新世纪

新世纪应用型高等教育
化工类课程规划教材

化学化工专业英语

新世纪应用型高等教育教材编审委员会 组编
主编 赵丽 白林

大连理工大学出版社

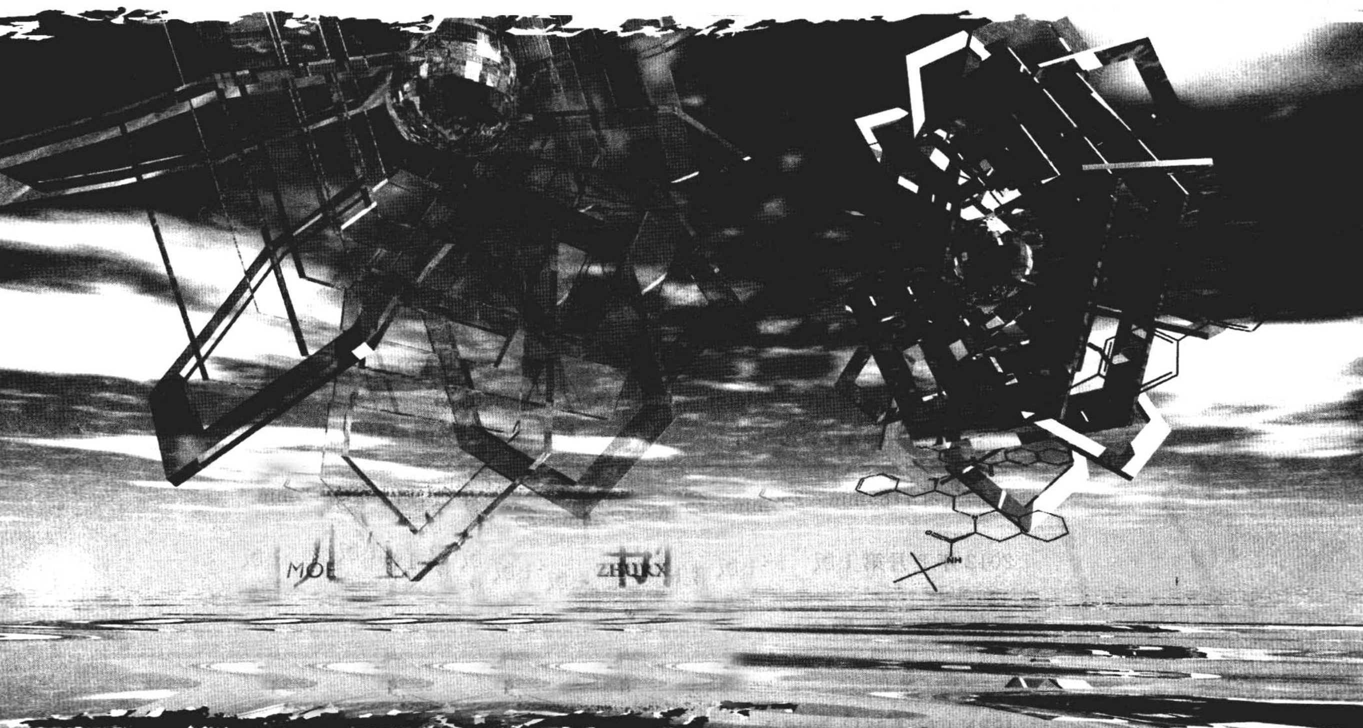
新世纪应用型高等教育
化工类课程规划教材

化学化工专业英语

HUAXUE HUAGONG ZHUANYE YINGYU

新世纪[redacted]用型高等教育教材编审委员会 组编

主编 赵丽 白林



大连理工大学出版社

图书在版编目(CIP)数据

化学化工专业英语 / 赵丽，白林主编. — 大连：大连理工大学出版社，2012.8

新世纪应用型高等教育化工类课程规划教材

ISBN 978-7-5611-7213-1

Ⅰ. ①化… Ⅱ. ①赵… ②白… 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. ①H31

中国版本图书馆 C[redacted]据核字(2012)第 189589 号

大连理工大学出版社出版

地址：大连市软件园路 80 号　邮政编码：116023

发行：0411-84708842　邮购：0411-84703636　传真：0411-84701466

E-mail：dutp@dutp.cn　URL：http://www.dutp.cn

大连业发印刷有限公司印刷　　大连理工大学出版社发行

幅面尺寸：185mm×260mm　印张：13.75　字数：313 千字

印数：1～1500

2012 年 8 月第 1 版　　2012 年 8 月第 1 次印刷

责任编辑：陈　畅　　责任校对：梁牧华

封面设计：张　莹

ISBN 978-7-5611-7213-1　　定　价：32.00 元

前　言

大学专业英语承担着“指导学生阅读有关专业的英语文献和英语书刊，使学生进一步提高阅读英语科技资料的能力，并能以英语为工具，获取专业所需的信息”的任务，专业英语既是基础英语的延伸，又是基础英语与专业教学的结合与实践，是提高大学生专业英语应用能力的一个重要教学环节。专业英语的重要性表现在多个方面：第一，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得信息资源的能力，以及与国外同行进行口头交流的能力的要求越来越高。在本科生就业时，英语能力尤其是专业英语的应用能力，是许多用人单位挑选毕业生的一项重要指标。第二，从目前国内形势来看，学好专业英语对本科生继续深造很有必要，许多院校已将专业英语纳入研究生入学面试内容。第三，在当前的出国热潮中，有英语基础，尤其是专业英语基础，将有助于出国生尽快融入学习、生活和工作中，对他们在国外的发展非常有利。

编者长期从事化学专业的基础教学与科研工作，近年来又从事专业英语、有机化学双语、文献检索与论文写作等课程的教学工作，在教学中对学生学习和应用英语的艰辛颇有感触，学生往往耗费了大量的时间和精力，结果却不尽如人意。原因之一与应试教育异化了学习英语的目的有着千丝万缕的联系，另一方面是化学专业英语的教材建设是一个薄弱环节。同样是化学化工专业英语，不同教材在内容上差异很大，有的比较重视化学基本理论和基本原理部分，对化工则一带而过，化学实验部分甚至没有；有的则偏重无机化学和有机化学而疏忽其他二级学科。这是缘于不同作者对基础教学的理解不同，而不同的学校都具有自己相对独立的教学体系，可以根据自己的教学实际自由选择教学内容。

因此，在上述思考的基础之上，编者决定结合专业英语的教学实践编写一本教材，在内容上既充分展示国外原

版教材的特点，又可以与中国现行的教学体系相吻合，只有这样才能扬长避短，取得较好的效果。与其他教材相比，本教材的优势体现在如下几个方面。

1. 本书选材于近年来国外最新出版的大学化学和化工专业教材、期刊全文数据库、电子出版物及国内同类教材，在保持语言原汁原味的基础之上尽可能简化语言描述层次，使其简单易懂。内容覆盖了化学、化工专业所必需的基础知识、重要词汇和语法现象，并突出化学专业英语文献在文章结构、文字表达方面的特点。

2. 化学、化工专业词汇量大，单词难发音（不同于基础英语），而且大多英汉专业词典没有音标。书中对专业词汇配有汉语解释及国际音标，帮助学生掌握标准的专业词汇发音，有助于学生对词汇的记忆和掌握，消除在专业交流上的语言障碍。附录部分的化学词汇构词规律，包括常用缩写词、符号，常用词汇前缀、后缀等，便于读者查阅和自学。掌握这些词汇，可较熟练地阅读各类化学、化工英语期刊、图书及其他文献，对于撰写英语论文也有很大帮助。

3. 集各家之所长，优势互补，将最精华的部分展现给读者。在内容、结构和编排上进行了大量的改写和调整，第1章是化学基础知识，目的是让学生从简单的专业英语入手，提高学习自信心。对无机化学、有机化学、分析化学、物理化学、高分子化学、化工基础各章，先是概括性的学科描述性短文（引言），介绍每一学科的主要研究内容及发展，其次是基本原理、相关基础知识，最后是学科术语，语言难度适中，由浅入深。这种编排更适应现阶段我国化学教育体系，达到既引入先进的教育理念和教学方法，又可与中国教育体系相融合的作用。

4. 根据现代科学技术的发展，化学、化工前沿领域的选材以绿色化学为主线，引入微波化学、能源与可持续发展、生物质等新知识，扩大专业面。

5. 化学实验是化学化工专业教学的重要组成部分，是培养学生掌握基本操作技能和技术、提高实践能力，同时也是培养学生创新能力、理论联系实际、养成科学精神、树立科学作风的必修课程。我们将基本实验仪器、实验基本操作、实验室安全规范、绿色化学实验指南纳入本书，同时也选编了不同类型的实验，这样既利于学生阅读英文文献，也为撰写论文提供参考。将化学实验内容编入专业英语教材，在国内同类教材中很少见到。

本书由兰州交通大学化学与生物工程学院赵丽副教授（编写第1章至第5章，附录Ⅰ～Ⅳ）和兰州城市学院化学与环境科学学院白林教授（编写第6章至第9章，附录Ⅴ～Ⅵ）合作编写，由白林教授对全书进行统稿、审阅和定稿。在编写过程中得到了兰州交通大学化学与生物工程学院和兰州城市学院化学与环境科学学院领导、化学专业双语班学生的大力支持，在此一并表示衷心的感谢。

最后感谢您选择本书，希望能对您的学习和工作有所帮助。由于编写时间仓促，书中可能会有一些不妥之处，请读者指正。

所有意见和建议请发往：dutpbk@163.com
欢迎访问我们的网站：http://www.dutpbook.com
联系电话：0411－84707604 84706231

编　者
2012年8月

Contents

Chapter 1 General Chemistry(基础化学) 1
1.1 Water: A Chemical Solution(水:一种化学溶液) 1
1.2 Composition, Changes and Properties of Matter(物质的组成,变化和性质) 4
1.3 The Elements and the Periodic Table(元素和周期表) 8
1.4 Atoms, Molecules and Compounds(原子,分子和化合物) 12
1.5 Chemical Bonds (化学键) 15
1.6 Acids,Bases and Salts(酸,碱和盐) 20
Chapter 2 Inorganic Chemistry(无机化学) 26
2.1 The Classification and Nomenclature of Inorganic Compounds(无机化合物的分类和命名) 26
2.2 Theory of Acid-Base(酸碱理论) 33
2.3 Inorganic Chemical Terms(无机化学术语) 35
Chapter 3 Organic Chemistry(有机化学) 42
3.1 Introduction to Organic Chemistry(有机化学导论) 42
3.2 Classification of Organic Compounds(有机化合物的分类) 45
3.3 Naming Organic Compounds (有机化合物的命名) 47
Chapter 4 Analytical Chemistry(分析化学) 55
4.1 Introduction to Analytical Chemistry(分析化学导论) 55
4.2 Quantitative Inorganic Analysis(无机定量分析) 58
4.3 Qualitative Organic Analysis(有机定性分析) 62
4.4 Classification of Methods Used in Gravimetric Analysis(重量分析法的分类) 64
4.5 Analytical Chemical Terms(分析化学术语) 67
Chapter 5 Physical Chemistry(物理化学) 73
5.1 Introduction to Physical Chemistry(物理化学导论) 73
5.2 The Rates of Chemical Reactions(化学反应速度) 76
5.3 The Chemical Thermodynamics(化学热力学) 80
5.4 Chemical Equilibrium and Kinetics(化学平衡和动力学) 84
5.5 Physical Chemical Terms(物理化学术语) 87
Chapter 6 Polymer Chemistry(高分子化学) 94
6.1 Classification and Characteristics of Polymer (高分子的分类和特性) 94
6.2 The Nomenclature and Structure of Polymer(高分子的命名和结构) 99

6.3 Types of Polymerization Reactions and Methods(聚合反应的类型和方法) …… 102
6.4 Polymer Terms(高分子术语) …… 105
Chapter 7 Chemical Engineering(化工基础) …… 113
7.1 What is Chemical Engineering?(什么是化学工程) …… 113
7.2 Chemical Process Equipments(化工过程设备) …… 115
7.3 Chemical Process Operations(化工过程操作) …… 120
7.4 Simulation of Chemical Process and Application of Computers(化工过程仿真及计算机在化工中的应用) …… 133
Chapter 8 Frontiers of Chemistry and Chemical Engineering(化学与化工前沿) …… 138
8.1 Green Chemistry(绿色化学) …… 138
8.2 Introduction to Microwave Chemistry(微波化学简介) …… 141
8.3 Chemical Engineering—Today and Tomorrow(化学工程的今天与未来) …… 146
8.4 Energy and Sustainable Development(能源与可持续发展) …… 149
8.5 Biomass(生物质) …… 153
Chapter 9 Chemistry Experiment(化学实验) …… 159
9.1 Laboratory Safety Policy and Rules(实验室安全守则) …… 159
9.2 Green Guidelines for Teachers and Students in Laboratory(基于指导教师与学生的绿色化学实验指南) …… 161
9.3 How to Keep a Laboratory Notebook(如何做好实验记录) …… 162
9.4 Basic Laboratory Apparatus(基本实验仪器) …… 165
9.5 Basic Laboratory Manipulation(基本实验操作) …… 170
9.6 Experiment(化学实验选编) …… 179
Appendix(附录) …… 190
Appendix Ⅰ IUPAC Names and Symbols of the Elements(元素 IUPAC 名称及符号) …… 190
Appendix Ⅱ Word-Formation of Common Compounds in Chemistry(化学常见化合物构词规律) …… 193
Appendix Ⅲ Abbreviations of Chemistry and Chemical Engineering Vocabulary(化学化工常用缩写词) …… 197
Appendix Ⅳ Numerial Prefix of Common Compounds in Chemistry(常用化学名称数字前缀) …… 203
Appendix Ⅴ Prefix of Chemistry and Chemical Engineering Vocabulary(常用化学化工词汇前缀) …… 204
Appendix Ⅵ Suffix of Chemistry and Chemical Engineering Vocabulary(常用化学化工词汇后缀) …… 208
References(参考文献) …… 211

Chapter 1

General Chemistry

1.1 Water: A Chemical Solution

1.1.1 The International Year of Chemistry

The International Year of Chemistry (IYC 2011) is an initiative of IUPAC, the International Union of Pure and Applied Chemistry, and of UNESCO, the United Nations Educational, Scientific and Cultural Organization. It involves chemical societies, academies, and institutions worldwide and relies on individual initiatives to organize local and regional activities.

IYC 2011 is a global celebration of the achievements of chemistry and its contributions to the well-being of humankind. Under the unifying theme "***Chemistry—our life, our future***," IYC 2011 will offer a range of interactive, entertaining, and educational activities for people all ages during 2011. The goals of IYC 2011 are to increase the public appreciation of chemistry in meeting world needs, particularly how chemistry helps achieve the U.N Millennium Development Goals; to encourage interest in chemistry among young people; to generate enthusiasm for the creative future of chemistry, and to enhance international cooperation.

Involving the public, and in particular students, in the activities of the International Year of Chemistry is one of the most important goals for chemistry in 2011. IUPAC and UNESCO have developed a set of activities called the Global Chemistry Experiment to entice students around the world to learn about how chemistry contributes to one of the most important resources in their daily lives. The global experiment engages students in schools across the world in practical activities around the theme "Water: A Chemical Solution". The chemistry of water as a solution as well as the role of water in society and the environment is highlighted.

1.1.2 The Global Chemistry Experiment—Water: A Chemical Solution

Water, H_2O, is the most abundant substance on the Earth's surface. Water is the only compound found naturally in the liquid, solid and gaseous states. It covers about 70% of the planet's surface, is essential for life, and it makes up about 70% of the human body. The unique chemical properties of water make it an ideal topic for the Global Chemistry Experiment.

Water is rarely found pure. Because many substances, mostly of mineral origin, dissolve in water, water is often referred to as the Universal Solvent. Interactions with natural and artificial systems lead to a diversity of aqueous solutions that play key roles in environmental phenomena and in a multitude of applications. 97% of the water on Earth is sea water of high salt content and is not adequate for most uses. Therefore the availability of water around the world, in terms of both quality and quantity, requires that practical methods be found for proper treatment. Water fit for human consumption, or potable water, is essential for health and well-being. Purification of potable water demands adherence to a series of quality criteria embodied in physical, chemical and microbiological parameters, all of which require measurement according to prescribed procedures. The Global Chemistry Experiment demonstrates these concepts clearly and simply for students around the world.

The Global Chemistry Experiment consists of four component activities: measurement of water quality, water purification, resources and communication, each can be carried out by children of all ages in schools across all continents. The activities are adaptable to the skills and interests of students of various ages and use equipment that is widely available at little or no cost.

(1)Measurement of water quality

pH: students collect data measuring the pH of a water body, using indicator solutions (and pH meters if available).

Salinity: students explore the salinity of a water body.

(2)Water purification

Filtration and disinfection: students will learn how chemistry is used to help provide safe drinking water.

Desalination: Students will construct a solar still from household materials and experiment with its use to purify water.

(3)Resources

Resources for teachers and students can be produced relatively easily. As a minimum requirement, resources for teachers will include written instructions. However, certain of the experiments could benefit from the use of particular reagents (e. g. a liquid indicator or reagents for precipitation tests).

(4)Communication

The International Year of Chemistry logo and the Global Experiment theme "Water: A Chemical Solution" should be as widely disseminated as possible (adverts in the written press, websites, flyers). The media and PR strategy for the Global Experiment will be developed with the collaboration of groups such as UNESCO, the Water World Council and the World Monitoring Day. These groups have long standing experience and expertise in similar initiatives from which to build.

The Global Chemistry Experiment will give students across the globe the opportunity to study water quality and water purification in their own environment. Each aspect is supported by two component activities from which teachers can choose the best fit to their own educational program. The activities provide students with an appreciation of chemical investigation and data collection and validation. By the end of 2011, the results will be displayed on an IYC data collection website as an interactive global data map—demonstrating the value of international cooperation in science.

The global experiment—an initiative of the IUPAC Committee on Chemistry Education—has been developed to appeal to students from primary school to senior high school. The activities that make up the experiment will help students appreciate the role of chemistry in issues of water quality and purification. At the same time, students will contribute to an online global map, reporting on their investigations of water quality and water treatment.

The global experiment directly addresses the IYC goal of "Increasing the public appreciation and understanding of chemistry in meeting world needs and encouraging interest in chemistry among young people." The central theme of the experiment will be "Water: A Chemical Solution." This will provide an outstanding educational opportunity to learn about the key role of chemistry in providing clean, safe water and the challenge of meeting the Millennium Development Goal of greatly improving access to safe drinking water before 2015. This activity will be used to emphasize the close relationship between water and climate change, human health, and energy security.

The theme for the global experiment project—"Water: A Chemical Solution"—implies the dual meaning of "solution." First, solutions are the answers that chemistry can provide to questions about delivering safe water to people all over the world. Second, in the chemical sense, the term is helpful for introducing important chemical principles such as pH, salinity, and solubility.

In the global experiment, teachers will involve classes of students in the investigation. Consider for a moment how many students might participate—100 countries, 1000 schools per country, 10 classes per school, and 10 students per class would lead to millions of participants and a giant experiment! With such an extensive reach comes a responsibility to achieve valuable educational goals. The context of water provides relevance and the experiment will give students learning experiences that are engaging and edifying so that they learn valuable practical skills and useful chemistry. At the same time, students will discover the power of chemistry to provide reliable information and data within our society.

New Words and Expressions

the International Union of Pure and Applied Chemistry 国际纯粹化学与应用化学会
entice [ɪn'taɪs] vt. 吸引，诱使
potable water 饮用水
parameter [pə'ræmɪtə] n. 参数，参量
salinity [sə'lɪnɪtɪ] n. 盐(浓)度，咸性
filtration [fɪl'treɪʃən] n. 过滤
disinfection [ˌdɪsɪn'fekʃən] n. 消毒，杀菌；清除
desalination [di: ˌsælɪ'neɪʃən] n. 脱盐(作用)
still [stɪl] vt. 蒸馏；n. 蒸馏器
indicator ['ɪndɪkeɪtə] n. 指示剂
precipitation [prɪˌsɪpɪ'teɪʃən] n. 快速，仓促
logo ['lɔgəu] n. 标识(图案)，标语
disseminate [dɪ'semɪneɪt] vt. 传播，撒播
flyer ['flaɪə] n. 飞信，(广告)传单
edify ['edɪfaɪ] vt. 教诲，开导，启迪
PR：public relations

1.2 Composition, Changes and Properties of Matter

1.2.1 Introduction

Dictionary definitions of chemistry usually include the terms matter, composition, and properties, as in the statement that "chemistry is the science that deals with the composition and properties of matter." In this section, we will consider some basic ideas relating to these three terms, in hopes of gaining a better understanding of what chemistry is all about.

Matter is anything that occupies space, displays a property known as mass, and possesses inertia. Every human being is a collection of matter. We all occupy space, and we describe our mass through a related property, weight. All the objects that we see around us consist of matter. The gases of the atmosphere, even though they are invisible, are examples of matter—they occupy space and have mass. Sunlight is not matter, rather, it is a form of energy.

Composition refers to the parts or components of a sample of matter and their relative proportions. Ordinary water is made up of two simpler substances—hydrogen and oxygen—present in certain fixed proportions. A chemist would say that the composition of water is 11.19% hydrogen and 88.81% oxygen by mass. Hydrogen peroxide, a substance used in bleaches and antiseptics, is also made up of hydrogen and oxygen, but it has a different composition. Hydrogen peroxide is 5.93% hydrogen and 94.07% oxygen by mass.

Properties are those qualities or attributes that we can use to distinguish one sample of matter from others. In some cases, we can establish properties visually. Thus, we can distinguish between the reddish brown solid, copper, and the yellow solid, sulfur, by the property of color. Properties of matter are generally grouped into two broad categories: physical and chemical.

1.2.2 Chemical and physical changes

Since the world around us is made of matter, it, too, is constantly undergoing change. Sometimes there is just a change in the way the matter looks; at other times, there is a change in the composition of the matter itself. Scientists divide the changes in matter into two categories: physical changes and chemical changes. A physical change is a change in the appearance or physical properties of a substance. A physical change does not produce a new substance. For example, tearing a piece of paper in half is a physical change. Although the paper is smaller, it is still paper. Some other examples of physical changes are listed on the following: Liquid water turning to ice (changes the state of matter); Liquid water turning to steam (changes the state of matter); Mixing salt and sugar (changes the appearance, but you can still separate the mixture); Mixing water and salt (changes the appearance, but you can still separate the mixture).

A chemical change is a change that makes a new substance. Suppose that you take the same piece of paper you tore in half and throw it into a fireplace. The burning of paper is a chemical change. The ashes left over by the burning process no longer look and feel like the original paper because it has been chemically changed into different substances that have different properties.

How will you know if a new substance has been produced? Some of the common signs that a chemical change has occurred are: (1) one or more substances are used up (at least partially), (2) one or more new substances are formed, (3) production of gas bubbles, (4) change in the way something smells, and (5) energy is absorbed or released. Here are some examples of chemical changes: Metal rusting (new substance formed); Stomach digesting food (break down of food to new substances); Plant carrying out photosynthesis (putting water and carbon dioxide together to make sugar); Mixing baking soda and vinegar (makes a neutral liquid and a gas).

In a chemical reaction, matter can change from one substance into another substance; however, the amount of matter used in the reaction does not change. This is a statement of the Law of Conservation of Mass. In other words, when a chemical reaction occurs, something new is formed. Although something new is formed, there will still be the same amount of matter in the new substance as there was in the substances used to produce the reaction. In a chemical reaction, the substances used to produce the reaction are called reactants. The substances produced by the reaction are called products. Therefore, according to the Law of Conservation of Mass, you must have the same amount of matter present in the products that you did in the reactants.

As substances undergo chemical changes, they demonstrate their chemical properties. A physical change, on the other hand, occurs with no change in chemical composition. Physical properties are usually altered significantly as matter undergoes physical changes. In addition, a physical change may suggest that a chemical change has also taken place. For instance, a color change, a warming, or the formation of a solid when two solutions are mixed could indicate a chemical change.

Energy is always released or absorbed when chemical or physical changes occur. Energy is required to melt ice, and energy is required to boil water. Conversely, the condensation of steam to form liquid water always liberates energy, as does the freezing of liquid water to form ice.

In summary, the most important point to remember about physical and chemical changes is that a chemical change produces new substances, and a physical change does not. When a chemical change occurs, new substances are produced, but the amount of matter used in the reaction stays the same.

1.2.3 Chemical properties and physical properties

To distinguish among samples of different kinds of matter, we determine and compare their properties. We recognize different kinds of matter by their properties, which are broadly classified into chemical properties and physical properties.

Chemical properties are exhibited by matter as it undergoes changes in composition. These properties of substances are related to the kinds of chemical changes that the substances undergo. For instance, we have already described the combination of metallic magnesium with gaseous oxygen to form magnesium oxide, a white powder. A chemical property of magnesium is that it can combine with oxygen, releasing energy in the process. A chemical property of oxygen is that it can combine with magnesium.

All substances also exhibit physical properties that can be observed in the absence of any change in composition. Color, density, hardness, melting point, boiling point, and electrical and thermal conductivities are physical properties. Some physical properties of a substance depend on the conditions, such as temperature and pressure, under which they are measured. For instance, water is a solid (ice) at low temperatures but is a liquid at higher temperatures. At still higher temperatures, it is a gas (steam). As water is converted from one state to another, its composition is constant. Its chemical properties change very little. On the other hand, the physical properties of ice, liquid water, and steam are different.

Properties of matter can be further classified according to whether or not they depend on the amount of substance present. The volume and the mass of a sample depend on, and are directly proportional to, the amount of matter in that sample. Such properties, which depend on the amount of material examined, are called extensive properties. By contrast, the color and the melting point of a substance are the same for a small sample and for a large one. Properties such as these, which are independent of the amount of material examined, are called intensive properties. All chemical properties are intensive properties.

Because no two different substances have identical sets of chemical and physical properties under the same conditions, we are able to identify and distinguish among different substances. For instance, water is the only clear, colorless liquid that freezes at 0℃, boils at 100℃ at one atmosphere of pressure, dissolves a wide variety of substances (e.g., copper(II) sulfate), and reacts violently with sodium.

New Words and Expressions

inertia [ɪ'nəʃɪə] n. 惯性，惯量

hydrogen peroxide 过氧化氢

bleach [bliːtʃ] vt. 漂白，变白

antiseptic[ˌæntɪ'septɪk] adj. 防腐的，杀菌的；n. 防腐剂，杀菌剂

sulfur ['sʌlfə] n. 硫黄

copper(II) sulfate 硫酸铜

sodium ['səudjəm] n. 钠

1.3 The Elements and the Periodic Table

1.3.1 Elements and Their Symbols

Substances which cannot be broken down chemically into simpler substances have historically been known as elements. Chemical elements are symbolized by one- or two-letter abbreviations derived from their modern names, or in some case from their old Latin names.

The term element refers to a pure substance with atoms all of a single kind. To the chemist the "kind" of atom is specified by its atomic number, since this is the property that determines its chemical behavior. At present all the atoms from $Z=1$ to $Z=107$ are known; there are 107 chemical elements. Each chemical element has been given a name and a distinctive symbol. For most elements the symbol is simply the abbreviated form of the English name consisting of one or two letters, for example:

oxygen = O   nitrogen = N   neon = Ne   magnesium = Mg   hydrogen = H

Some elements, which have been known for a long time, have symbols based on their Latin names, as the following table.

Modern name	Symbol	Derivation of Symbol
antimony	Sb	stibium
copper	Cu	cuprum
gold	Au	aurum
iron	Fe	ferrum
lead	Pb	plumbum
mercury	Hg	hydrargyrum
potassium	K	kalium
silver	Ag	argentum
sodium	Na	natrium
tin	Sn	stannum
tungsten	W	wolfram

A complete listing of the elements may be found in **Appendix Ⅰ**.

1.3.2 The Periodic Table of Elements

Beginning in the late seventeenth century with the work of Robert Boyle, who proposed the presently accepted concept of an element, numerous investigations produced a considerable knowledge of the properties of elements and their compounds. In 1869, Dmitri Mendeleev and Lothar Meyer, working independently, proposed the periodic law. In modern form, the law states that the properties of the elements are periodic functions of their atomic numbers. In other words, when the elements are listed in order of increasing atomic number, elements having closely similar properties will fall at definite intervals along the list. Thus it is possible to arrange the list of elements in tabular form with elements having similar properties placed in vertical columns. Such an arrangement is called a periodic table.

Each horizontal row of elements constitutes a period. It should be noted that the lengths of the periods vary. There is a very short period containing only 2 elements, followed by two short periods of 8 elements each, and then two long periods of 18 elements each. The next period includes 32 elements, and the last period is apparently incomplete. With this arrangement, elements in the same vertical column have similar characteristics. These columns constitute the chemical families or groups. The groups headed by the members of the two 8-element periods are designated as main group elements, and the members of the other groups are called transition or inner transition elements.

In the periodic table, a heavy stepped line divides the elements into metals and nonmetals. Elements to the left of this line (with the exception of hydrogen) are metals, while those to the right are nonmetals. This division is for convenience only; elements bordering the line—the metalloids—have properties characteristic of both metals and nonmetals. It may be seen that most of the elements, including all the transition and inner transition elements, are metals.

Except for hydrogen, a gas, the elements of group IA make up the alkali metal family. They are very reactive metals, and they are never found in the elemental state in nature. However, their compounds are widespread. All the members of the alkali metal family form ions having a charge of 1^+ only. In contrast, the elements of group IB—copper, silver, and gold—are comparatively inert. They are similar to the alkali metals in that they exist as 1^+ ions in many of their compounds. However, as is characteristic of most transition elements, they form ions having other charges as well.

The elements of group IIA are known as the alkaline earth metals. Their characteristic ionic charge is 2^+. These metals, particularly the last two members of the group, are almost as reactive as the alkali metals. The group IIB elements—zinc, cadmium, and mercury are less reactive than are those of group IIA, but are more reactive than the neighboring elements of group IB. The characteristic charge on their ions is also 2+.

With the exception of boron, group IIIA elements are also fairly reactive metals. Aluminum appears to be inert toward reaction with air, but this behavior stems from the fact that the metal forms a thin, invisible film of aluminum oxide on the surface, which protects the bulk of the metal from further oxidation. The metals of group IIIA form ions of 3+ charge. Group IIIB consists of the metals scandium, yttrium, lanthanum, and actinium.

Group IVA consists of a nonmetal, carbon, two metalloids, silicon and germanium, and two metals, tin and lead. Each of these elements forms some compounds with formulas which indicate that four other atoms are present per group IVA atom, as, for example, carbon tetrachloride, CCl_4. The group IVB metals—titanium, zirconium, and hafnium—also form compounds in which each group IVB atom is combined with four other atoms; these compounds are nonelectrolytes when pure.

The elements of group VA include three nonmetals—nitrogen, phosphorus, and arsenic—and two metals—antimony and bismuth. Although compounds with the formulas N_2O_5, PCl_5, and $AsCl_5$ exist, none of them is ionic. These elements do form compounds—nitrides, phosphides, and arsenides—in which ions having charges of minus three occur. The elements of group VB are all metals. These elements form such a variety of different compounds that their characteristics are not easily generalized.

With the exception of polonium, the elements of group VIA are typical nonmetals. They are sometimes known as the chalcogens, from the Greek word meaning "ash formers". In their binary compounds with metals they exist as ions having a charge of 2−. The elements of group ⅦA are all nonmetals and are known as the halogens, from the Greek term meaning "salt formers". They are the most reactive nonmetals and are capable of reacting with practically all the metals and with most nonmetals, including each other.

The elements of groups ⅥB, ⅦB and ⅧB are all metals. They form such a wide variety of compounds that it is not practical at this point to present any examples as being typical of the behavior of the respective groups.

The periodicity of chemical behavior is illustrated by the fact that, excluding the first period, each period begins with a very reactive metal. Successive elements along the period show decreasing metallic character, eventually becoming nonmetals, and finally, in group ⅦA, a very reactive nonmetal is found. Each period ends with a