

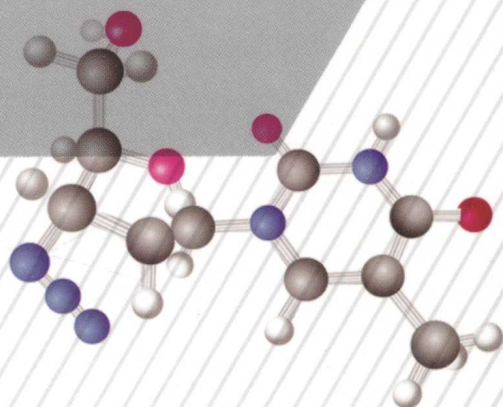
◆ 高等医药院校药学专业本科双语教材

General Chemistry Experiment

基础化学实验

主 编：刘 静

副主编：黎红梅



东南大学出版社
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前 言

本书为大学一年级的基础化学实验教材。基础化学实验作为学生进入大学所接触到的第一门化学实验课,具有启蒙作用,要解决诸多重要问题,例如,使学生形成科学态度和科学方法,使他们养成良好的习惯,培养他们的基本实验技能和技巧。这些对学生的成长影响深远。因此,本教材注重对学生化学实验基本知识的培养、实验操作技能以及综合运用知识能力的训练,同时注重对学生进行实验研究方法的启蒙和初步训练。

本教材内容分为“基本要求与实验室规则”、“实验基本操作与技能”、“实验数据的处理”、“实验部分”以及“附录”几个部分。在“基本要求与实验室规则”部分,对本课程的学习提出了明确的要求,特别强调了学习的目标和方法以及实验诚信原则;“实验基本操作与技能”不仅介绍了基本仪器及操作,还用较大的篇幅介绍应该如何做规范的实验记录、如何处理与表达实验数据;为了使學生尽早明白“量”的概念、懂得任何测量都存在某种程度的误差,我们在“实验数据的处理”部分介绍了实验误差理论;“实验部分”的安排本着循序渐进的原则,将各个基本操作和训练有机分布在各个类型的实验中,使用时教师可根据实验内容指导学生阅读前几部分的相关内容。本教材中所列实验包括四大板块:无机制备、无机定性分析、化学定量分析、化学常数测定。这些实验既可以独立开设,也可以对其中的一些实验稍加整合作为系列实验进行。为方便学生查找相关信息,在“附录”部分,除了常用的数据表以外,还附有 Excel 作图指南,此外还有中国药典中常见的无机离子的鉴别。

由于本教材主要用于以化学作为基础课的药学专业学生,“实验部分”有意结合了药物的相关内容,使学生对用实验手段研究实际问题有一些感性认识,以期提高学生的学习兴趣。

我们编写双语教材的主要目的是帮助学生尽早接触专业英语。在编写时参考了大量国外同行使用的教学内容和专业用语,尽可能用流畅、地道的英语表达教学内容,同时尽可能保持中英文的一致性。在教与学中尽量使用英语,但不唯英语,早日学会阅读英文文献、用英语进行学术交流,这才是使用双语教学的目的。当然,我们主要的目标还是通过实验教学使学生掌握实验的方法和技术。

本教材在中国药科大学无机化学教研室多年的实验教学改革和双语实验教学的基础上编写而成。刘静负责本书第三部分、第五部分和部分实验的编写,黎红梅负责第一、第二部分和部分实验的编写。参编人员还有王越、熊晔蓉、何海军、李嘉宾、陈亚东,王越、熊晔蓉老师还参加了本书的校阅工作。由于编者水平有限,书中如有错误和不妥之处,欢迎读者批评指正。

编 者

2010 年 8 月

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基础化学实验

General Chemistry Experiment

Part 1 Laboratory General Information

1.1 Learning Objectives

This course is the first year of general chemistry laboratory. The lab will provide you with instruction in common laboratory manipulations, data collection and interpretation, record keeping, and stoichiometric(chemical) calculations. You will become familiar with some of the chemist's basic laboratory equipment and will learn why and when this equipment is used. This lab should help you connect theory with the real world. You will be concentrating on the correct use of various kinds of laboratory equipment and procedures, but the lab will reinforce chemical principles covered in your lecture. You will be educated for the scientific method of chemistry. This lab helps you establish a "practice first" point of view. You will develop a scientific approach of seeking truth and a scientific method of logical thinking. You will be trained to conduct experiments in the correct, meticulous, tidy way. The objectives of this course are following as:

Technique

Considering the ease and speed of use and the desired precision and accuracy, you should be able to choose the right piece of equipment and follow proper technique to use it. You must be familiar with the following:

1. Mass measurement; proper weighing technique and use of the balance.
2. Volume measurement; volumetric pipet, Mohr pipet, buret, volumetric flask, graduated cylinder and other measuring equipment. This includes interpolation and estimating between the marks on a scale; using appropriate number of significant figures in reporting measured quantities.
3. Temperature measurement; use of thermometer.
4. Heating procedures; use of waterbath and hot plate.
5. pH measurement; use of pH paper and pH meter.
6. Separation of solids from liquids; gravity filtration, vacuum filtration and centrifugation.
7. Qualitative analysis; using flame tests, observing and describing the formation and dissolving of precipitates and gases.
8. Quantitative techniques; titration, quantitative transferring and weighing.
9. Proper cleaning of glassware, mixing of solutions, and use of reagents without causing cross-contamination.
10. Laboratory safety; safe use and disposal of chemical reagents and safe use of lab equipment; awareness of lab hazards and safety equipment procedures.

Calculations

1. Basic calculations used in this lab; percent by mass, concentration, using a chemical formula to calculate molar mass, conversion from grams to moles or moles to grams using the molar mass, use of concentration units such as molarity, calculation of the simplest formula,

第一部分 基本要求与实验室规则

1.1 课程教学目标

本课程是基础化学实验课程之一,是同学们进入大学的第一门实验课程。本课程将引导同学学习如何进行常用实验仪器的操作、如何收集和分析实验数据、如何做实验记录以及如何进行相关化学计算。在本课程的学习中,同学们要熟悉化学实验基本仪器,掌握如何选择和使用这些常用的仪器。化学实验可以帮助大家学会“理论联系实际”。因此,本课程不仅注重于训练同学正确使用仪器和掌握正确的操作技能,同时也注重加深同学们对化学原理的理解。化学实验课程蕴含科学方法的训练,同学们要通过实验逐步树立“实践第一”的观点,养成实事求是的科学态度和科学的逻辑思维方法,逐步培养正确、细致、整洁地进行科学实验的良好习惯。下面是本课程的具体教学目标。

操作技能

要想方便、快速地开展实验,同时又能满足一定的精密度和准确度要求,必须做到正确选择和使用实验仪器。同学们必须熟悉和掌握的基本操作有:

1. 质量测量:正确的称量方法和天平的使用。
2. 体积测量:移液管、吸量管、滴定管、容量瓶、量筒等仪器的使用,这些仪器可用于液体体积的测量,但其精度和体积大小各不相同,要求能根据实验具体情况正确选用,定量测定时能根据仪器的精密度正确记录测量值的有效数字。
3. 温度测量:温度计的使用。
4. 加热操作:水浴加热和电炉加热。
5. pH 值测量:pH 试纸和 pH 计的使用。
6. 固液分离:常压过滤、减压过滤和离心分离。
7. 定性分析:焰色反应,观察和描述沉淀的生成和溶解,观察气体的生成。
8. 定量操作:滴定操作、定量转移和称量。
9. 玻璃仪器洗涤、溶液混合,以及在多种试剂使用时能避免溶液的交叉污染。
10. 实验室安全技能:正确使用和处理实验用化学试剂,保证实验设备的安全使用,对实验室可能发生的事故有清醒的认识,对实验设备的安全操作心中有数。

Part 1 Laboratory General Information

simple dilution calculations using $M_1V_1 = M_2V_2$, use of chemical equations in calculations, calculation of the median and the average from a set of data taken in the lab, calculation of deviation and relative standard deviation.

2. Data recording: proper format and rules.
3. Significant figures should be understood and the appropriate number of digits should be used for recording data, doing calculations, and predicting precision; in addition, mean or average, median, and error analysis will be introduced.
4. Graphing data and using linear regression to predict values.

1.2 General Guidelines

Process of an Experiment

Before lab, write the prelab write-up You must preview the materials entirely and comprehend the experimental purpose, principle, procedures and the cautions, also, complete the assigned prelab problems for the experiment provided in the lab manual. You must turn in your prelab write-up before the lab lecture begins. The prelab write-up is a part of the notebook, which contains sections, such as the experimental objective, reference, the outline or the flowchart of the experiment procedure, and the method to deal with the data. You will be allowed to do the experiment only when you have completed the prelab write-up. Please come to the lab 10 minutes before the lab lecture and prepare the equipment used in the experiment before. Your instructor will check your prelab work. You must complete the assigned prelab problems and notebook preparation before you come to lab lecture or you will not be permitted to continue the lab. In the lab lecture, your instructor will comment this experiment and answer your questions. Then, you can start to do the experiment.

Before leaving the laboratory, check your data You must have your TA (teaching assistant) check that your notebook contains all the data and observations necessary for the successful completion of the lab write-up. He or she will initial your notebook, and if items are missing, your TA or faculty instructor will decide how the missing work is to be completed. Barring major disasters, you will have time to do all the needed work during your regular lab period, especially if you come to lab prepared and stay organized during the lab period.

After the lab, write the experiment report You should look at your results, complete all the calculations and complete either your data sheet or formal report. You have one week to complete and turn in the formal report.

Your formal reports will be examined and graded by your TA to evaluate theory section, your procedure, data, presentation of results, including graphs, answers to questions posed in the manual, a concluding discussion and a discussion of errors and uncertainties, when appropriate. Specific point credit distributions will vary from experiment to experiment, but emphasis will be placed on the accuracy of your final results in those experiments which are quantitative in nature. Grade deductions will be made for late notebooks.

Cleanliness Points

Poor housekeeping can contribute to accidents in the lab and it is your responsibility to keep the lab clean and safe. You will be sharing glassware and equipment with students in other lab sections, so it is common courtesy to clean up your area when you are done. Your teaching assistant (TA) will check to make sure you have cleaned up your equipment and chemicals at the

计算技能

1. 基本计算:质量百分比计算,浓度计算,根据化学式计算摩尔质量,质量和物质的量间换算,能正确使用浓度单位,化简,根据 $M_1V_1 = M_2V_2$ 进行溶液稀释的浓度计算,根据化学方程式进行有关计算,平行实验数据的平均值以及中值计算,偏差和相对标准偏差的计算。

2. 数据记录:按正确的格式和规则记录实验数据。

3. 有效数字:正确理解有效数字的意义,并能正确记录数据的有效数字,掌握有效数字的运算法则,能根据有效数字预测实验的精度。另外,要了解平均值、中值以及误差分析等方面的知识。

4. 数据作图和线性回归:通过对实验数据进行作图或线性回归分析,预测实验变量之间的关系。

1.2 实验的基本要求

实验环节

实验前写预习报告 实验前做好充分的预习,弄清实验的目的、原理、步骤以及注意事项,回答实验教材提出的有关实验问题,写预习报告。预习报告是实验记录的一部分,包括实验目的、参考文献、实验大致步骤或实验流程图、数据处理方法。只有写好预习报告的同学才可以进入实验室进行实验。实验时,请提前 10 分钟到达实验室,并做实验前的仪器准备。实验老师会检查预习情况,没有写好预习报告的同学不允许进实验室做实验。实验课开始,实验老师先对本次实验做讲解,并回答同学们的提问,之后,同学们方可动手实验。

离开实验室时检查实验记录 实验记录要经老师检查数据是否完全、记录是否正确,经签字同意后方可离开实验室。如果有遗漏或错误,则需要继续实验直至完成。为了避免较大错误的出现,事先需要做好准备和筹划。实验时要做到有条不紊,认真操作,以保证能在规定的时间内完成全部实验。

实验后写正式实验报告 实验结束后,要尽快检查实验结果,完成有关计算,然后写正式的实验报告。实验报告要求在实验后一周之内上交。

教师对实验报告的评价要点包括:实验原理和实验过程的表述、实验数据处理、实验数据和结果及表达(包括图表)、回答实验教材所提出的问题情况、根据实验的具体情况对误差和不确定度的讨论以及总结性讨论。不同类型的实验评分标准的侧重点有所不同,如,对于定量实验其重点自然会放在最后实验结果的准确度上。另外,迟交实验报告实验成绩将会受到影响。

实验室卫生要点

混乱是实验事故的诱因,所以保持实验室的整洁和安全是每个人的责任。每位同学都与其他班的多位同学共用同一实验柜和同一套仪器。因此,做完实验后,请务必将实验仪器清洗干净,并整齐摆放在实验柜中。这项工作做得好坏不仅体现了个人的实验素养,而且还

end of each lab before you can leave.

1. Make sure your lab area cleaned up. Your lab area is all your work places, including the lab bench, reagent rack, sink, and balance table.
2. Make sure all the equipment you used is cleaned up and your lab drawer is set up correctly.
3. Make sure your glassware drawer is inventoried, with missing items replaced and extra items removed.

If you do not follow the requirements, you will lose points from your lab write up for the week.

1.3 Honor Principle

The principle of academic honesty is at the very heart of experimental science. The following remarks apply to the laboratory component;

1. Use of another student's laboratory data is a violation of the Honor Principle, unless permission is granted by the instructor.
2. When use of another's data is allowed, the source of the data must be indicated with a clear reference in the laboratory notebook.
3. Fabrication of data, alteration of your own data, or fabrication of observations to secure some desired result is a clear violation of the Honor Principle.
4. All laboratory reports must represent your independent calculations and individual conclusions, although comparison of numerical results with those of another student is permitted, with appropriate attribution of the other student's results.
5. Copying of any portion of another student's laboratory report is a serious violation of the Honor Principle.

1.4 General Safety Rules

Safe laboratory practice is based on understanding and respect, not fear. The regulations below are intended to help you work safely with chemical reagents. These guidelines cover ordinary hazards and apply to any laboratory experiments you will encounter. Your instructors will discuss specific safety precautions relevant to each experiment during laboratory lecture. Your laboratory textbook or manual will point out specific hazards and precautions. Before beginning an experiment, be sure you have this information at hand and that you understand it. Do not hesitate to consult with your instructors if you have questions about any experiment or about these regulations.

Safety Rules in the Chem Lab

1. Contact lens don't be worn at all times when in a laboratory.
2. Open flames(burners, matches, *etc.*) are not permitted.
3. Use every precaution to keep all chemicals off your skin and clothing, out of your nose, mouth and eyes, and away from flames. It is strictly forbidden to eat or drink anything(including water) in the laboratory.
4. Long hair and billowy clothing must be confined when in the laboratory. Shoes are mandatory; sandals or open-toed shoes are not allowed, even if socks are worn. The lab cloth must be worn at all times when in a laboratory.
5. All accidents, including contact with chemicals, cuts, burns, or inhalation of fumes must

体现了个人的品行。为了督促同学做好此项工作,教师会在实验结束前做如下检查,凡是没有按要求做的同学,实验成绩将会受到一定的影响。

1. 实验工作区有没有打扫和整理。实验工作区包括你用过的所有区域,如实验台、试剂架、水槽、天平操作台。
2. 实验仪器是否清洗干净,实验仪器有没有全部、正确地放回实验柜中。
3. 实验柜里的仪器是否多余或者缺失,要将多余的拿出来,不够的要补上。

1.3 实验的诚信原则

科学诚信是实验科学的灵魂。在实验课中,我们要遵守如下规则:

1. 没有得到指导老师的同意,不能擅自使用其他同学的实验数据。
2. 使用他人的数据和资料时,需要在实验记录本和实验报告中清楚地注明出处。
3. 不得伪造和修改实验数据或对观察现象进行修改使其符合期望的结果,否则视为严重违反诚信原则的行为。
4. 可以将自己的结果与其他同学的结果进行比较,也可以与其他同学进行讨论,甚至可以引用他人结果,但必须建立在独立完成计算和得出结论的基础上。实验报告必须自己独立完成。
5. 不得抄袭他人的实验报告,哪怕只有一点,都是严重违反科学诚信的行为。

1.4 实验室安全

实验室安全操作规范的形成不是由于人们对实验的诚惶诚恐,而是基于对实验室安全的充分认识和高度重视。以下规则有助于化学试剂的安全使用,对实验中通常可能出现的一般危险之防范皆适用。至于某实验中的特殊安全要求,指导老师将会在该次实验的讲解中特别指出,实验教材或实验指导对实验中可能发生的具体危害和防范措施也有说明,实验开始前,请务必清楚和理解这些有关的实验安全要求。如果对实验或安全规则有任何疑问,应该毫不犹豫地立即向指导老师咨询。

实验室安全规则

1. 在实验室中不要戴隐形眼镜。
2. 轻易不要使用明火,如打火机、火柴等。
3. 使用药品时要极其小心。任何药品都不要让其接触到皮肤和衣服,要避免药品进入鼻子、嘴巴和眼睛里,药品更要远离火源。严禁在实验室喝水和吃东西。
4. 在实验室时,要将长头发扎起来。不要穿拖鞋之类容易脱落的鞋子,最好不穿露脚指头的鞋子,并尽量穿上袜子,以免药品不慎溅到脚上。在实验室里,要自始至终穿着实验服。
5. 无论什么样的事故发生,如皮肤接触到化学药品、割伤、烧伤、吸入有害气体等,都要

be reported to an instructor immediately. Any treatment beyond emergency first aid will be referred to the student infirmary. Severe emergencies will be referred to the hospital emergency room.

6. It is your responsibility to read and abide by the "Laboratory Safety" section of the lab manual and to keep it with you in the laboratory. Any other safety handouts or special precautions mentioned during lab lecture must be scrupulously observed.

7. Laboratory equipment and work area must be cleaned after finishing work.

Failure to observe laboratory safety rules and procedures may result in injury to you or to fellow students. Accidents in the laboratory are often the result of carelessness or ignorance either by you or by your neighbors. It is in your own best interest to stay alert and to be aware of possible hazards in the laboratory. Do not hesitate to call the attention of the instructors to unsafe practices by your colleagues.

Safety Hazards

The safety precautions outlined below will be worthless unless you understand, and think through the consequences of every operation before you perform it. The common accidents, which often occur simultaneously, are fire, explosion, chemical and thermal burns, cuts from broken glass tubing and thermometers, absorption of toxic, non-corrosive chemicals through the skin, and inhalation of toxic fumes. Less common, but obviously dangerous, is the ingestion of a toxic chemical.

1. Fire. There should never be open flames in the lab. Make it a working rule that water is the only nonflammable liquid you are likely to encounter. Treat all others in the vicinity of a flame as you would gasoline. Specifically, never heat any organic solvent in an open vessel, such as a test tube, Erlenmeyer flask, or beaker, with a flame. Such solvents should be heated in a hood with a steam bath, not a hot plate. Never keep volatile solvents, such as ether, acetone, or benzene in an open beaker or Erlenmeyer flask. The vapors can and will creep along the bench, ignite, and flash back if they reach a flame or spark.

2. Explosion. Never heat a closed system or conduct a reaction in a closed system (unless specifically directed to perform the latter process and then only with frequent venting). Before starting a distillation or a chemical reaction, make sure that the system is vented. The results of an explosion are flying glass and spattered chemicals, usually both hot and corrosive.

3. Chemical and Thermal Burns. Many inorganic chemicals such as the mineral acids and alkalis are corrosive to the skin and eyes. Likewise, many organic chemicals, such as acid halides, phenols, and so forth are corrosive and often toxic. If these are spilled on the desk, in the hood, or on a shelf, call for assistance in cleaning them up. Be careful with hot plates to avoid burns. Always assume that hot plates are HOT.

4. Cuts. The most common laboratory accident is probably the cut received while attempting to force a cork or rubber stopper onto a piece of glass tubing, a thermometer, or the side-arm of a distilling flask. Be sure to make a proper-sized hole, lubricate the cork or stopper (lubrication is essential with a rubber stopper), and use a gentle pressure with rotation on the glass part. Severed nerves and tendons are common results of injuries caused by improper manipulation of glass tubes and thermometers. Always pull rather than push on the glass when possible.

5. Absorption of Chemicals. Keep chemicals off the skin. Many organic substances are not corrosive, do not burn the skin, or seem to have not any serious effects. They are, however,

立即报告老师。非紧急情况送医务室处理,紧急情况需要尽快送医院。

6. 务必认真阅读和遵守实验手册中关于“实验室安全规则”的内容,做实验时,要将这些规则时刻铭记在心。对于指导老师提到的任何安全知识和注意事项都必须小心、认真对待。

7. 实验完毕,实验仪器和操作台必须进行打扫和整理。

不遵守安全规则和操作程序就有可能给你或他人造成伤害。实验事故常常是由不慎和疏忽引起的,为了维护每个同学切身的安全和利益,我们要意识到事故随时都可能发生,并时刻保持警惕;发现有同学进行不安全的操作时,要立即向老师报告。

安全事故的预防

只有事前对安全措施的每个步骤都能做到充分的理解和认真的思考,才能在应用它们时得心应手,否则,临时抱佛脚是无济于事的。化学实验室的一般事故,如火灾、爆炸、化学灼伤和热烫伤、被破碎玻璃管或温度计割伤、吸入毒物、非腐蚀性化学药品的透皮吸收、有毒烟雾的吸入等等,常常会同时发生。有毒化学药品入口的情况虽不常见,但显然也是非常危险的。

1. 防火灾

在实验室里最好永远不要使用明火。记住:水是唯一不会产生火焰的液体,除水之外,所有处于火焰附近的液体都应将其视为汽油处理,要将这种观念当作一条规则。在此,要特别指出的是:永远不要在火焰上使用敞口容器(如试管、锥形瓶、烧杯)加热有机溶剂。加热有机溶剂时,应将有机溶剂放在加盖的容器中,采用水浴或蒸汽浴在通风橱中进行,而不能用电炉直接加热。也不要将挥发性溶剂(如乙醚、丙酮、苯等)存放在开口容器(如烧杯、锥形瓶)中,以免其蒸气浓度到达着火浓度,达到着火浓度的蒸气一旦被点燃就会着火。

2. 防爆炸

不要加热封闭容器,除非特殊需要,也不要再在密闭容器中进行化学反应。在进行蒸馏或化学反应之前,一定要确保系统有排气口与外界相连。爆炸时,崩裂乱飞的碎玻璃和飞溅的化学药品会伤到人,而且溅出的化学药品往往是烫人的且具有腐蚀性的,这将会造成更严重的后果。

3. 防化学灼伤和热烫伤

许多无机酸、碱对皮肤和眼睛都具有腐蚀性,同样,许多有机试剂如卤代酸、苯酚等等,不仅具有腐蚀性,而且还具有毒性,一旦将这些试剂洒落,要立即擦净。使用电炉时要小心,避免烫伤。记住:热电炉总是会烫人的。

4. 防割伤

实验室最为常见的事故大概就是割伤了。例如,用力将一根玻璃管、温度计、蒸馏烧瓶的支管插入橡皮塞或软木塞时,很容易发生割伤。这时,需要选择合适的孔径,并对软木塞或橡皮塞的孔洞进行润滑,以轻轻转动方式将玻璃插入塞子,这些措施会大大降低割伤事故发生的概率。玻璃管、温度计使用不当极有可能使手腕神经和肌腱受到严重的损伤,在操作玻璃仪器时,要尽可能采用“拉”的方式代替“推”的方式。

5. 防化学药品的透皮吸收

不要让皮肤接触到化学药品。许多有机物质虽然表面看没有什么危险,既无腐蚀性又