LABORATORY MANUAL

CHEMISTRY II

TMS 0434

SITI RUBAINI MAT
LATIPAH MOHD NOOR

UNIVERSITI SAINS ISLAM MALAYSIA
جامعة العلوم الإسلامية الماليزية
ISLAMIC SCIENCE UNIVERSITY OF MALAYSIA

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USIM Publisher
Universiti Sains Islam Malaysia
Bandar Baru Nilai
Negeri Sembilan
2011

FIRST PRINTING 2011

Published in Malaysia by:

USIM Publisher
UNIVERSITI SAINS ISLAM MALAYSIA
Bandar Baru Nilai, 71800 Nilai
Negeri Sembilan Darul Khusus
Tel:06-798 8226/6081 Faks:06-798 6083
www.penerbit.usim.edu.my
pej.penerbitan@usim.edu.my

Printed in Malaysia by:

Cetak Ratu Sdn. Bhd.
No. 12, Jalan Permatang 8, Taman Desa Jaya,
81100 Johor Darul Ta'zim
Tel: 07-355 6921/6922 Faks: 07-355 6919
Email: admin@cetakratu.com

USIM Publisher is a member of the
MALAYSIAN BOOK PUBLISHERS ASSOCIATION (MAPIM)

National Library of Malaysia Cataloguing-In-Publication-Data

Siti Rubaini Mat
Laboratory manual ; chemistry II. TMS 0434 / Siti Rubaini Mat,
Latipah Mohd Noor.
ISBN 978-967-5295-96-6
1. Chemistry--Laboratory manuals. 2. Chemistry--Experiments.
I. Latipah Mohd Noor . II. Judul.
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DIRECTOR'S KEY NOTE

Assalamualaikum warahmatullah,

I would like to express gratitude to those involved in this publication straight from the beginning when a workshop was proposed for the Tamhidi Chemistry Unit. Dedications, cooperation and strong teamwork during those sessions by the lab assistants and teachers were very much appreciated.

This Laboratory Manual is a guideline for students in Semester II to complete their studies of foundation chemistry. Each experiment is carefully chosen and edited for the purpose of maximizing the impact in the learning outcome. Students should be able to incorporate what they have learnt in the lecture hall and tutorials classes with the experiments in this Laboratory Manual. Students should also be curious enough to explore similar experiments which they can find in many websites, some with even related simulations, calculations and discussions.

I believe that this Laboratory Manual will be used to its full potential for the teaching and learning purposes, and these students may still going to refer to this manual when they have moved on to the undergraduate level. It is hoped that Tamhidi Centre will be able to develop students that can integrate the naqli and aqli knowledge along with good character development as a platform to create an excellent generation corresponding with the university's mission.

Berilmu, Beramal, Bertaqwa.

Dr Nurlida Basir
Director of Tamhidi Centre, USIM
25 May 2011

LABORATORY SAFETY RULES AND AGREEMENT

Name : _____

Matrics Number : _____ **Tutorial :** _____

Lecturer's Name: 1) _____

2) _____

Read these General Laboratory Safety Rules carefully.

1. Attendance is **COMPULSORY.** If a student is unable to attend any practical classes, a medical certificate (MC) or a letter of exemption should be produced.

2. **SAFETY IS A PRIORITY.** Remember the location and proper use of all laboratory safety equipment, including eyewash, safety shower, fire alarm, fire extinguisher, and telephone. Notify your lecturer immediately of **ANY** injury, spill, fire, or explosion. **NEVER** leave an ongoing experiment unattended. Always know the hazards and physical and chemical properties of the materials used. Notify your lecturer and follow appropriate procedures if there is a mercury spill due to a broken mercury thermometer. Take every precaution to keep all chemicals from coming into contact with your skin and clothing, and away from flames.

3. When attending practical classes, every student should bring along a small towel, a jotter / log book ready and wear a **LAB COAT**, proper closed toed shoes (no sandals or slippers) and safety goggles (when needed). Pants (or long skirts) and closed toed shoes are required for admittance to the labs. You will not be allowed into the lab if you show up dressed inappropriately. Long hair and loose clothing must be confined or tied back. Head scarves should be tucked under your lab coat. High heels, baggy clothing, dangling jewellery, and shoes made of woven materials are strongly discouraged. Do not wear contact lenses for experiments when handling volatile solutions because they may be trapped under the lenses.

4. Every student must check the condition of all the apparatus to be used before starting the experiments. If there is a shortage of apparatus or breakage, please report it to the lecturer or the lab assistant immediately.

5. Be careful not to contaminate the chemicals. To avoid contamination, **NEVER** put your pipette into the reagent bottle and **NEVER** return unused chemicals to their bottle. When pouring out reagents, hold the stopper in your hand. Do not put it on the table. When replacing the stopper, place it first at the opening

to ensure that any droplets present do not split outside the reagent bottle. When diluting concentrated acids, always add the acids to water.

6. Take only sufficient amounts of chemicals for your experiments and use them with care. Try to dispense only what will be needed. Share any excess. Do not waste chemicals.

7. Playing, pranks and other acts of mischief are strictly forbidden. You are strictly forbidden to eat or drink in the laboratory at anytime. Do not taste anything. If instructed to smell a chemical, do so by carefully fanning the top of test tube or bottle so that a little of the vapour is directed towards your nose.

8. Never remove chemicals from the labs or stockrooms without proper authorisation. Unauthorized experiments, work, and preparations are not allowed. Know and follow the specified procedures for each experiment.

9. Read labels carefully. Label all containers to avoid errors. Make sure that the label is at the top when pouring out liquids from their bottles.

10. Turn off or lower all Bunsen flames when not in use. When heating liquid in a beaker, always place it on wire gauze on a tripod stand. Ensure that the mouth of the test tube is not pointed towards yourself or your friends when heating liquids in a test tube.

11. Handle compounds that emit irritating vapours in the fume cupboard. Ensure there are no flames in the vicinity before working with inflammable compounds. Immediately douse off any flame with fire extinguisher.

12. Keep your work area clean and tidy. All glassware must be washed after use. Return the apparatus and reagent bottles after the experiments. Clean up small spills immediately. Do not throw any solid wastes into the sinks. Dispose of organic solvents in the waste container provided.

13. Wash your hands and arms with soap and water before you leave the lab, even if you have been wearing gloves.

I understand that the laboratory situation is potentially dangerous. Therefore, I have read and understood the lab rules and regulations as stated above. I agree to abide by all these rules, follow the lecturer's instructions and act responsibly at all times.

Signed : _____ Date : _____

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12. Keep your work area clean and tidy. All glassware must be washed after use. Return the apparatus and reagent bottles after the experiments. Clean up small spills immediately. Do not throw any solid wastes into the sinks. Dispose of organic solvents in the waste container provided.

13. Wash your hands and arms with soap and water before you leave the lab, even if you have been wearing gloves.

I understand that the laboratory situation is potentially dangerous. Therefore, I have read and understood the lab rules and regulations as stated above. I agree to abide by all these rules, follow the lecturer's instructions and act responsibly at all times.

Signed : _____ Date : _____

PREFACE

This Laboratory Manual is created especially for the Tamhidi Programme of Medicine (TM), Dentistry (TD) and Science and Technology (TST), Tamhidi Centre, USIM. The topics are arranged according to the syllabus of chemistry for foundation studies. The main objectives of the laboratory practices is to provide better understanding of the concepts of chemistry discussed in the lectures by carrying out experiments.

During this semester, students will be exposed to the concepts of thermodynamics, reaction rates, electrochemistry and organic chemistry. It is critical for the students to read through the lecture notes on relevant topic prior to the laboratory sessions. Only two hours is given to the students in groups of three to complete each experiment.

It is important for the students to read and sign the Laboratory Safety Rules and Agreement as the first task. Submission of this agreement is crucial as the students should take precautions and be very careful in the laboratory. Before the students start any activity, a briefing will be provided by the instructors and demonstrators.

The schedule of laboratory rotation will be provided in the course outline available online. Students should be able to log in individually using their own accounts in MyLMS and GOALS. The vacant days when the students will not have laboratory sessions will be filled with topical quizzes and revision classes.

During laboratory sessions, students will be evaluated by the instructors and demonstrator with the help of lab assistants on dress code, apparatus handling, experimental procedures, behaviour during sessions, report submitted and team work.

At the end of each session, students would have to submit the laboratory handout on time. Each group is required to submit only one set of handout as the report of the day. The students should also fill in the handout in their respective laboratory manual as at the end of the semester, a laboratory theory exam will be carried out. The report submitted will not be returned back to the students.

Finally, we would like to welcome any comments from any parties especially academicians and chemists to improve this Laboratory Manual.

Chemistry Unit
Tamhidi Centre, USIM
May 2011

ACKNOWLEDGEMENT

We would like to thank the Director of Tamhidi Centre, Dr Nurlida Basir for her encouragement and support starting from the beginning, when this Laboratory Manual is firstly initiated. It was suggested by the laboratory staff for us to publish a manual which reflects the quality of experiments done by the Tamhidi students. A workshop was held on 30 March 2011 and all the experiments were carried out and the procedures were improved.

Material supports and ideas are also contributed by the facilitator of the workshop, Dr Salina Mat Radzi whom at that time was the coordinator of the Science Programme in Tamhidi Centre. Her attention to Chemistry Unit is a motivation for us to keep continuing a good teamwork in the laboratory.

Our teams in the lab are Cik Norhafiza Abdul Ghafar, En Muhammad Fariz Mat Saad and En Mohd Yusuf bin Itam Abdullah. Thank you very much for the cooperation and hard work given not only during the workshop but also throughout the whole laboratory session with the students.

Last but not least, we would like to thank our parents and families for their unlimited support for our work and studies.

Siti Rubaini Mat
Latipah Mohd Noor
6 September 2011

LIST OF APPARATUS AND CHEMICALS

Topic	Apparatus	Quantity	Chemical Reagents	Quantity
Experiment 1 Thermochemistry	coffee cup calorimeter with lid 100 mL beaker measuring cylinder conical flask thermometer stop watch water bath/hot plate	1 1 1 1 1 1	NaOH 1.0 M HCl 1.0 M distilled water	75 mL 75 mL 50 mL
Experiment 2 Electrochemistry	Voltmeter salt bridge sand paper pipette filler crocodile clips 50 mL beaker 25 mL pipette 25 mL volumetric flask 50 mL volumetric flask 5 mL graduated pipette 1 mL graduated pipette	1 1 1 2 2 2 1 1 1 1	0.1 M $CuSO_4$ 0.1 M $ZnSO_4$ zinc electrode copper electrode	75 mL 75 mL
Experiment 3 Reaction rates	boiling tubes steam bath stop-watch thermometer Bunsen burner 10 mL pipette 50 mL burette 100 / 250 mL conical flask glass rod	6 1 1 1 1 1 4 1	0.10 M HCl 10% $MnSO_4$ 0.2 M $KMnO_4$ 2.00 M H_2SO_4 0.10 M $Na_2S_2O_3$ 0.25 M $H_2C_2O_4$ distilled water	50 mL 10 drops 20 mL 40 mL 160 mL 40 mL 100 mL

Topic	Apparatus	Quantity	Chemical Reagents	Quantity
Experiment 4 Hydrocarbons	evaporating dish wooden splinter dropper test tubes tile/ A4 white paper	1 2 2 1	cyclohexane cyclohexene toluene basic $KMnO_4$	2 mL 2 mL 2 mL 2 mL
Experiment 5A Aldehyde and Keton	test tubes with corks water bath dropper 10 mL measuring cylinder	10 2 2	n-butanol 2-butanol t-Methyl-2-propanol / tert-butanol alcohol X concentrated H_2SO_4 1% $Na_2Cr_2O_7$ (aq) anhydride glacial acetic acid Lucas' reagent	2 mL 2 mL 2 mL 2 mL 2 mL 1 mL 1 mL
Experiment 5B Aldehyde and Keton	test tubes thermometer water bath stopper	10 1 2	ethanal benzyldehyde, butanone 1 sample of an unknown compound 2,4-dinitrophenylhydrazine Fehling's solution Schiff's reagent Iodine solution 10% NaOH solution $AgNO_3$ NaOH NH_4OH Dioxane or its equivalent	2 mL 2 mL 2 mL 2 mL 3 mL 8 mL 4 mL 3 mL 2 mL 5 mL 5 drops 2 mL

INTRODUCTION TO LABORATORY RULES AND USAGE OF LABORATORY EQUIPMENT

Objectives

1. To read and understand all chemistry laboratory safety rules and regulations.
2. To know the correct techniques of handling laboratory apparatus.

Introduction

The chemistry laboratory should be a safe place to work in. For this reason, students should know all laboratory rules and regulations, including the correct way of using lab apparatus and handling of chemicals.

Laboratory Rules and Regulations

1 Attendance

Attendance is **COMPULSORY**. All students undergoing the **TAMHIDI OF MEDICINE, TAMHIDI OF DENTISTRY** and **TAMHIDI OF SCIENCE AND TECHNOLOGY** programmes in **UNIVERSITI SAINS ISLAM MALAYSIA, USIM** are required to attend practical classes of two hours each. Students are required to complete five experiments each semester. If a student is unable to attend any practical classes, he / she should produce *a medical certificate (MC)* or *a letter of exemption.*

Every student should:
(i) Bring along a small towel,
(ii) Have a Laboratory Manual and laboratory handouts ready, and
(iii) Wear a lab coat, proper closed toed shoes (no sandals or slippers) and safety goggles (when needed).

2 Apparatus

SAFETY IN THE LAB IS FIRST PRIORITY. Every student must check the condition of all the apparatus to be used before starting the experiments. If there is a shortage of apparatus or breakage, please report it to the lecturer or the lab assistant immediately.

Every student is required to use and handle all apparatus with care. All apparatus and the work area must be cleaned after completing experiments. Check all glassware for cracks before using it. Cracks could cause the glassware to fail

during use, causing severe injuries. Report to your lecturer or lab assistant in case of any break or malfunction of apparatus during the experiment.

3 Chemicals

All volatile or dangerous chemicals such as concentrated acids are usually placed in the fume cupboards. Chemicals that are less dangerous are usually placed on shelves or on the table. However, it is wise to treat every chemical as if it were hazardous.

Be careful not to contaminate the chemicals. To avoid contamination, NEVER put your pipette into the reagent bottle and NEVER return unused chemicals to their respective bottles.

When pouring out reagents, hold the stopper in your hand. Do not put it on the table. When replacing the stopper, place it first at the opening to ensure that any drips do not spill outside the reagent bottle.

Take only sufficient amounts of chemicals for your experiments and use them with care. Share any excess. Do not waste chemicals. Dispose of excess chemicals in appropriate waste containers.

4 Cleaning laboratory apparatus

In order for experiments to run smoothly and yield accurate results, all apparatus used must be clean. Apparatus should be washed with a soap solution and brushed with a suitable brush. Rinse with tap water and then with distilled water. Clean apparatus does not have traces of fat or oil on the surface.

5 Using some common lab apparatus

The graduated cylinder

A graduated cylinder is used for measuring solutions when the volume needed is not required to be precise. The surface of a liquid in a cylinder curves to form what is known as a **meniscus**. The meniscus of most liquids curves up the sides of the container, making the centre of the curve appear lower than the edges. Mercury is one of very few exceptions; **it curves down at the edges**. Since reading the meniscus at the top or at the bottom of the curve will make a difference in the volume measured, it is generally agreed that the reading at the bottom of the curve is taken. Figure 1.1 is the meniscus in a 10 mL graduated cylinder.

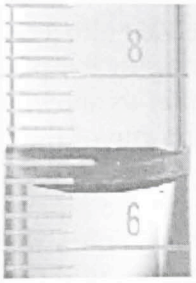
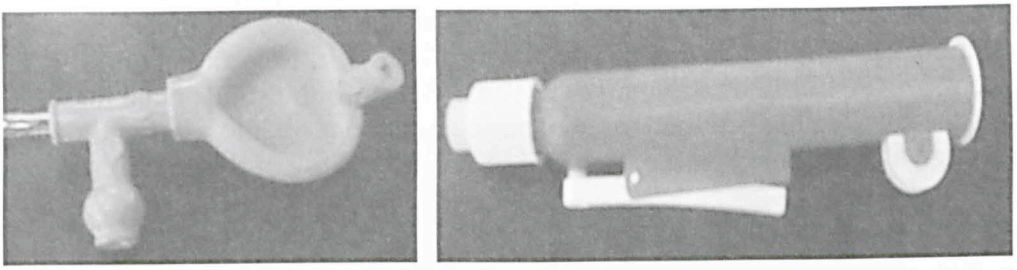


Figure 1.1: The volume is 6.6 mL, not 6.8 mL

The pipette

The pipette (Figure 1.2) is used for transferring an accurate and precise volume of a solution. Unlike graduated cylinders, the solution must be drawn into the pipette. This is done by using pipette filler. Before using the pipette, clean it and then rinse it with the solution to be transferred. The pipette comes in various sizes, i.e 5 mL, 10 mL, 20 mL, 25 mL and 50 mL.



A: Pipette Pump B: Pipette Bulb

Figure 1.2: The two of several types of pipette fillers used to draw a liquid into a pipette. The Pipette Pump (A) and Pipette Bulb (B).

Rinse the pipette with the solution to be transferred by drawing a small amount of the solution into the pipette with pipette filler. Close the top opening of the pipette with the tip of your finger. Then, position the pipette horizontally and rotate it so that the whole pipette is wet with the solution. Discard the solution.

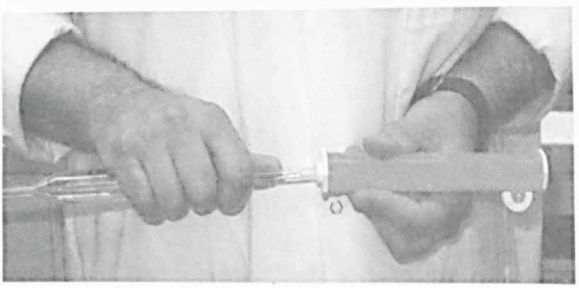


Figure 1.3: The correct insertion of pipette to the pipette bulb

Pour slightly more liquid than needed into a beaker. **Never fill a pipette directly from a reagent bottle.** Dip the tip of the pipette into the liquid in the beaker. If you are using a bulb pipette filler as shown in Figure 1.3, squeeze the pipette filler and attach it firmly to the top end of the pipette.

Gradually release the pressure on the pipette filler and allow the liquid to be drawn into the pipette. Draw more liquid than needed, but **do not allow the liquid to enter the filler**. With the tip of the pipette still dipped in the solution, quickly remove the filler and place your finger or thumb over the top end of the pipette to prevent the solution from draining back into the container. Record the exact volume of liquid in the pipette (remember the meniscus). **NEVER USE MOUTH SUCTION TO FILL A PIPETTE.**

The volumetric flask

A volumetric flask (Figure 1.4) is used to make up a solution of fixed volume very accurately. The flask cannot be heated and is not used for preparing hot solutions. To make a standard solution, first, weigh the solid to be dissolved accurately in a beaker. Then, add distilled water to dissolve it. Stir the solution, and if necessary, heat it to dissolve all the solids. When all the solids have dissolved, and the solution has returned to room temperature, pour it into a volumetric flask through a filter funnel with a glass rod to direct the flow of the solution.

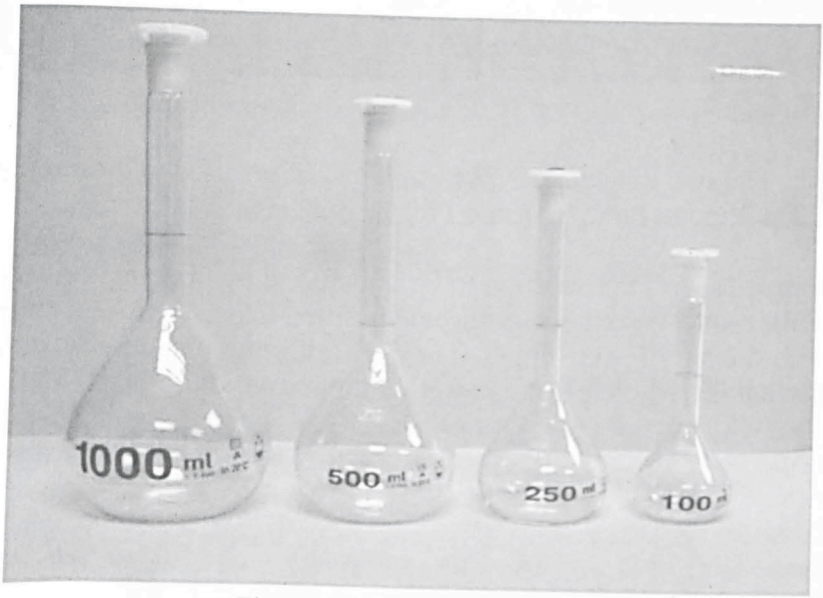


Figure 1.4: Volumetric Flask

Look at the mark on the neck of the flask at eye level so that the circle around the neck appears as a line, not an ellipse. Then add distilled water a drop at a time until the bottom of the meniscus is aligned with the mark on the neck of the

flask. Ensure that there are no droplets of liquid in the neck of the flask above the mark. Replace the stopper of the volumetric flask, pressing it in securely with your palm. Invert and shake the flask a few times.

The burette and titration flask

A burette is used to dispense solutions in precisely-measured amounts. It is used primarily to dispense reactants in the process of titration.

Before using the burette, it must be cleaned and then rinsed with distilled water. To fill a burette, close the stopcock at the bottom of the burette. Using a dry filter funnel, fill the burette to above the zero mark (Figure 1.5).

Remove the filter funnel from the burette and clamp the burette vertically to a retort stand. Before titrating, check that the solution in the burette is flowing freely by opening and closing the stopcock.

Check the tip of the burette for air bubbles. If there are air bubbles, remove them by tapping gently the side of the tip of the burette while allowing the solution to flow. Air bubbles may cause errors in readings if they are not removed.

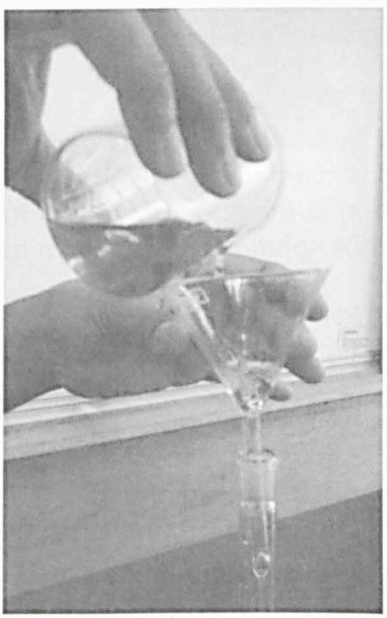


Figure 1.5: Filling a burette

When your burette is conditioned and filled, with no air bubbles or leaks, take the initial volume reading. Burette readings should be up to two decimal points ($\pm$ 0.05).

You may use a magnifying glass to get a more accurate reading. Take the reading at the *bottom* of the meniscus. Be sure your eye is at the level of the meniscus, not above or below. Reading from an angle, rather than straight on results is a parallax error.

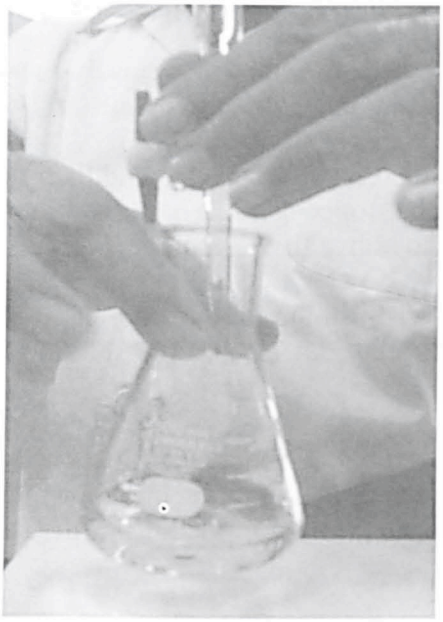


Figure 1.6: Titrating

Put a white tile under the burette, and put a conical/ titration flask on top of the white tile. The titration flask commonly used is the 100 mL and 250 mL conical flask. Dispense the solution in the burette into the titration flask by turning the stopcock slowly to allow the solution to flow down gently into the flask.

While titration is in progress, always control the stopcock with your left hand, and swirl the solution in the conical flask with your right hand (Figure 1.6). Initially, the solution should be dispensed quickly until a few milliliters from the endpoint. When the endpoint is close, titrate slowly, a drop at a time.

Record the level of the meniscus in the burette carefully after every titration. Use a wash bottle to rinse the tip of the burette and the sides of the flask.

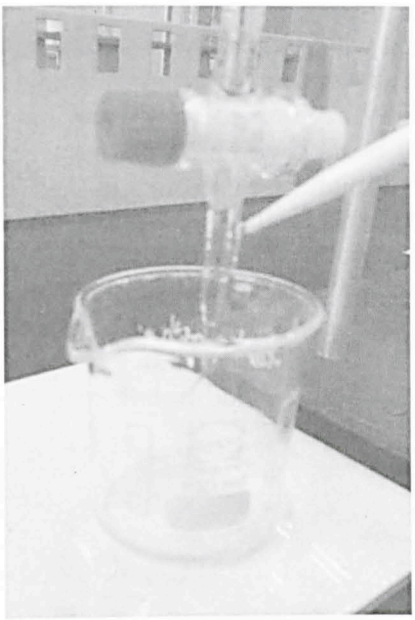


Figure 1.7: Rinsing the tip of the burette

The Bunsen burner

Many chemistry experiments require something to be heated. This is done with one of several types of laboratory burners. Bunsen burner (Figure 1.8) is the most commonly used burner in the laboratory.

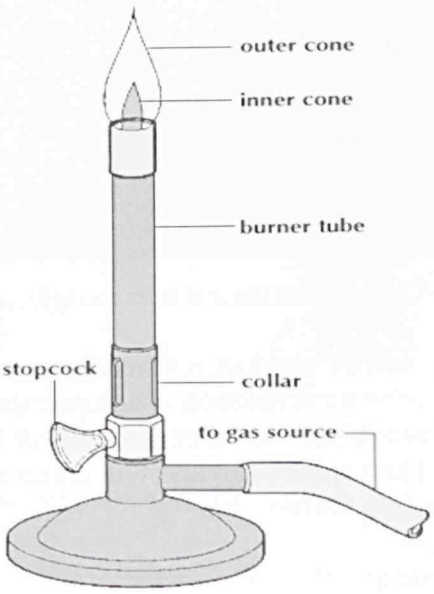


Figure 1.8: Bunsen Burner

Caution:
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 with a steam bath, not a hot plate, if possible and the flammable vapours drawn off with an aspirator tube or, preferably, by working in a hood.

Do not heat the test tube towards yourself or your friend (Figure 1.9). It is students' responsibility to know where the nearest shower and fire extinguisher are located and how to operate them. Point an extinguisher at the outer reaches of flames and work inwards. Call for additional extinguishers if necessary.

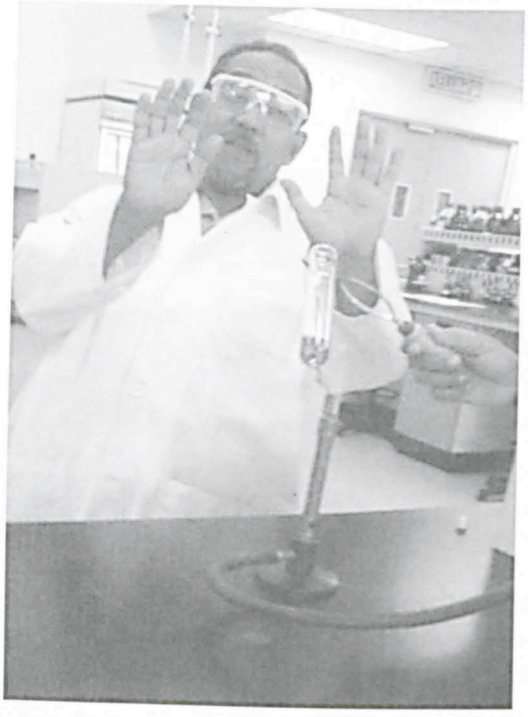
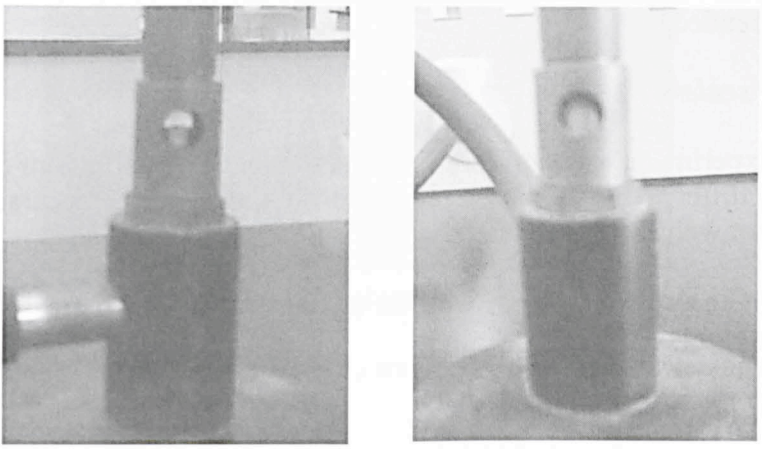


Figure 1.9: Do not heat the test tube towards your friend.

Never heat a closed system or conduct a reaction in a closed system. Before starting a distillation or a chemical reaction, make sure that the system is vented. **Never** keep volatile solvents, such as ether, acetone, or benzene in a beaker or open Erlenmeyer flask. The vapours can and will creep along the bench, ignite, and flash back if they reach a flame.

Lighting the Bunsen burner:

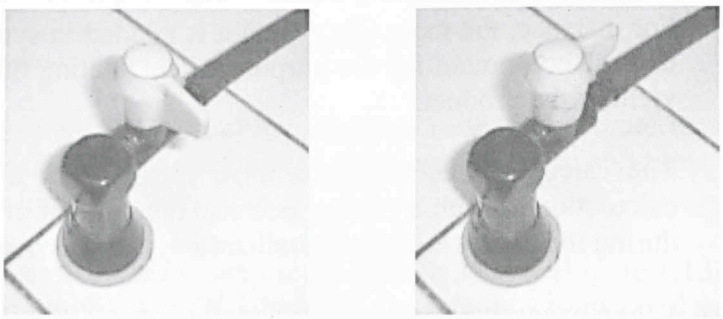
The first step is to **check for safety** - lab coat on, long hair tied back, safety glasses on, books and papers away from the flame, apparatus set up not too close to the edge of the table. The second step is to look at the openings of the air control vent. The size of the openings can be adjusted to let in more or less air by turning the collar (Figure 1.10).



A: Open B: Closed

Figure 1.10: The opening (A) and the closing (B) position of the Bunsen burner.

After attaching the hose to the gas outlet, turn the handle on the outlet parallel to the nozzle to open the gas valve. The gas valve is turned off by turning the handle 90 degrees in either direction (Figure 1.11) .



A: Tap closed B: Tap open

Figure 1.11: The off (A) and on (B) position of the gas valve.

When the gas valve is turned on, listen for any hissing sound that indicates gas leakage. At the lecturer's instruction, light the match. Then turn on the gas tap. To turn the gas tap on, first push it downwards before turning it sideways. This

is a safety feature so the taps are not accidentally pushed open. Bring the lighted match close to the Bunsen burner and this should ignite the burner. Adjust the flame by turning the collar so that you have the ideal medium blue flame required for the experiment.

Stay vigilant throughout the experiment so that if a problem occurs, you are ready to turn off the flame quickly. This means that you should not leave your table unattended.

Weighing scales

In some experiments, students are required to measure the **mass** of compounds. However, different experiments require different extent of accuracy. To save time, do not weigh more accurately than is needed.

Usually, there are two types of weights (or masses), namely, gross weights and accurate weights.

Gross weights

Gross weights refer to masses of compounds that are not used in quantitative calculations. In this case, the extent of accuracy needed is approximately 0.1 gram.

Example:

1) **When measuring the mass of a reactant for a qualitative type of experiments.**

   For instance, the mass of a reactant is needed in synthesizing an organic compound for the purpose of calculating the percentage yield of the product.

   The calculation of the percentage yield is not a quantitative calculation of high accuracy because the amount of product lost during the process, i.e. recrystallization, is not known accurately.

2) **When excessive reactant is needed.**
   For instance, potassium iodide used in an iodometric titration is needed in excess. Thus, readings up to 1 decimal place would be sufficient.

If possible, use only the top-loading balance that is also available in the weighing room. AVOID using the analytical balance for measuring gross weights.

The top-loading balance

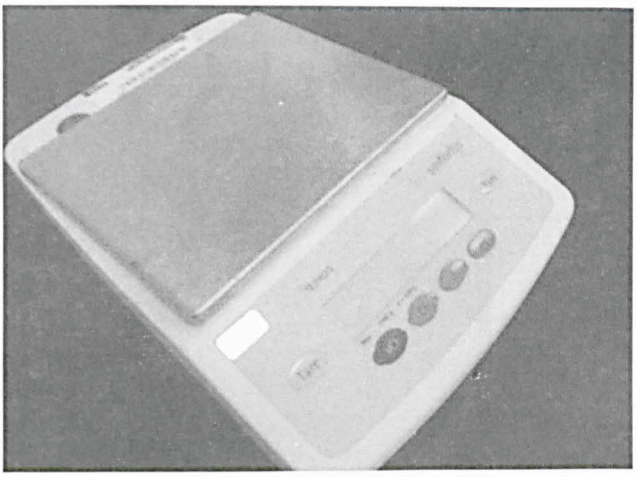


Figure 1.12: Top-loading Balance

Use top loading balance (Figure 1.12) to weigh solid material when an accuracy of 0.1g is adequate.

Using the top-loading balance:

i. Check if the balance is turned on. If not, press the on/off button and wait until the display reads 0.0 g.
ii. Place a container on the balance pan. Push the TARE button to set the reading to zero.
iii. Carefully add the substance to the container. Record the mass. Use the brush provided to clean up any spills.

Accurate weights

All masses used in quantitative calculations must be accurate masses. These include the mass of chemicals needed to prepare standard solutions, weights of samples for volumetric analysis etc.

To measure mass accurately, use the analytical balance (Figure 1.13) located in the weighing room. By using this balance, the accuracy is up to 4 d.p. (0.0001g).

The analytical balance

Analytical balances are accurate and precise instruments used to measure masses. They require a draft-free location on a solid bench that is free of vibrations.

Figure 1.13: Analytical Balance

Using the analytical balance:

1. Before turning on, be sure that all three doors (top and both sides) doors of the balance are closed and the pan is not touching the draft ring.
2. If there is no display, press the ON/OFF button and let it up quickly. The display lights up for several seconds.
3. Once the balance has initialized, set the reading to zero by pressing the TARE/RE-ZERO button. Wait until the display reads 0.0000 g.
4. Gently open one of the side doors and place the weighing vessel on the balance pan, and then gently close the sliding glass door.
5. Wait until the display becomes constant and a small "g" appears after the last decimal place. Note that the reading may change by $\pm 0.0001g$; this is typical for digital displays and should not become cause of concern. For some models, the green indicator light on the left will go out. This is the stability indicator light, indicating that the weight is stable.
6. Press the TARE/RE-ZERO button to cancel out the weight of the container or paper. The display will again read 0.0000g.
7. Carefully add the substance to be weighed up to the desired mass. Do not attempt to reach a particular mass ***exactly***.
8. Before recording the mass, close the glass doors and wait until "g" appears OR the stability detector lamp goes out. Record the mass of the substance.

Do not pick up containers with bare hands since your fingerprints add mass. Use thongs to prevent this AND do not LEAN on the bench while weighing as vibrations would affect your readings.

CLEAN-UP: Use the brush provided to clean spills in the weighing chamber.

Average deviation

"Average deviation" is the average of the deviation of individual weighing of the average mass.

Table A: Five readings from an analytical balance.

Experiments	I	II	III	IV	V	Average
Mass(g)	2.104	2.105	2.103	2.107	2.105	2.105
Deviation	0.001	0.000	0.002	0.002	0.001	0.001

The average deviation for the above is the mass deviation of each individual weighing. Thus, the result can be recorded as (2.105 ± 0.001) g.

APPENDIX 1

TABLE OF STANDARD REDUCTION POTENTIALS

Cathode (Reduction)	Half Reaction Standard Potential E^o (V)
$Li^+_{(aq)} + e^- \rightarrow Li_{(s)}$	-3.0401
$Cs^+_{(aq)} + e^- \rightarrow Cs_{(s)}$	-3.026
$Rb^+_{(aq)} + e^- \rightarrow Rb_{(s)}$	-2.98
$K^+_{(aq)} + e^- \rightarrow K_{(s)}$	-2.931
$Ba^{2+}_{(aq)} + 2\ e^- \rightarrow Ba_{(s)}$	-2.912
$Sr^{2+}_{(aq)} + 2\ e^- \rightarrow Sr_{(s)}$	-2.89
$Ca^{2+}_{(aq)} + 2\ e^- \rightarrow Ca_{(s)}$	-2.868
$Na^+_{(aq)} + e^- \rightarrow Na_{(s)}$	-2.71
$Mg^{2+}_{(aq)} + 2\ e^- \rightarrow Mg_{(s)}$	-2.372
$Al^{3+}_{(aq)} + 3\ e^- \rightarrow Al_{(s)}$	-1.662
$Mn^{2+}_{(aq)} + 2\ e^- \rightarrow Mn_{(s)}$	-1.185
$2H_2O_{(l)} + 2\ e^- \rightarrow H_{2\ (g)} + 2\ OH^-_{(aq)}$	-0.8277
$Zn^{2+}_{(aq)} + 2\ e^- \rightarrow Zn_{(s)}$	-0.7618
$Cr^{3+}_{(aq)} + 3\ e^- \rightarrow Cr_{(s)}$	-0.744
$Cd^{2+}_{(aq)} + 2\ e^- \rightarrow Cd_{(s)}$	-0.403
$Co^{2+}_{(aq)} + 2\ e^- \rightarrow Co_{(s)}$	-0.28
$Ni^{2+}_{(aq)} + 2\ e^- \rightarrow Ni_{(s)}$	-0.257
$Sn^{2+}_{(aq)} + 2\ e^- \rightarrow Sn_{(s)}$	-0.1375
$Pb^{2+}_{(aq)} + 2\ e^- \rightarrow Pb_{(s)}$	-0.1262
$2\ H^+ + 2\ e^- \rightarrow H_{2\ (g)}$	0
$Sn^{4+}_{(aq)} + 2\ e^- \rightarrow Sn^{2+}_{(aq)}$	0.151
$Cu^{2+}_{(aq)} + 2\ e^- \rightarrow Cu^+_{(s)}$	0.153
$AgCl_{(s)} + e^- \rightarrow Ag_{(s)} + Cl^-$	0.22233
$ClO^-_{3\ (aq)} + H_2O_{(l)} + 2\ e^- \rightarrow ClO^-_{2\ (aq)} + 2\ OH^-_{(aq)}$	0.33

$Cu^{2+}_{(aq)} + 2\ e^- \rightarrow Cu_{(s)}$	0.3419
$ClO^-_{4\ (aq)} + H_2O_{(l)} + 2\ e^- \rightarrow ClO^-_{3\ (aq)} + 2\ OH^-_{(aq)}$	0.36
$Cu^+_{(aq)} + e^- \rightarrow Cu_{(s)}$	0.521
$I_{2\ (s)} + 2\ e^- \rightarrow 2\ I^-_{(aq)}$	0.5355
$MnO^-_{4\ (aq)} + H_2O_{(l)} + 3\ e^- \rightarrow MnO_{2\ (s)} + 2\ OH^-_{(aq)}$	0.595

LABORATORY MANUAL

CHEMISTRY II TMS 0434

This Laboratory Manual is a text book for the Tamhidi Programme of Medicine, Dentistry and Science and Technology of the Tamhidi Centre, USIM which whom undergoing the core subject TMS 0434 Chemistry II. There are five experiments carefully selected, which is arranged accordingly correlated to the syllabus of chemistry for foundation studies. The main objectives of the laboratory practices are to provide better understanding of the concepts of chemistry discussed in the lectures and tutorial sessions. During this semester, students will be exposed to the concepts of thermodynamics, reaction rates, electrochemistry and organic chemistry.

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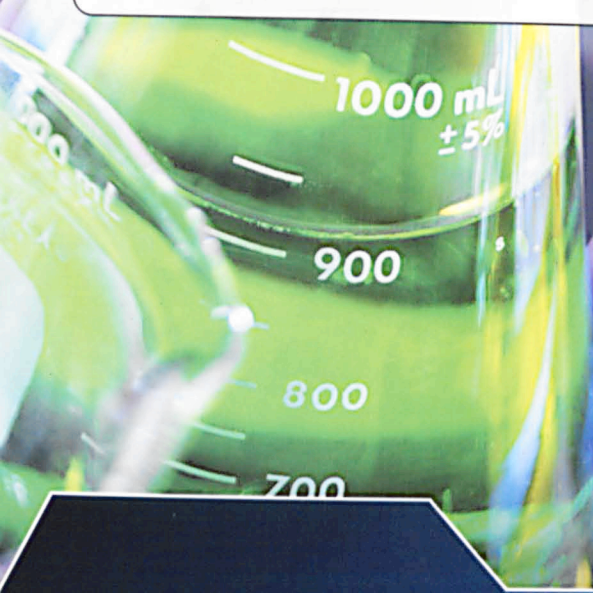

ISBN 978-967-5295-96-6
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