



普通高等教育“十一五”国家级规划教材配套教材

(供临床·预防·儿科·护理·病理·口腔·影像·药学
·麻醉·法医·中西医等专业用)

基础化学实验

(双语教材)

EXPERIMENT FOR
FUNDAMENTAL CHEMISTRY

主编 祁嘉义

副主编 胡 琴 赵 光



高等教育出版社
Higher Education Press

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内容提要

本书是普通高等教育“十一五”国家级规划教材祁嘉义主编《基础化学》(第2版)的配套双语教材,根据基础化学课程的要求和各医学院校实验教学的实践编写而成,注意培养学生的动手能力,创新意识和分析问题、解决问题的能力。

全书精选了21个实验,分别属于基本操作实验、基础理论实验、综合性实验、设计性实验。全书采用中英文对照,适应双语教学的要求。

本书使用对象为高等医学院校各专业本、专科学生及留学生。

图书在版编目(CIP)数据

基础化学实验/祁嘉义主编. —北京:高等教育出版社, 2008.9

双语教材. 供临床·预防·儿科·护理·病理·口腔·影像·药学·麻醉·法医·中西医等专业用

ISBN 978-7-04-024745-9

I. 基… II. 祁… III. 化学实验-双语教学-医学院校-教材 IV. 06-3

中国版本图书馆CIP数据核字(2008)第120856号

策划编辑	秦致中	责任编辑	董淑静	封面设计	张楠	责任绘图	尹莉
版式设计	范晓红	责任校对	金辉	责任印制	尤静		

出版发行 高等教育出版社
社 址 北京市西城区德外大街4号
邮政编码 100120
总 机 010-58581000
经 销 蓝色畅想图书发行有限公司
印 刷 北京铭成印刷有限公司

购书热线 010-58581118
免费咨询 800-810-0598
网 址 <http://www.hep.edu.cn>
<http://www.hep.com.cn>
网上订购 <http://www.landraco.com>
<http://www.landraco.com.cn>
畅想教育 <http://www.widedu.com>

开 本 787×1092 1/16
印 张 14.25
字 数 330 000

版 次 2008年9月第1版
印 次 2008年9月第1次印刷
定 价 23.90元

本书如有缺页、倒页、脱页等质量问题,请到所购图书销售部门联系调换。

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物料号 24745-00

前 言

基础化学实验是基础化学的重要部分,也是培养医学人才不可缺少的环节。

本书参照《基础化学和基础化学实验大纲》,结合多年来基础化学实验教学经验,在实验双语教学实践的基础上,借鉴和吸收各医学院校基础化学实验教学改革经验编写而成。基于实验教学的特点,教材扼要介绍了基础化学实验的基础知识、仪器及操作。实验包括四个部分:基本操作实验、基础理论实验、综合性实验、设计性实验。

本教材具有以下特点:

1. 对各学校开设的基础化学实验内容进行精选。
2. 新增综合性、设计性实验,有利于提高学生分析问题、解决问题的能力 and 创新意识。
3. 采用双语体系编写。

参加本书编写工作的有祁嘉义(前言、实验十三、附录),胡琴(实验十四),赵光(实验室规则和安全要求,实验十五、二十),姚碧霞(实验二、九、十)、孙勤枢(实验四,六、十一)、林丽(实验七、二十一)、杨金香(实验八、十九)、邓克敏(实验十七、十八)、宋慧(基础化学实验基本操作、实验五)、黄丽芳(实验一、十六)、许贯虹(实验三、十二)。

本书供高等医学院校基础化学实验教学使用,实验内容可根据教学需要适当选做,同时也可供医学工作人员参考。

本教材中的错误敬请读者批评指正。

祁嘉义
2008年4月

Preface

The experiments of fundamental chemistry is an important part of fundamental chemistry, and also an essential part in cultivating students with medical ability.

Based on “the brief of fundamental chemistry and it’s experiment” and the experience in experimental teaching of fundamental chemistry as well as bilingual teaching of this course for many years, by using the experiences of the reform in experimental teaching of fundamental chemistry in medical colleges for reference, we have compiled this book, which compendiously introduces the basic experimental knowledge of fundamental chemistry, the instruments and operations. The experiments consist of four parts: basic operations, chemical principle experiments, comprehensive experiments, and designing ones as well.

The textbook possesses the following features:

1. The contents in this textbook are carefully chosen from the experimental materials used in medical colleges of our country.
2. The comprehensive and designing experiments help a lot in enhancing the students’ ability to analyze and solve problems, and cultivate their creative consciousness.
3. This textbook is bilingual.

This book was composed by Jiayi Qi (preface, exp13, appendix), Qin Hu (exp 14), Guang Zhao (rules and safety requirements for laboratory, exp 15, 20,), Bixia Yao (exp 2, 9, 10), Qinshu Sun (exp 4, 6, 11), Li Lin (exp 7, 21), Jinxiang Yang (exp 8, 19), Kemin Deng (exp 17, 18), Hui Song (basic operations of fundamental chemistry experiment, exp 5), Lifang Huang (exp 1, 16), Guanhong Xu (exp 3, 12).

It’s an experimental teaching book of fundamental chemistry course for medical colleges, and experiments can be done with choice according to the teaching needs. It can also serve as a good reference book for those engaged in medical researches.

Please make comments or criticism on this book! Your suggestions are greatly appreciated!

Jiayi Qi

Apr, 2008

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通信地址： 北京市西城区德外大街 4 号

高等教育出版社打击盗版办公室

邮 编： 100120

购书请拨打电话：（010）58581118

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实验室规则和安全要求

一、实验要求

1. 实验前

充分预习实验教材是保证做好实验的一个重要环节。实验之前学生应认真看实验讲义,查阅相关文献,明确实验目的、原理、方法和步骤。初步估计实验结果。认真写出预习报告并回答思考题。

2. 实验过程中

学生应遵守实验室规则,接受教师指导,按照实验讲义上所指导的方法、步骤、要求及药品的用量进行实验;并细心观察现象,如实记录于实验报告中。同时,应深入思考,分析产生现象的原因。如果遇到意外情况需要改实验步骤,先和指导教师商量,得到同意后再改。实验过程中可以相互讨论,但不要太大声。

3. 实验报告

实验完毕后,学生应当堂(或在指定时间内)做好实验报告。实验讲义示例了实验的报告格式,供学生书写实验报告时参考。实验报告是对实验的总结,报告中计算实验结果并做出相关解释。内容包括以下几方面:实验名称、实验目的、实验原理、实验过程、实验结果、实验讨论。实验讨论可以衡量学生从实验中到底学到了多少知识。实验讨论中应分析实验条件和结果以及实验过程中出现的问题,回答实验讲义中的参考题等。所以学生都应重视实验讨论。实验报告要记录清楚、结论明确、文字简练、书写整洁。

二、实验规则

1. 进实验室应穿白大褂并把长头发扎起来。

实验前要清点仪器,如果发现有破损或缺少,应立即报告教师,按规定手续到实验预备室补领。

实验时仪器若有损坏,也应按规定手续到实验预备室换取新仪器。未经教师同意,不得拿用其他位置上的仪器。

实验过程中应严格按照教师的指导,不做教师没有授权的实验。

2. 实验时应保持安静,注意力集中,认真操作,仔细观察现象,如实记录结果,积极思考问题。

3. 实验时要爱护仪器,注意节约水、电、药品。

所有试剂都应贴上标签,包括实验台上的试剂和自己手边的试剂。取试剂前应先检查标签。药品自瓶中取出后,不能放回原瓶。瓶塞不可以朝下放在桌面,以免沾上杂质,取样后尽快盖上瓶塞,以免盖错瓶塞。不要把不干净的药匙或移液管插到试剂瓶内。如果只取

少量溶液,可先将适量溶液倒入干净烧杯中,然后从烧杯中取,取完后立即将试剂瓶放回原处。

4. 实验时应保持实验室和桌面清洁整齐。

固体废弃物倒入垃圾桶,废液倒入指定回收瓶内,严禁将其倒入水槽内以防止堵塞、腐蚀和污染。

5. 使用精密仪器时,应严格按照操作规程进行,要谨慎细致。如果发现仪器有故障,应立即停止使用,及时报告指导教师。分析天平用完后应立即将残留的固体清理干净。

6. 实验时要求按正确操作方法进行,注意安全。不要用湿手触摸电源。

7. 实验完毕后应将玻璃仪器洗涤洁净,放回原处。值日生负责打扫整个实验室。清洁并整理好桌面,打扫干净水槽和地面。实验室内的一切物品(仪器、药品和实验产物等)不得带离实验室。离开实验室前应洗净双手并检查电源、水龙头、窗户是否关好。

三、安全守则

化学药品中有很多是易燃、易爆、有腐蚀性或有毒的。使用化学试剂和操作特殊的实验仪器设备时,如果使用或操作不当会有危险。如果充分了解安全注意事项,在思想上高度重视安全问题,集中注意力,遵守操作规程,便能有效避免事故的发生。

1. 火灾和爆炸的预防

(1) 易燃材料要远离明火,实验室常用的易燃材料有:苯、钠、乙醚、二硫化碳、磷、硫磺、丙酮等。明火不用时要及时熄灭,不能离开无人看管的明火。

(2) 乙醚、乙醇、丙酮、苯等有机易燃物质,安放和使用时必须远离明火,取用完毕后应立即盖紧瓶塞和瓶盖。不能用明火直接对易燃液体加热,可使用电热套或水浴加热。

(3) 尽量避免易燃气体和空气进行混合,如需混合,容器要用布围住或在有隔离罩处混合。

(4) 化学反应或加热产生气体时,要注意压力的调节。避免对封闭的容器加热,以免引起爆炸。

(5) 强氧化剂与强还原剂要分开存放。

(6) 使用酒精灯时,应随用随点燃,不用时盖上灯罩。不要用已点燃的酒精灯去点燃别的酒精灯,以免酒精溢出而失火。

(7) 实验室禁止吸烟。

2. 预防中毒

(1) 由于有可能试剂瓶上的标签误标所以应养成习惯在实验室不要吃、喝、尝任何试剂。

(2) 不要让试剂药品与皮肤接触,可以利用实验室的移液管、吸量管、漏斗、药匙等工具移取化学试剂药品。

(3) 闻试剂的气味时,不能直接用鼻子闻,可使用招气入鼻法。

(4) 要特别注意有强腐蚀性或剧毒药品,实验室常用的有毒试剂如下:浓酸,浓碱,硫化物,四氯化碳和其他的氯化物,铬化合物,碘,溴,氰化物,银盐,铅、汞、砷及其化合物。这些试剂不可以入口或接触伤口,也不能将有毒药品随便倒入下水管道。

(5) 使用移液管转移溶液时,不要用嘴吸,应该用洗耳球。

(6) 任何有毒、有刺激性的气体或有恶臭的气体的实验都应在通风橱内或通风处进行。

(7) 有些有毒试剂通过沾在手上后可入口或直接渗透皮肤被吸收,所以要养成离开实验室前洗手的习惯。

(8) 禁止将食物带到实验室。

3. 防止化学灼伤

(1) 浓酸和碱是尤其危险的,严重灼伤皮肤和眼睛后有可能无法治愈。移取这些试剂时要加倍小心。假如在不能确定是否安全的情况下,不要把这些试剂加入其他的化学试剂中。避免所有这些化学试剂与皮肤的直接接触。

(2) 用塞子堵住试管和烧瓶振摇,不可以用手或拇指塞堵瓶口。

(3) 白磷、溴、氟化氢是有慢灼烧性的,处理这些试剂时要做适当的保护。

(4) 浓硫酸的稀释过程产生大量的热容易引起喷溅而灼伤,注意要将浓酸缓慢加入水中而不要将水加入酸中。

(5) 加热试管时,不要将试管口指向自己或别人,不要俯视正在加热的液体,以免液体溅出,受到伤害。

四、实验室意外事故的处理

1. 着火

(1) 衣服起火,寻求帮助的同时躺在地上滚动使火熄灭。

(2) 溶剂或化合物起火,应快速用湿布或沙土将其扑灭。

(3) 若遇电气设备着火,必须先切断电源,再用泡沫式灭火器或四氯化碳这类灭火器灭火(实验室应备有灭火设备)。

(4) 有机化合物起火不要用水灭火,因为这样只会使火蔓延。

(5) 如果火势很大无法控制,立即撤出实验室并与教师取得联系或在一个安全的地方拨打 119。

(6) 听见火警铃响起应立即离开实验室。

2. 中毒

(1) 如果怀疑自己吸入有害的气体,要离开实验区域吸取新鲜空气,情况严重的要立即进行急救。若吸入氯、氯化氢等气体,可立即吸入少量酒精和乙醚的混合蒸气以解毒;若吸入硫化氢气体,会感到不适或头昏,应立即到室外呼吸新鲜空气。

(2) 如果有毒物质不慎入口,首先应用大量水漱口,用手指插入咽喉处催吐,然后送医院治疗。

3. 割伤

如果割伤,应立即挤出污血,用消毒镊子夹出碎玻璃,用大量冷水冲洗伤口。然后涂上碘酒,用绷带包扎。

4. 化学灼伤

(1) 如果腐蚀性试剂如浓酸或碱溅到衣服或皮肤上,应立即脱下衣服,用大量水冲洗至少 10 min,然后通报指导教师处理。

(2) 眼睛被酸或碱灼伤时,应立即用大量水冲洗,然后送往医院治疗,不能加任何中和试剂。

(3) 如果皮肤被溴烧伤了,应立即把溴擦掉,用乙醇或石油醚洗,然后用 2% $\text{Na}_2\text{S}_2\text{O}_3$

溶液清洗。

(4) 遇有烫伤事故,可用高锰酸钾溶液或苦味酸溶液揩洗灼伤处,再搽上凡士林或烫伤油膏。

遇有触电事故,首先应切断电源,然后在必要时进行人工呼吸。对伤势较重者,应立即送医院医治,任何延误都可能使治疗复杂和困难。

(赵 光)

Rules and Safety Requirements for Laboratory

I . Requirements of experiment

1. Before experiments

Preparation before experiment is a very important link. Before the experiment students should read the teaching materials seriously and know the purpose, content, principle, operation method and experiment notice, and estimate the results of every step. Write out the pre-lab report according to different experiments and the request of the instructor. Seriously think about the questions before experiment.

2. During experiments

You should do experiment according to the experiment textbook obeying the rules for lab. Record faithfully the exact phenomenon and data you observe. Deeply think what you see and analyze the reason for producing the phenomena. If you meet some incidents and want to change the procedure, ask for the instructor first and make the changes after permission. You can talk about the experiment each other but not too loudly.

3. Writing experimental report

You should finish experimental report in class or in a finite time and hand in to the teacher. You can refer to the experimental report examples. A report is the summarization of the experiment. In the section of the report you evaluate and interpret your experimental results. Reports should be written orderly with actual results and conclusion. Several items should be included as following: Name of experiment; Purpose; Principles; Procedure; Results; Discussion. Discussion can show how much knowledge you gain from the experiment. In this part you analyze the experiment condition and result, the problems occurred during the experiment, answer the questions in the teaching materials, and so on. All the students should pay great attention to the discussion. The report should be recorded clearly, and with definite results, simple and clean writing.

II . Rules for laboratory

1. You should wear a laboratory coat and tie back long hair as long as you are in the laboratory.

Check all the apparatus before the experiment. If there are any questions, report to the instructor. If there is a lack of equipment or some experiment apparatus are broken, you should tell the instructor. If the equipment apparatus is broken during experiment, you can change a new one according to the rules of preparation room. You should not use the equipment from other place without agreement of the instructor. Whenever you are in the chemistry laboratory, follow the directions of the instructor strictly. Do not attempt to do experiments not specifically authorized by the instructor.

2. During the experiment you should keep quiet, operate accurately, watch carefully and make the exact record.

3. In the experiment, use the equipment carefully and skillfully, and save power, water and chemicals. All chemicals in the laboratory must be clearly labeled. This applies not only to the bottles on the shelves but also to chemicals on or in your desk. Check the labels before using chemicals. Never return chemicals to bottles of their origins. It's better to waste a small amount of the chemical than to risk contaminating the entire contents of the bottle. Put the stopper upside down on the bench and cover the stopper of the container immediately after use to avoid the stopper being confused as well as the chemicals being contaminated. Never insert an unclean spatula or pipette into a reagent bottle. If you need a few drops of solution, pour a little into a beaker and then take what you need from the beaker. Place the container to original position.

4. Keep the laboratory tidy all the time during the experiment. All the wastes especially the poisonous chemicals should be pour into the assigned recycling bottle not sewerage.

5. When using specific instruments you should strictly follow operation processes. If the instrument is broken, stop using it and report to the instructor. After using the analytic balance, clean up any spills at once.

6. In the experiment, operate with the experimental procedures and safety consciously. Don't touch the electrical equipments as your hands are wet.

7. After finishing the experiment, clean all the apparatus and place them back. Students on duty should clean the whole laboratory. Clean table, sink and floor. Wash your hands thoroughly. All stuffs that belong to the lab must not been taken away. Before leaving the laboratory, check whether the electricity, all the water taps and windows are switched off safely.

III. Safety regulations

Chemicals are hazardous because of their flammable, explosive, corrosive and toxic properties. As part of laboratory experiences you will handle many chemical substances and manipulate specialized laboratory equipments. Many of these substances pose a health risk if handled improperly, while some of the laboratory equipments can cause severe injury if used improperly. The chemistry laboratory is really not a dangerous place, but it demands reasonable prudence on the part of an experimenter to keep it safe. You should completely know the safety regulations. In the experiment, you should attach importance to the safety and adhere to experimental procedures.

1. Prevention of fires and explosions

(1) Keep flammable materials away from flames. A few of the flammable chemicals common-

ly encountered in the laboratory are: Benzene; Sodium; ether; Carbon disulfide; Phosphorus; Sulfur; Acetone. Extinguish all flames when not use it anymore. Never leave a flame unattended.

(2) 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. Use an electric heater or a water bath for heating flammable liquids. Never heat them over a direct flame.

(3) Avoid, wherever possible, mixing air and flammable gases or volatile liquids. If the mixture is needed, wrap the container with a cloth or place it behind a shield.

(4) When gases or vapors are generated by heat or chemical reaction, provide for pressure release to prevent explosion. Never cap a vessel being heated.

(5) Keep strong oxidizing agents away from strong reducing agents.

(6) During using an alcohol lamp, light it up when you use it and extinguish it after use. You must not light an alcohol lamp with a litten alcohol lamp.

(7) Smoking is not permitted in the laboratory.

2. Prevention of Poisoning

(1) Regard all chemicals in the laboratory as poisonous and never eat, drink, or taste anything while in the chemistry laboratory. It is always possible that the bottle is mislabeled.

(2) Handle chemicals in such a way that they do not come into contact with your skin. Utilize the tools of the laboratory; transfer pipette, measuring pipette, funnel, spoon, and so on.

(3) When it is necessary to note the odor of a substance, waft the fumes gently with your hand toward your nose. Never smell concentrated fumes.

(4) Note before performing the experiment whether any of the chemicals are especially poisonous. A few of the particularly poisonous chemicals commonly used in the laboratory are as follows: Acids (especially when concentrated); Alkalies (such as NaOH and KOH); Arsenic (As) and its compounds; Hydrogen sulfide (H_2S) and sulfides; Carbon tetrachloride (CCl_4) and other chlorinated hydrocarbon; Chromium compounds (such as $\text{K}_2\text{Cr}_2\text{O}_7$); Iodine (I_2); Bromine (Br_2); Cyanides (such as HCN, KCN, and NaCN); Silver salts (such as AgNO_3); Lead (Pb) and its compounds; Mercury (Hg) and its compounds. Keep them away from your mouth or cut, and never pour them into the sewer.

(5) Use mechanical devices for applying suction in pipetting. Never use your mouth for this purpose.

(6) Carry out all experiments involving poisonous, irritating, or objectionable gases in a ventilating hood or in a well-ventilated circumstance.

(7) A possible poisoning hazard, frequently overlooked, is contamination through the hands. Some poisons-e. g., benzene-are rapidly absorbed through the skin. All poisons can stick to the hands and eventually end up in the mouth. Immediately scrub your hands thoroughly after exposure to hazardous chemicals, and get into the habit of always washing your hands before leaving the laboratory.

(8) Food should not be brought into the laboratory.

3. Prevention of Chemical Burns

(1) Concentrated acids and alkalies are particularly dangerous and can produce painful burns

on skin and eyes, which may not be healed. These reagents must be dispensed with great care, never add them directly to other chemicals unless you are certain that it is safe to do so. Avoid all contact of the skin with these materials.

(2) Use the corks to stopper all test tubes or flasks when shaking them, do not use your hand or thumb as a stopper.

(3) White (yellow) phosphorus, bromine, and hydrofluoric acid produce very painful, slow-healing burns. Handle them only with your hands adequately protected.

(4) When diluting concentrated sulfuric acid, add the acid slowly to the water. Never add water to the concentrated sulfuric acid. The considerable heat evolved can cause the acid to spatter and result in serious burns.

(5) When heat test tube, must not make the test tube rim point to yourself or others. Do not look down the boiling liquid lest you are hurt by spilling liquid.

N. Ways of dealing with laboratory accidents

1. Fire

(1) If your clothing catches fire, immediately drop to the floor and roll to smother the flames and call for help.

(2) If a compound or solvent catches fire, cover the flames with a piece of glassware or sand as quickly as possible.

(3) If the fire is caused by electrical appliances, first of all, cut off the power, and put the fire out with a fire extinguisher.

(4) Do not put water on an organic chemical fire because it will only spread the fire.

(5) If the fire is out of control, evacuate the lab and the building immediately and tell the instructor or call 119 from a safe phone.

(6) If the fire alarm sounds for any reason, leave the room immediately and exit the building.

2. Poisoning

(1) If you inhale vapors, leave the area immediately — at least into the hallway. Tell the instructor or the coordinator, they will take you outside into the fresh air, and if necessary provide first aid or take you to get medical attention. If chlorine or HCl gas is inhaled, you should immediately breathe a little of mixed steam of alcohol and ether for detoxification; If H_2S 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.

(2) In case some poison being taken, first gargle with large amount of water, touch your finger deep into the throat to vomit, then go to hospital for treatment.

3. Cuts

If you cut yourself, extrude the dirty blood immediately, nip out the broken glasses with disinfected forceps, wash the wound with large amount of cool water. Then daub the wound with iodine tincture and bind with bandages.

4. Chemical Burns

(1) If you accidentally spill a corrosive chemical, such as a concentrated acid or base, on your-