

高等学校教材

Inorganic Chemistry Experiment

无机化学实验

(英汉双语教材)

主 编 李于善

副主编 贺 艳 涂志英



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内 容 提 要

本书依据无机化学实验双语教学的实践经验,采用英汉两种语言,结合国内外无机化学实验的教学实际情况编写而成。中英文各分为5个部分:无机化学实验的一般知识;基本化学原理实验;元素性质和定性分析实验;综合性研究式实验;附录。

本书可使学生在学习和掌握无机化学实验技能的同时,提高英语阅读能力和水平,适合化学及相关专业的本科生、专科生、教师和相关学科工作人员使用和参考。本书也可作为化学及相关专业硕士研究生的实验参考书。

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前 言

近年来，无机化学实验课程在教学内容、教学方法、教学手段上都有了很大的变化，实验技术的更新、双语教学的实施不断为这门传统的基础实验课程注入了新的生机和活力。我们在总结多年来无机化学实验的教学经验及近年来实施双语教学实践的基础上，参考了国内外出版的许多同类教材并向国内外同行专家们请教，注重无机化学实验的微量化、绿色化，以英文为主，并有中文相对应，编写了这本《无机化学实验（英汉双语教材）》。

本书对基本操作和实验方法用英文作了较为详细和精练的描述，为了加强基本实验技能的训练，使学生加深对实验原理和实验操作的理解，达到培养学生创新意识、全面提高学生素质的教育目的，本书在有关章节中均附有详细的注释、思考题、参考文献和实验操作提示，以便于教学或学习。本书中涉及的无机物制备实验和综合性研究式实验，皆是编者多年来教学研究与实践所形成的较成熟的实验。

本书得到三峡大学重点教材基金的资助。

本书主编李于善，负责实验内容编撰、统稿、编辑策划，副主编贺艳负责本书的部分编辑工作和第二部分基础操作实验、第三部分元素性质实验的汉译英工作，副主编涂志英负责本书第一部分无机化学一般知识、第四部分综合性研究式实验和附录的汉译英工作。参编人员李涛、周强、许澄清、张昕、贾漫珂等老师承担了本书的校阅工作。在本书的编写过程中，得到了颜克美教授、黄应平教授、代忠旭博士、王力老师的精心指导和大力帮助，在此一并表示真诚的感谢！

由于编者水平所限，错误和不妥之处，恳请读者批评指正。

编者

2007年4月

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英文部分





Part I Introduction

1.1 Purpose of experiment

Inorganic chemistry is a basic course of experiment science. Experiment is an important part of inorganic chemistry and an important link in training skills of independent operation, observation and recording, analysis and induce, writing laboratory report, etc. The main purpose of this course is as follows:

- (1) Confirm and improve important theories and concepts learned in class and enlarge knowledge. Inorganic chemistry experiment not only makes theory knowledge visualize, but also explain conditions, range and method when using these theories.
- (2) Correctly master the basic operation techniques by the experiment. Correct data and results will be obtained only by correct experiment operation.
- (3) Develop independent thinking and working ability. Students should know how to combine theory knowledge with experiment phenomena, how to analyze the phenomena and to process the data and summary results.
- (4) Develop scientific attitude and habit of working. Scientific attitude means practical and realistic way of doing things. So you should be faithful to what you observe during experiment. When you find the phenomenon do not agree with theories, you should check whether operation is right or the theory is appropriate.

1.2 Procedure and requirements

- (1) Preparation (pre-lab). Preparation before experiment is a very important link. You should know the purpose, content, principle, operation method and experiment notice, and estimate the results of every step and write pre-lab report according to requirements of teacher. Seriously think about the questions before experiment.
- (2) Questioning and checking. Instructor will ask and check some individual students or the whole class some questions. The contents of questioning are about the purpose, content, principle, operation method and experiment notice, etc. If some students do not prepare well, teacher will end their experiment and they should make up it in an appointed time.
- (3) Experiment. Under the direction of teacher, you should do experiment according to the experiment textbook obeying the rules for lab. Observe the phenomena and record it faithfully. Deeply think what you see and analysis the



reason for producing the phenomena.

(4) Writing laboratory report. You should finish laboratory report in class or in a finite time and hand in to the teacher. Students will design the report format by themselves according to different requirements. You can reference the lab report examples. The report should be record clearly, and with definite results, simple and clean writing. If the report is disqualification, teacher will ask you to do it again. When check the reports, teacher may ask some questions about experiment to test the students again.

1.3 Rules for laboratory

(1) Before doing experiment, check all glass equipment. If there is a lack of equipment or some equipment are broken, you should tell teacher. If the equipment is broken during experiment, you can change a new one according to rules in preparation room. You should not use equipment from other place without agreement of teacher.

(2) In the experiment, keep silence, operate with care, adhere to the experiment and record experiment results.

(3) In the experiment, keep your experiment area and the whole lab tidy. All kinds of solid or liquid waste should be placed in various authorized containers.

(4) In the experiment, use the equipment carefully and skillfully, and save power, water and chemicals. When using specific instruments you should strictly follow operation processes. If the instrument is broken, stop to use it and report your instructor. Use chemicals only as required and the chemicals that has been taken out must not been put it back to containers and avoid taking impurities into container. Cover the stopper of the container immediately after use, and avoid the stopper being confused as well as the chemicals being contaminated. Place the container to original position.

(5) In the experiment, operate with the experimental procedures and safety-conscious.

(6) After the experiment, clean all glass equipment up and keep it in order. Clean table, sink and floor. Wash your hands thoroughly.

(7) Before leaving lab, check carefully whether water and power are switched off safely. All stuffs that belong lab must not been taken away.

1.4 Safety regulations

Chemicals are hazardous because of their flammable, explosive, corrosive and



toxic properties. You should completely know the safety regulations. In the experiment, you should attach importance to the safety and adhere to experimental procedures:

- (1) When heat test tube, must not make the test tube rim point to yourself or others. Do not look down boiling liquid lest you are hurt by spilling liquid.
- (2) When smell gas, you should blow the gas slightly to yourself with hand and then smell it.
- (3) During using alcohol lamp, light it up when you use it and extinguish it after use. Must not light an alcohol lamp with a litten alcohol lamp.
- (4) Concentrated acids and bases are strong corrosive. It should be used with great care in order to avoid contacting with your cloth and skin, especially your eyes. When dilute concentrated sulfuric acid, the sulfuric acid should be added into water. Water must not be added into concentrated sulfuric acid lest the acid will be spilled.
- (5) Flammable organic chemicals such as ether, ethanol, acetone and benzene should be kept away from an open flame. Cover the stopper of container immediately after use.
- (6) The experiment with an irritative or toxic gas discharged must be always carried out in a hood or in a well-ventilated circumstance.
- (7) Do not touch the toxic chemicals, such as potassium bichromate, barium salt, lead salt arsenic compound and mercury compound, etc. especially cyanide. Keep them away from your mouth or cut, and never pour them into the sewer.
- (8) Do not smoke or eat in the lab. Before leaving lab, wash your hands thoroughly with soap and water.

1.5 Disposal of contingency in lab

- (1) In case of a fire caused by alcohol, benzene or ether, etc. put the fire out with wet cloth or sand. If the fire is caused by electrical appliances, first of all, cut power, and put the fire out with a fire extinguisher.
- (2) If someone is scalded, wash the burning wound with potassium permanganate solution or picric acid and smear some Vaseline or scald ointment.
- (3) If strong acids or strong bases contact with your eyes or skin, wash the affected area immediately with copious amounts of running water, and then further treatments with NaHCO_3 solution or boric acid correspondingly (smear



some Vaseline finally if skin is burned).

(4) If chlorine or HCl gas is inhaled, you should immediately breathe a little of mixed steam of alcohol and ether for detoxification; If H₂S gas is inhaled and feel dizziness during experiment you should leave the laboratory area and move to an area where you can breath fresh air.

(5) If you are cut by glassware, the cut should be rinsed thoroughly with running water to ensure that all tiny pieces of glass are removed. After this, disinfect the cut and bind up with gauze.

(6) In case of electric shock accidents, cut power immediately and make artificial respiration if necessary.

(7) In case of the condition of an injury is sever, you should receive medical treatment. Any delay will result in more complicated therapy.

1.6 Laboratory report format

The report format described here is a demonstration for junior students. Senior students may design the report format according to the requirements under the direct of teacher. The general principles are simplicity and clear expression with chemistry language, symbol and drawing.

Example 1.1 Report format of "inorganic preparation experiment"

Name _____ Class _____ Number _____ Date _____

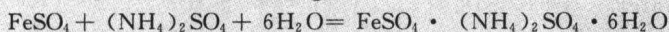
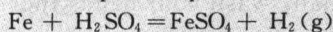
No. _____ Room No. _____ Position _____ Direct teacher _____ Score _____

Course: Inorganic experiment 1

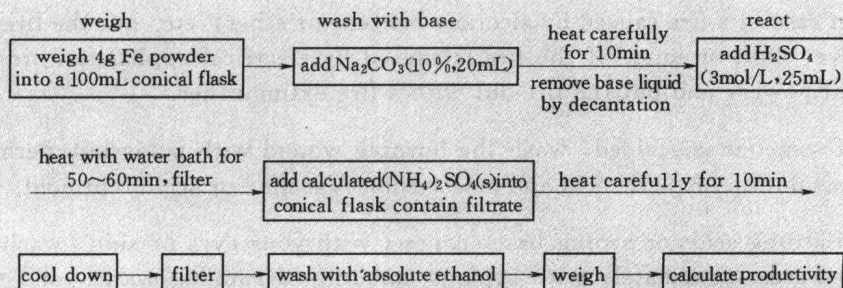
Experiment: Preparation of iron ammonium sulfate

1. Purpose of experiment (omit)

2. Principle of experiment



3. Procedure of experiment





4. Controlled analysis

Principle: $\text{Fe}^{3+} + n\text{SCN}^- = [\text{Fe}(\text{SCN})_n]^{3-n}$

Method: optical colorimetry

5. Experiment results

Calculate of theory productivity:

Yield: Productivity:

Product grade:

Example 1.2 Report format of "determination experiment"

Name _____ Class _____ Number _____ Date _____

No. _____ Room No. _____ Position _____ Direct teacher _____ Score _____

Course: Inorganic experiment 2

Experiment: Determination of dissociation constant of acetic acid

1. Purpose of experiment (omit)

2. Principle of experiment (omit)

3. Procedure of experiment

(1) Determination of standard dissociation constant and degree of dissociation of acetic acid.

1) Prepare HAc solution with different concentration.

The concentration of HAc solution supplied by lab is _____ mol/L

Number of HAc solution	1	2	3	4	5
Volume of added HAc solution (mL)	5.00	10.00	25.00	50.00	25.00
Volume of added NaAc solution (mL)	—	—	—	—	5.00
Concentration of HAc after diluting to 50mL (mol/L)					

2) Determine the pH of HAc solution from the diluted to concentrated.

3) Data recording and results.

Number	c (mol/L)	pH	$c(\text{H}^+)$ (mol/L)	$c(\text{Ac}^-)$ (mol/L)	K_a^\ominus	α
1						
2						
3						
4						
5						

(2) Determination of standard dissociation constant of unknown weak acid.

Using phenolphthalein as indicator, titrate 10mL unknown weak acid solution with NaOH to the end-point. Add 10.00mL of this weak acid solution again. The measured pH of this solution is _____.

The standard dissociation constant of this unknown weak acid is _____.

4. Questions and discussion (omit).



Example 1.3 Report format of "property experiment"

Name _____ Class _____ Number _____ Date _____
 No. _____ Room No. _____ Position _____ Direct teacher _____ Score _____

Course: Inorganic experiment 3

Experiment: Acid-base reaction and buffer solution

- Purpose of experiment (omit)
- Procedure of experiment (part of the content)

Procedure		Phenomenon	Explain and conclusion (including reaction equation)
1. Common-ion effect	(1) 1mL 0.1mol/L HAc + 1 drop of methyl orange 1mL 0.1mol/L HAc + 1 drop of methyl orange + NaAc (s)	Solution is red Solution is yellow	$\text{HAc} = \text{H}^+ + \text{Ac}^-$ The added NaAc increase the $c(\text{Ac}^-)$, and equilibrium transfer to left because of common-ion effect. The $c(\text{H}^+)$ decrease and methyl orange change from red to yellow
	(2) 5 drops of 0.1mol/L MgCl_2 + 5 drops of 2mol/L $\text{NH}_3 \cdot \text{H}_2\text{O}$ 5 drops of 0.1mol/L MgCl_2 + 5 drops of saturated NH_4Cl + 5 drops of 2mol/L $\text{NH}_3 \cdot \text{H}_2\text{O}$	White deposition No deposition	$\text{NH}_3 \cdot \text{H}_2\text{O} = \text{NH}_4^+ + \text{OH}^-$ $\text{Mg}^{2+} + 2\text{OH}^- = \text{Mg}(\text{OH})_2(\text{s})$ NH_4Cl decrease $c(\text{OH}^-)$ because of common-ion effect, so the $\text{Mg}(\text{OH})_2$ deposition will not produce
2. Preparation of buffer solution and property	(1) 8.5mL 0.1mol/L HAc and 1.5mL 1mol/L NaAc form buffer solution. Test the pH with pH test paper	pH=4	$4.0 = 4.74 + \lg \frac{V(\text{NaAc})}{V(\text{HAc})}$ $V(\text{NaAc}) + V(\text{HAc}) = 10\text{mL}$ $\therefore V(\text{HAc}) = 8.5\text{mL}$ $V(\text{NaAc}) = 1.5\text{mL}$
	(2) 5mL buffer solution + 1 drop of 1mol/L HCl. Test the pH 5mL buffer solution + 1 drop of 1mol/L NaOH. Test the pH	pH=4	When add a little of acid or base to buffer solution, the pH almost do not change
	(3) Test pH of distilled water 5mL distilled water + 1 drop of 1mol/L HCl. Test the pH 5mL distilled water + 1 drop of 1mol/L NaOH. Test the pH	pH=2 pH=12	Water has no buffer capacity

**Example 1.4 Report format of "chemical analysis experiment"**

Name _____ Class _____ Number _____ Date _____
 No. _____ Room No. _____ Position _____ Direct teacher _____ Score _____

Course: Inorganic experiment 4

Experiment: Preparation and calibration of HCl solution

1. Purpose of experiment (omit)
2. Principle of experiment (omit)
3. Procedure of experiment

Accurately weigh 0.15 - 0.2g Na_2CO_3 → add 80mL water to dissolve → add 9 drops of bromocresol green → dimethyl yellow mixed indicator → titrate with HCl waiting to calibrate to change the color from green to bright yellow.

4. Data recording and results

Recording item	Number		
	1	2	3
Weighing bottle + mass of Na_2CO_3 (before spill) (g)			
Weighing bottle + mass of Na_2CO_3 (after spill) (g)			
Mass of Na_2CO_3 (g)			
HCl: End reading (mL)			
Initial reading (mL)			
Net consumed (mL)			
c (HCl) (mol/L)			
c (HCl) (mol/L)			
Relative average deviation			

5. Questions and discussion (omit)

Example 1.5 Report format of "basic operation experiment"

Name _____ Class _____ Number _____ Date _____
 No. _____ Room No. _____ Position _____ Direct teacher _____ Score _____

Course: Inorganic experiment 5

Experiment: Purification of sodium chloride

1. Purpose of experiment

- (1) Master the principle and method of NaCl purification.
- (2) Learn basic operation of dissolve, deposit, vacuum filter, evaporating concentrate, crystallize and drying, etc.
- (3) Understand the qualitative identification of SO_4^{2-} , Ca^{2+} , Mg^{2+} , etc.