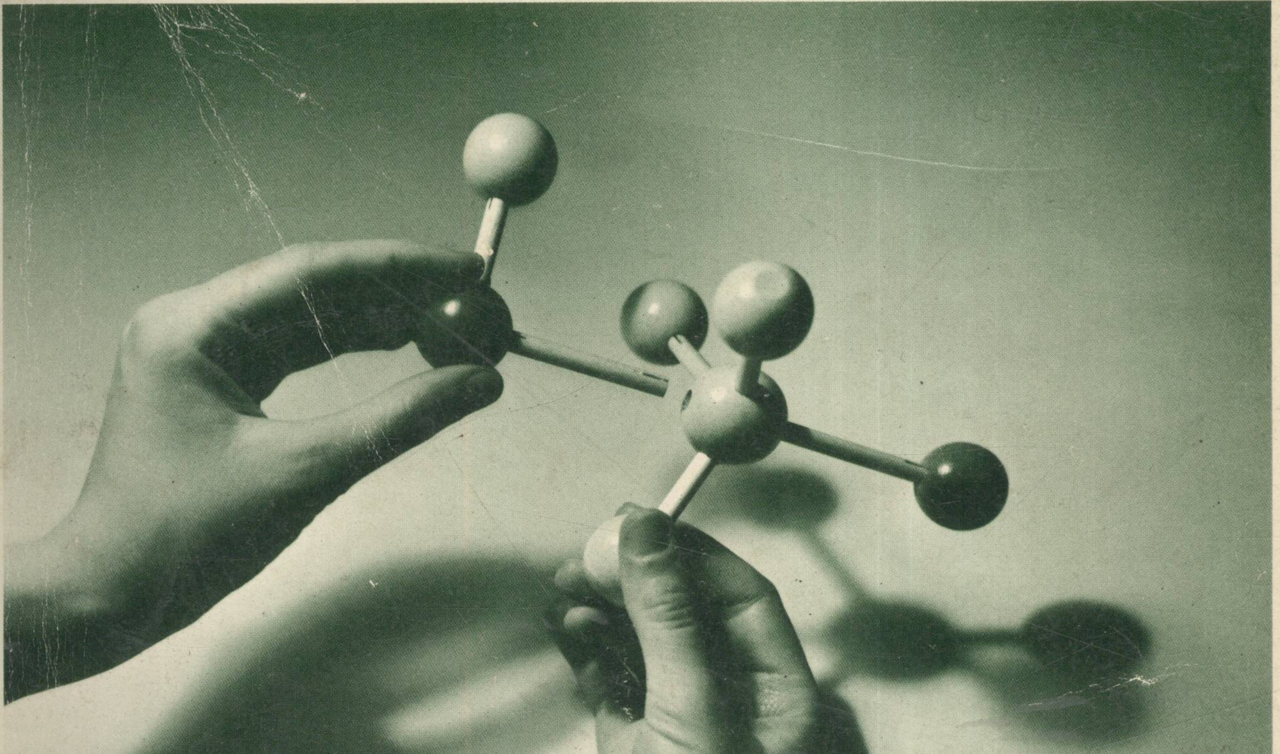
Harold G. Burman

Laboratory Manual to accompany PRINCIPLES OF GENERAL CHEMISTRY



LABORATORY MANUAL
to accompany
PRINCIPLES OF GENERAL CHEMISTRY

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LABORATORY MANUAL

to accompany

PRINCIPLES OF GENERAL CHEMISTRY

TO THE INSTRUCTOR

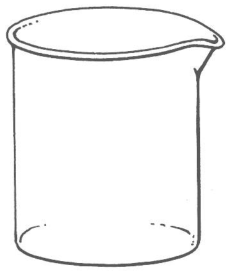
The laboratory manual has been written to accompany *Principles of General Chemistry,* and an effort has been made to include something directly related to each chapter. Experiments have been prepared for those chapters in which there are concepts that can be illustrated and made clear by experiment. Review exercises are presented for those chapters containing subject matter not very suitable for experiment. Some of the exercises encompass more than a single chapter.

The objectives of the manual are 1) to cause the student to become aware of experimental method, 2) to illustrate major concepts by experiment and 3) to furnish additional help for making concepts clear by the use of review exercises.

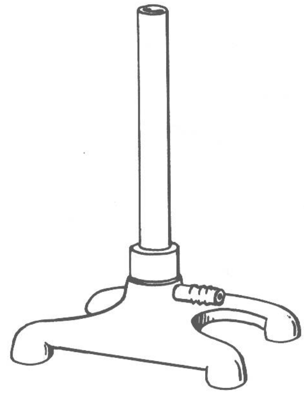
Answers to some of the alternate review exercises are given in the appendix.

RECOMMENDED DESK EQUIPMENT

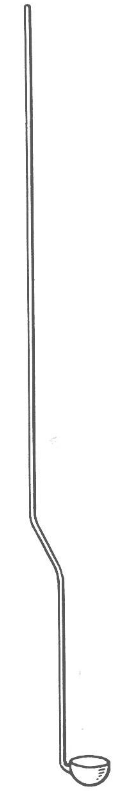
1	400 ml beaker
1	250 ml beaker
1	150 ml beaker
1	50 ml beaker
1	wide mouth bottle
1	test tube brush
1	burner
1	wingtip
1	crucible with cover
2	evaporating dishes
2	watchglasses
2	125 ml Erlenmeyer flasks
1	100 ml graduated cylinder
1	25 ml graduated cylinder
1	10 ml graduated cylinder
1	25 ml pipette
1	10 ml pipette
1	glass plate
1	150 mm ruler
1	test tube 22 by 175 mm
6	test tubes 18 by 150 mm
1	wire test tube holder
1	test tube rack
1	crucible tongs
1	clay triangle
1	stirring rod
1	wire gauze
1	stainless steel forceps



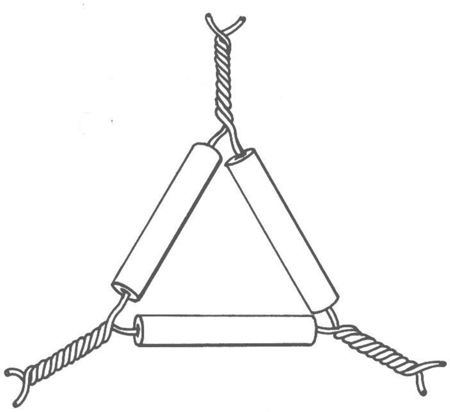
Beaker



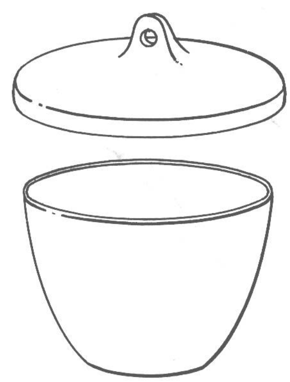
Burner



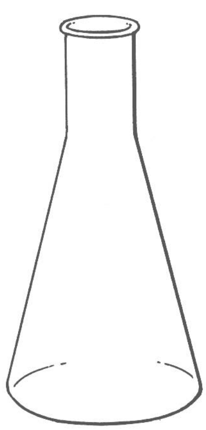
Deflagration spoon



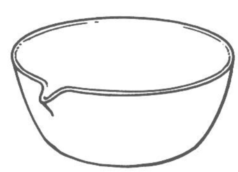
Clay triangle



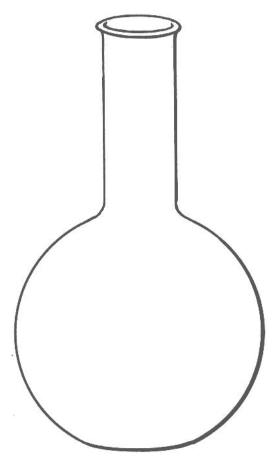
Crucible and cover



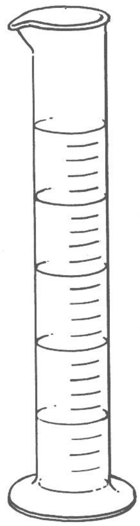
Erlenmeyer flask



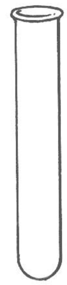
Evaporating dish



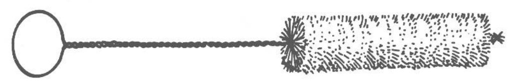
Florence flask



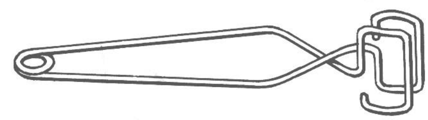
Graduated cylinder



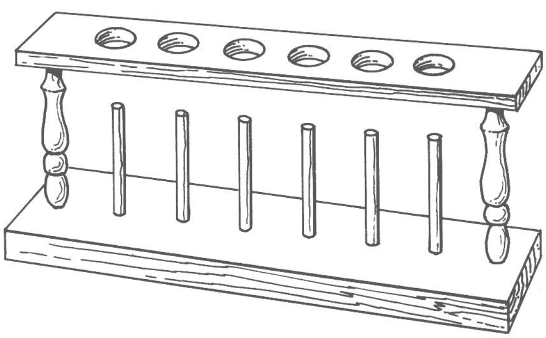
Test tube



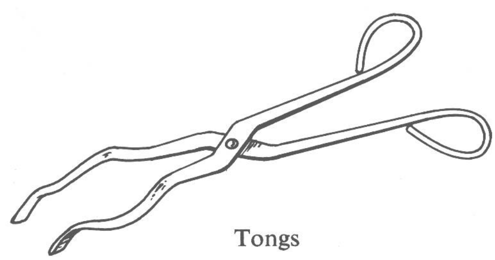
Test tube brush



Test tube holder

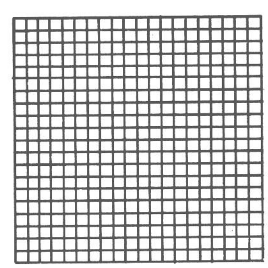


Test tube rack



Tongs

Watch glass



Wire gauze

TABLE OF CONTENTS

INTRODUCTION

SAFETY

By being aware of the hazards that are involved in laboratory work, recognizing their causes, and following directions for good laboratory procedure, accidents can be eliminated or reduced to a minimum. Accidents in a chemistry laboratory arise chiefly from three sources: fire, cuts from broken glass, and spilling of acids or bases or other corrosive chemicals on the person or on the clothing. Fires and burns result from improperly placed lighted burners during laboratory procedures or from picking up hot glassware or hardware with bare fingers. Chemical burns result from improperly heating solutions or improperly handling reagent bottles. Cuts result chiefly from the breaking of glass tubing or thermometers as they are thrust into or removed from stoppers.

In order to minimize the possibility of accidents, there are certain rules for good laboratory practice that must be followed. Before starting laboratory work, a student should become familiar with the location and use of fire extinguishing equipment, safety showers, etc. He should also know the location of first aid kits and how to use them in case of minor cuts and burns. Anything more than minor injury, however, should always be reported to the instructor.

When doing an experiment that calls for the use of a lighted burner, the burner should be placed so there is no danger of igniting hair, clothing, books or burner tubing. When heating flammable liquids, the directions given in the outline of the procedure should be followed.

One of the major sources of accidents is the spilling of corrosive solutions on the skin or on clothing. Most of these accidents result from improperly heating solutions. Solutions should never be heated in storage containers or in graduated cylinders that are not designed or intended to be used for heating. Both these kinds of apparatus are usually made of soft glass which is apt to break as it is heated. When heating a solution in a test tube, the flame should be applied along the side of the tube and below the surface of the liquid in order to distribute the heat over a greater area of the tube. When a solution is heated by a burner placed at the bottom of the test tube, the solution is very likely to superheat, and when it begins to boil it will be ejected out of the mouth of the tube. When heating a liquid in a test tube, be certain that the tube is not pointed toward yourself or some other person. Liquids heated in a beaker also may boil over because of uneven heating. To properly heat a liquid in a beaker, place the beaker on a wire gauze which is on a mounted iron ring or tripod and heat with a moderate flame. As the liquid starts to boil, the size of the flame should be reduced. Boiling chips should be used whenever possible.

Contact with liquid that runs down the neck of a reagent bottle or is spilled on the desk is another cause of chemical burns. When pouring solutions of corrosive liquids, care must be exercised to avoid spilling such liquids and, if spilled, they should be wiped up immediately and the area affected should then be washed. If spilled on the skin, wash immediately with water.

When diluting solutions, the concentrated solution should be poured *into* the water, not the reverse. A good rule to remember is:*Add acid (or other concentrated solutions) to water, never water to acid.* The heat produced is distributed throughout the solution and spattering because of local boiling is prevented.

Whenever a piece of glass tubing or a thermometer is inserted into or removed from a rubber stopper, great care must be exercised to prevent breaking the tubing. The bend in a piece of glass tubing should never be used as a lever for turning the tubing as it is thrust into or pulled out of the stopper. Glass tubing breaks with a razor sharp edge. The tubing or thermometer should first be wet with water or glycerol, then wrapped with a towel, grasped close to the stopper, and pushed straight into the stopper.

LABORATORY PRACTICE

In addition to rules designed to eliminate accidents there are rules for good laboratory practice. These rules help to make general laboratory work more productive of good results and more enjoyable for everyone.

Reagent bottles provided on side shelves should not be taken to working areas. Chemicals should be removed and the bottles placed back on the shelf. This eliminates time going around the laboratory looking for the bottle.

Stoppers for bottles should not be mixed. If bottles with standard taper stoppers are used, the stopper can be held between the fingers while the bottle is grasped for pouring.

When measuring a solution for an experiment, pour out approximately the amount needed. Any excess must be discarded and *not* poured back into the bottle. Excess solid materials that are removed from bottles should be placed in a box or disposal jar provided for that purpose.

Laboratory working area and laboratory equipment should be left clean at the end of each working period. Any reagents spilled on the desk should be washed off.

Never dip glass tubing or medicine droppers into a reagent bottle. The solution is of high purity and there is no certainty that the purity will remain after tubing or droppers are dipped into it.

Be certain to read the label on the bottle before removing chemicals. Concentrated H_2SO_4 **(con H_2SO_4)** is very different from dilute H_2SO_4 **(dil H_2SO_4)**. An error in reading a label can cause trouble.

The best way to clean glassware is to use a brush with detergent or soap, rinse with tap water and then rinse with distilled or demineralized water. Distilled water to be used in experimental work is expensive and should not be wasted.

If solutions are spilled on the skin, the local area should be washed with running water. Acid should be neutralized with baking soda (sodium bicarbonate). Bases may be neutralized with dilute acetic acid. These substances may also be used to neutralize strong acid or base spilled on clothing.

In the chemistry laboratory it is a good policy not to taste solutions unless instructed to do so; and, when an experiment calls for noticing the odor of a substance or solution, the odor should be detected by cautiously fanning the fumes toward the nose.

Unauthorized experimentation, such as mixing chemicals just to see what happens, is strictly not allowed. A student who mixes materials without regard to resultant hazards or wasting of supplies is not useful in a well-organized chemistry laboratory.

CONCLUSION

These rules are common sense rules. Any student who applies good judgement to his work is sure to have an enjoyable experience in the laboratory.

EXPERIMENT I

USE OF THE METRIC SYSTEM

The purpose of this experiment is to examine the metric system of weights and measures and to emphasize its importance as the scientific language used all over the world. It is the adopted system of weights and measures of every major industrial nation except the United States. Some of the reasons for such wide acceptance are: 1) It is the simplest system to use and 2) the units for measuring length, volume and mass are all in units of tens. Conversions within a unit of measurement are made by moving the decimal point. For example, $1.00 is equivalent to 10.0 dimes or to 100 cents or to 1000 mills. On the other hand, 100 cents is equivalent to $1.00.

Note that prefixes are used to indicate fractional or multiple parts:

deci = 1/10	milli = 1/1000
centi = 1/100	kilo = 1000

EQUIPMENT

Balance
Metal cylinder that has been previously weighed and the density determined
Metric-English ruler

PROCEDURE

I. Unit of length

a) Using a metric ruler, determine the number of centimeters equivalent to one inch.

b) Measure the (vertical) length of this page in inches. Use the figure obtained in part (a) to calculate the length in centimeters, then measure the length in centimeters.

c) Convert the length of the page to meters and millimeters.

II. Unit of volume

The standard unit of volume in the metric system is the *liter* which is equivalent to 1.06 quarts. 1 liter (1l) is equivalent to 1000 milliliters (ml). 1 milliliter is considered to be identical with 1 cubic centimeter (cc) (thus, 1000 ml = 1000 cc). The graduated cylinder is generally used for measuring small volumes and is usually calibrated in ml.

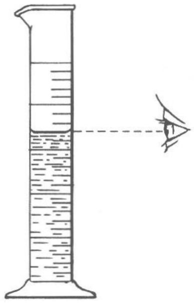


Figure 1.1
Reading the meniscus

a) Pour water into a 25 ml graduated cylinder until it is a little over half full. Note that the top surface of the water is curved. This curved surface is called a *meniscus.* When the volume of a solution is properly read, the eye should be on the same level as the *bottom* of the meniscus. Note further that the cylinder is marked "TC". This indicates "to contain" and, when the cylinder is filled to a definite mark, it holds the indicated volume of liquid. When a liquid (especially water) is poured out, some of it remains in the cylinder wetting the walls and the volume delivered is slightly less than that indicated. Read and record the volume of water to an accuracy of 0.1 ml.

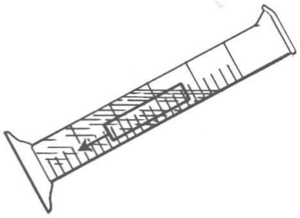


Figure 1.2
Sliding metal into graduated cylinder

b) Tilt the cylinder and slide a metal cylinder down into it being careful to avoid breaking the graduated cylinder. Read the new volume. The difference in the two readings is the volume of the metal cylinder.

III. Unit of mass

In the metric system the unit of mass is the kilogram or the gram. The conversion units between the English system and the metric system are:

1 kg = 2.2 pounds

1 pound = 454 grams

Note: Instruction must be given for proper use of a laboratory balance. Before proceeding to weigh an object be certain correct procedures are understood and followed.

a) Dry the metal cylinder used in Part II with a towel and weigh it. Precision in weighing with a good student grade balance should be to two or three decimal places.

Convert the weight of the metal cylinder to kilograms, to milligrams, and to pounds.

b) The density of matter is defined as the weight of a unit volume. The density of the metal cylinder is calculated by dividing its weight in grams by its volume in ml. The answer has units in grams/ml (g/ml).

Calculate the density of the metal cylinder and record this value. Also record the number on the cylinder or its composition (brass, copper, aluminum, etc.).

RESULTS

I. a) Metric equivalent of 1 inch = ______________ cm/in

b) Length of page in inches = ______________ in

Calculated length in cm = ______________ cm

Measured length in cm = ______________ cm

c) Length in meters = ______________ m

Length in millimeters = ______________ mm

II. a) Volume of the water = ______________ ml

b) Volume with metal cylinder added = ______________ ml

Volume of metal cylinder (b) – (a) = ______________ ml

III. a) Weight of metal cylinder = ______________ g

Calculated weight in Kg = ______________ Kg

in mg = ______________ mg

in lb = ______________ lb

b) Density of the metal cylinder = ______________ g/ml

Number or composition of cylinder = ______________

EXERCISES

1. From the measurements in Part I (b) calculate the number of inches equivalent to 1 meter. The actual value is 39.4 inches/meter. Account for any difference between the calculated and the actual value.

____

____

2. What is the volume of a rectangular copper block that has dimensions 5 cm by 15 cm by 20 cm?

____

____

3. If 1 cc of copper weighs 8.92 grams, what is the weight of the block of copper in question 2?

____

4. Calculate the metric equivalent of 5 inches in (a)______________ cm

(b)______________ mm

(c) ______________ m