Concise Inorganic Chemistry

林世威　刘春明　李晓莉／主编

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序

语言自古以来就是人类赖以生存的基本技能。进入21世纪之后，国际性的政治、经济、体育、文化、学术交流活动愈发频繁，世界的全球化特征日益凸现，掌握双语或多种语言成为现代人的基本技能之一。

在20世纪末我国教育界就已经意识到，在世界全球化、一体化进程加快，我国顺利“入世”以及奥运会申办成功以后，社会对高素质双语人才一定会产生迫切需求。一些先觉的有创新意识的学校开展了“全部或部分地采用外语（英语）教授数学、物理、化学、历史、地理等非语言学科的教学”的双语教学实验。其目的主要在于提高学生英语水平，培养汉英兼通，中西文化兼容，富有实践能力和创新精神，德智体美全面发展的国际性复合型双语人才，以满足国家、社会和学生未来发展的需要。

时至今日，越来越多的地区和学校已经实施或准备实施双语教学。双语教学实验出现了“捷报频传，四面开花”的局面。广州、深圳、上海、北京、大连、青岛、南京、杭州等国际交往频繁的大中城市和经济发达的沿海地区，都已开展了双语教学实验，并在多年的实验与实践中积累了丰富的经验与成果，夯实了理论基础，完善了实践模式。

然而，这些只是阶段性的成果，我国的双语教学还存在许多问题。缺乏合格的双语师资和规范的双语教材是制约我国双语教学进一步发展与提高的瓶颈之一。现存的这些问题对师范院校的人才培养提出了新要求，也为师范院校的发展创造了新机遇。

师范院校实施双语教学既是对基础教育呼唤双语师资的回应，也是顺应我国高等院校双语教学发展趋势的需要。2001 年《教育部关于加强高等学校本科教学工作，提高教学质量的若干意见》(教高[2001]4 号)发出了高等院校实施双语教学的强烈信号。2004 年 8 月，教育部办公厅颁布的《普通高等学校本科教学工作水平评估方案(试行)》明确规定：适宜的专业，特别是生物技术、信息技术、金融、法律等双语授课课程比例不低于 10%。同时，教育部高等教育司成立了高等学校双语教学协作组，制定了《高等学校双语教学协作组章程》，协作组的组长高校为浙江大学，副组长高校有 6 所，成员高校有 29 所。2006 年，由浙江大学承建的“全国高校双语教学资源网”在浙江大学图书信息中心开通，它是教育部高教司直接管辖的第三个网站。2007 年，《教育部、财政部关于实施高等学校本科教学质量与教学改革工程的意见》(教高[2007]1 号)出台，意见指出，为了培养一批教学理念先进、教学方法合理、教学水平高的双语教学师资，发挥项目的示范辐射作用，提高高等学校双语教学水平，教育部启动双语教学示范课程建设项目，按照分批建设的原则，从 2007 年至 2010 年共支持建设 500 门双语教学示范课程，每年将确定有关学科领域进行重点建设。

教育部对于双语教学的态度十分明朗，并且在几年时间内采取了强有力的措施促进高校双语教学的健康发展。但是很多高校对于双语教学的认识和思想观念没有跟上时代发展。就在大家还迟疑不决的时候，长春师范学院自 2003 年起，就先后在化学、物理、生物、数学、地理、体育、小学教育等学科专业开展了双语教学与双语师资培养实验。它们和南京晓庄学院一样，在我国开展双语教学和培养中小学双语师资方面，是敢于“先吃螃蟹”的高师本科院校，在多年的双语教学与双语师资培养实验与实践中，积累了经验，完善了理论，初步形成了适合我国国情的比较完善的双语教学与双语师资培养模式与理论体系。

化学是一门自然学科，高水平的国际交流中用的全是英语。在化学专业实施双语教学不应是锦上添花可有可无的事情，而应当成为化学专业本科教育的基本办学条件。

长春师范学院化学系在双语教学方面做了卓有成效的工作，编写了适用于本科阶段无机化学双语教学的教材《简明无机化学》。该书主要由长春师范学院化学学院教师合作编写，南京晓庄学院的教师参与了部分编写工作。编写者都是多年从事无机化学双语教学工作的教师，有着丰富的化学双语教学理论基础与实践经验。本书是他们实践经验的总结，双语教学智慧的结晶，有着坚实的理论基础和实践经验。本书有以下几个显著特点：

第一，教材体现了学科基本的逻辑结构，反映了具有重要性、基础性和典型性的知识系统。取材的深广度和编排方式作者都作了精心策划和反复推敲，遵循了无机化学教材编写的基本原则。

第二，立足校本，适应性、应用性强。长期以来，双语课程教材是制约我国双语教育教学发展的一大瓶颈。国外引进的原版英文教材由于社会、文化、语言和国情的差异，其适应性与应用性是难以逾越的障碍。长春师范学院组织编写的《简明无机化学》立足校本双语教学与双语师资培养实践，针对国情、校情与学生的实际情况，很好地解决了教材的适应性与应用性问题，是适合我国经济、社会和双语教育现实需要的具有很强适应性与应用性的化学双语教材。

第三，教材语言纯正地道，具有示范性。双语教学的第一要求是语言纯正。本书的编写人员都有着很好的英语功底，且都经过英语方面的学习培训，有的教师还有海外培训背景。因此，本书无论是在语言运用上，还是在语言组织上，都展现了纯正地道的语言水准，具有很好的示范性。

在我国双语教学迅速发展的时代背景下，在双语教材严重短缺的现实困难前，此书的出版是我国师范院校无机化学双语教学改革与实验成果的结晶，能在一定程度上缓解我国无机化学双语教学的

困难，对从事双语教育教学工作的一线教师及研究者都有一定的指导与借鉴作用。

路漫漫其修远兮，吾将上下而求索。衷心地希望更多的学者、同仁关心双语，支持双语，研究双语，为我国的双语教育与双语教学健康、持续、快速的发展贡献力量。

周志华

于南京师范大学

2008 年 8 月 6 日

前 言

双语教学在我国基础教育课程改革中呈现出生机勃勃的发展趋势，这是我国教育适应经济全球化发展需要的必然选择。然而，缺乏合格的双语师资是制约基础教育双语教学发展的瓶颈之一。在此背景下，作为培养基础教育师资力量的师范院校承担着重要的历史使命。

无机化学是师范类化学专业学生的第一门专业基础课。它不仅有着自身丰富的教学内容，还为后续的专业学习作好了必要准备，同时为学生将来从事中学化学教学工作奠定了知识基础。所以在某种意义上说，无机化学是师范类化学专业学生最重要的专业基础课，同时在无机化学课程中开展双语教学更是培养合格中学化学双语师资的重要环节。

本书的参编教师来自长春师范学院、南京晓庄学院的无机化学双语教学第一线。我们在锤炼与改造教学讲义的基础上，广泛参考国外原版教材，对内容进行了仔细雕琢。本书可作为师范院校、综合性院校化学类各专业的无机化学双语教材。在编写过程中，我们力求使本书具有如下特色：

首先，内容与国内同类教材基本相当。无机化学作为大学的一门课程与作为一门学科在研究内容上是不能等同的。在我国，无机化学作为课程，其理论部分与元素部分并举，而许多国外教材则侧重理论部分。该书以国内教材为蓝本，在取材的深广度、编排体系等方面力求与国内教材基本相当。

其次，语言地道、流畅。对双语教材来说，语言上的原汁原味是

保证教学质量的重要前提。我们在编写过程中参考了大量国外原版教材与教学资料，从而保证了英语表达的规范。

本书由林世威、刘春明、李晓莉任主编，龙琪、张永宏、李红玫任副主编。参加编写的人员有林世威、刘春明、李晓莉、龙琪、张永宏、李红玫、岳淑美、齐艳娟、陈瑞战、毕淑云、王彬彬、佟文宇、原玲、王春娇、盛忠诚等。最后由林世威进行了统一整理、补充、修改和定稿工作。

英国语言专家 Simon Lee 认真阅读了全书并提出了许多重要改正意见。长春师范学院各级主管领导从本书的策划、编写到出版自始至终给予了高度的重视和关心。本书的责任编辑东北师范大学出版社的李燕同志对全书进行了认真校对。在此，全体参编人员对他们致以诚挚谢意。

编写师范类无机化学双语教材是我们在双语教学改革中的一个大胆尝试。由于编者水平有限，时间仓促，本书还有许多不足，错漏之处也在所难免，恳请广大读者和同行不吝赐教，以期再版时得以改正。

林世威

2008 年 8 月 8 日

于长春师范学院

Contents

1

General Knowledge

- ⇨Introduction
- ⇨Gas
- ⇨Liquid and Solution

1—1 Introduction

1—1—1 What is inorganic chemistry

Chemistry is the science that is concerned with the composition, structure, properties of matter and what it undergoes. Chemistry comprises of two related but distinct activities: (i) the quest for an understanding of matter and material change; (ii) the utilization of material change for human ends. Ideally, the first activity provides the necessary know-how for the pursuit of the second, but in practice, the help it can give is only partial, and the second activity has to fall back on trial and error techniques in order to achieve its ends. This means that a good chemist is one who not only has a mastery of chemical theory, but also a good knowledge of chemical facts. With such a knowledge he can direct a trial-and-error approach to practical problems in the most promising directions.

If organic chemistry is defined as the chemistry of hydrocarbon compounds and their derivates, inorganic chemistry can be described broadly as the chemistry of "everything else". This includes all the remaining elements in the periodic table, as well as carbon, which plays a major roll in many inorganic compounds. With the development of chemistry, the definitions above seem a bit out of date though they appear in textbooks widely in China even now. There are many new inorganic compounds that are very similar to those studied under traditional organic chemistry (e. g. the silicon analogues of the hydrocarbons). In some foreign textbooks, therefore, inorganic chemistry is described as the chemistry of all the elements, with organic chemistry as being a more detailed study of certain important aspects of one of them—the hydrocarbons and their derivatives.

Inorganic chemistry is very important for normal university students whose major is chemistry. Inorganic chemistry knowledge is the basis for further chemistry study as well as for teaching in middle school.

1—1—2 History of inorganic chemistry

Even before alchemy became a subject of study, many chemical reactions were used and the products were applied to daily life. For example, the first metals used were probably gold and copper, which can be found in the metallic state.

Alchemists were active in China, Egypt, and other centers of civilization early in the first centuries AD. Although much effort went into attempts to "transmute" base metals into gold, the treatises of these alchemists also described many other chemical reactions and operations. Distillation, crystallization, and her techniques were developed and used in their studies. Gunpowder was used in Chinese fireworks as early as 1150 AD, and alchemy was also widespread in China and India at that time.

By the 17th century, the common strong acids (nitric, sulfuric, and hydrochloric) were known, and more systematic descriptions of common salts and their reactions were being accumulated. The combination of acids and bases to form salts was appreciated by some chemists. As experimental techniques improved, the quantitative study of chemical reactions and the properties of gases became more common. Atomic and molecular weights were determined more accurately, and the groundwork was laid for what later became the periodic table. By 1869, the concepts of atoms and molecules were well established, and it was possible for Mendeleev and Meyer to describe different forms of the periodic table.

In 1896, Becquerel discovered radioactivity, and another area of study was opened. Studies of subatomic particles, spectra, and electricity finally led to the atomic theory of Bohr in 1913, which was soon modified by the quantum mechanics of Schrödinger and Heisenberg in 1926 and 1927. Nowadays, inorganic chemistry is developing rapidly and its bright future is attracting more and more youngsters' dedication.

1—2 Gas

1—2—1 The ideal gas equation

The behavior of gases can be described by three laws:

Boyle's law: $V=\frac{\text{constant}_B}{p}$ (T, n constant)

Charles' law: $V=\text{constant}_C \times T$ (p, n constant)

Avogadro's law: $V=\text{constant}_A \times n$ (T, p constant)

So we can draw a conclusion that:

$$pV = nRT. \qquad \text{(Equation 1. 1)}$$

Equation 1. 1 is called the Ideal Gas Equation or ideal gas law. V is the volume of the gas, p is the pressure of the gas, n is the number of moles of gas, R is proportionality constant and the value of R is 8. 314 $J \cdot mol^{-1} \cdot K^{-1}$, T is the Kelvin temperature.

1—2—2 Van der Waals Equation

Engineers and scientists who work with gases at low temperatures and high pressures need an equation that is more accurate than the ideal gas equation. These equations use constants besides R to make the equation better fit the experimental data. One of the real gas equations is the Van der Waals Equation:

$$\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT. \qquad \text{(Equation 1. 2)}$$

It is a simple example of a more accurate equation. It uses two constants besides R. The term an^2/V^2 is added to p because the presses observed for real gases are low as a result of the attractive forces between molecules. The term nb is subtracted from V because the volumes observed for real gases are high as a result of the volume of real gas molecules.

1—2—3 Dalton's Law of partial pressures

The pressure of each gas in a mixture is called the partial pressure of that gas. The total pressure of a mixture of gases is equal to the sum of the partial pressures of gases in the mixture.

$$p_{total} = p_{gas\,1} + p_{gas\,2} + \cdots \qquad \text{(Equation 1. 3)}$$

This is called Dalton's Law of Partial Pressures.

Sample problem 1. 1: Suppose that hydrogen is collected over water at 22℃. How much H_2 (expressed in moles) has been collected when the volume of gas is 126 mL under atmospheric pressure of 100 kPa? The vapour pressure of water at 25℃is 2. 7 kPa.

Solution: $p_{atm} = p_{H_2} + p_{H_2O}$, $p_{atm} = 100$ kPa, $p_{H_2O} = 2.7$ kPa,

so $p_{H_2} = p_{atm} - p_{H_2O} = 100 - 2.7 = 97.3$ kPa.

Solving the ideal gas equation for n, we find:

$$n_i = \frac{p_i V_i}{RT} = \frac{97.3 \times 10^3\ \text{Pa} \times 0.126 \times 10^{-3}\ \text{m}^3}{8.314\ \text{J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \times 295\ \text{K}} = 0.005\ \text{mol}$$

1—2—4 Graham's Law of effusion and diffusion

In the early 19th century, the Scotch chemist Thomas Graham studied the rates of effusion of different gases under the same conditions. He found the Graham's Law of Effusion:

$$\frac{\text{rate of effusion of gas 1}}{\text{rate of effusion of gas 2}} = \sqrt{\frac{M\text{gas 2}}{M\text{gas 1}}}. \qquad \text{(Equation 1.4)}$$

At the same temperature and pressure, the rates of effusion of different gases are inversely proportional to the square roots of their molecular masses. In everyday language, under the same conditions, light gas molecules effuse faster than heavy gas molecules.

Sample problem 1. 2: An unknown gas composed of homonuclear, diatomic molecules effuses at a rate that is only 0. 355 times that of O_2 at the same temperature. What is the identity of the unknown gas?