By means of it he calculates just how much material he needs for a given reaction and how large an amount of product he may hope to get. In actual practice, however, he very seldom gets the full amount of the product as calculated from the equation. Therefore he computes the efficiency of his industrial process, i. e. what fraction the actual yield is of the theoretical yield as computed from the chemical equation. These computations are all based on the chemical equations of the reactions and require only the simplest arithmetical work. They can be classified into several typical cases.

Type 1. molecular weight of a compound from its formula. A formula represents not only the name of the compound but also the weight of a molecule referred to the oxygen atom as 16. To compute the molecular weight of a compound from its formula, we have only to add the weights of all the atoms in the molecule. But since the atomic weights are only relative weights, the molecular weight must be relative also.

For example, the molecular weight of calcium carbonate ($CaCO_3$) is $40+12+(16\times3)$, or 100. Again, the molecular weight of copper sulfate ($CuSO_4$) is $63.6+32+(16\times4)$, or 159.6.

Another example. Find the molecular weight of gypsum ($CaSO_4\cdot 2H_2O$). Now gypsum is crystallized into calcium sulfate, and each molecule of calcium sulfate carries along two molecules of water. This so-called *water of hydration* or of crystallization is chemically united with the calcium sulfate, as is indicated by the dot in the formula, which means in this place *plus*. The molecular weight then of $CaSO_4 \cdot 2H_2O$ is 40+32+(16×4)+2(2+16), or 172.

Perhaps a better term for molecular weight is formula weight because it more accurately describes what it actually is.

Type 2. Percentage composition of a compound from its formula. If the chemist knows the formula of a compound and has a table of atomic weights, he can easily work out the percentage of each element present in the compound.

For example, he wishes to find the percentage composition of calcium carbonate ($CaCO_3$). The atomic weight of calcium is 40, of carbon is 12, and of oxygen is 16; 40+12+(16×3) make the formula weight 100. Therefore calcium carbonate contains 40/100, or 40 percent calcium, 12/100, or 12 percent carbon, and 48/100, or 48 percent oxygen. This problem is especially easy because the formula weight is equal to 100.

Another example. Find the percentage composition of potassium chlorate ($KClO_3$). The atomic weight of potassium is 39, of chlorine 35.5, and of oxygen 16, then the formula weight is 39+35.5+(16×3), or 122.5. Therefore potassium chlorate contains

$$\frac{39}{122.5}=0.318,\ \text{or } 31.8\%\ \text{potassium,}$$

$$\frac{35.5}{122.5}=0.290,\ \text{or } 29.0\%\ \text{chlorine, and}$$

$$\frac{48}{122.5}=0.392,\ \text{or } 39.2\%\ \text{oxygen}$$

Check. Total is 100.0%.

Still another example. How much metallic copper can be got from a ton (2000 lbs.) of crystallized copper sulfate? Given the formula of copper sulfate crystals as $CuSO_4 \cdot 5H_2O$. The formula weight of this compound is 63.6+32+(16×4)+5(2+16), or 249.6.

The percentage of copper is 63.6/249.6 = 0.255, or 25.5 percent, and the weight of copper in a ton of copper sulfate crystals is 0.255×2000, or 510 lbs.

In general, to find the percentage composition of a compound from its formula, first calculate the formula weight, then divide the atomic weight of each element by this formula weight, and express the quotient as a decimal. Keep three significant figures. The first two decimals express the percentage.

Type 3. Problems involving weight only. For example, what weight of iron will be just enough to unite with 10 grams of sulfur to form iron sulfide (FeS)?

To avoid mistakes it is well to arrange the work very clearly and to do it methodically.

We first write the equation:

$$Fe+S \longrightarrow FeS$$

Then we write under each symbol and formula the weight it represents:

$$\begin{array}{ccc} Fe + & S \longrightarrow & FeS \\ 56 & 32 & 88 \end{array}$$

This means that 56 parts by weight of iron combine with 32 parts by weight of sulfur to give 88 parts by weight of iron sulfide. We have here quantitative meaning of the equation.

Next, we again read the problem and place above the symbol for sulfur the actual weight given, which is 10g, and above the formula for iron X g, which is the weight we wish to find:

$$\begin{array}{ccc} X\text{ g} & 10\text{g} & \\ Fe + & S \longrightarrow & FeS \\ 56 & 32 & 88 \end{array}$$

Finally we state the equation between the ratios of the actual to the formula weights thus:

$$\frac{X}{56} = \frac{10}{32}$$

Hence $$X = \frac{56 \times 10}{32}, \text{ or } 17.5 \text{ grams of iron}$$

Now we shall check up the reasonableness of our answer by roughly estimating what it ought to be. In this case we know that 56 parts of iron will unite with 32 parts of sulfur. Therefore we shall need about seven-fourths as much iron as the sulfur with which we started. Hence our answer 17.5 is reasonable. In this way we may quickly detect such a mistake as the misplacing of a decimal point or the inverting of a fraction.

Another example. Suppose we want to calculate what weight of iron sulfide (FeS) can be made from 10 grams of sulfur, assuming that the necessary iron is available.

$$\begin{array}{ccc} & 10\text{g} & X\text{ g} \\ Fe + & S \longrightarrow & FeS \\ & 32 & 88 \end{array}$$

$$\frac{X}{88} = \frac{10}{32}$$

$$X = \frac{88 \times 10}{32} = 27.5 \text{ grams of iron sulfide}$$

Check. Wt. of iron(17.5) + wt. of sulfur (10g) = wt. of iron sulfide (27.5g)

Another method of attack. We know that 32 grams of sulfur yield 88 grams of iron sulfide (FeS) when properly combined with sufficient iron. Then 1 gram of sulfur would yield 1/32 of 88 grams of iron sulfide and 10 grams of sulfur would yield 10 times 1/32 of 88 grams i. e., $\frac{88 \times 10}{32}$, or 27.5 grams.

The arithmetical computation amounts to the same as that given above, but the