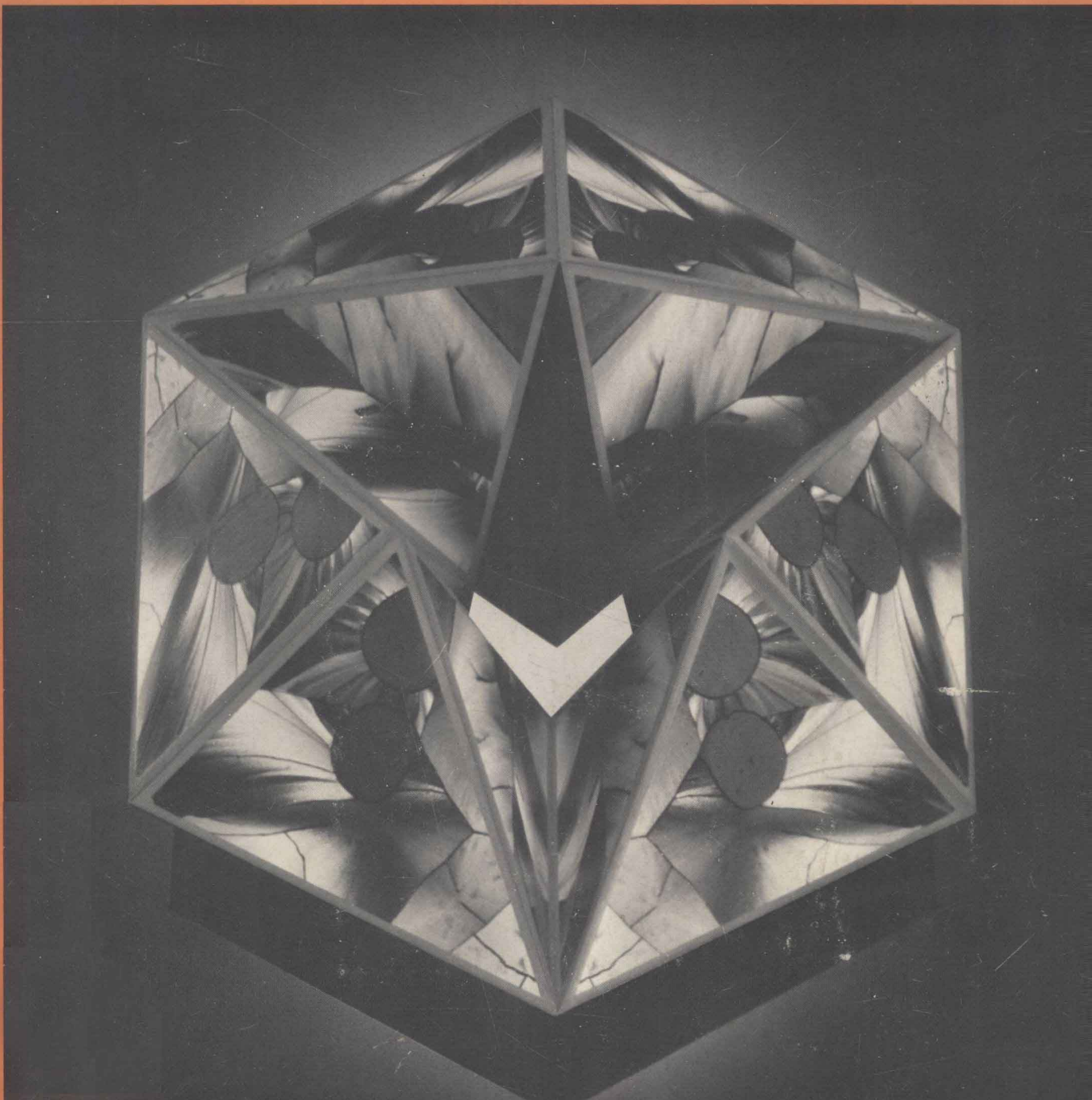
*Sixth Edition*

# Laboratory Manual for College Chemistry

William E. Bull, William T. Smith, Jr. and Jesse H. Wood



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SIXTH EDITION

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Laboratory Manual for College Chemistry, Sixth Edition



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# Preface

This laboratory manual has been written to accompany the textbook *General College Chemistry* by Charles W. Keenan, Donald C. Kleinfelter, and Jesse H. Wood. However, a sufficient variety and number of laboratory exercises are included to allow its use with most general chemistry texts. Only a brief general description of the principles involved precedes the outline of the experimental work. Therefore, the textbook should be brought to the laboratory and consulted freely.

As in earlier editions, a balance of quantitative experiments and common descriptive exercises of the chemical properties of a few elements is maintained. The exercises utilize a variety of common laboratory techniques and demonstrate concepts most frequently presented in introductory courses. Qualitative analysis with an abbreviated laboratory version, chosen carefully to illustrate the systematic principles associated with the separations and confirmatory tests, is included. Modification of exercises to minimize costs of equipment, chemicals, and disposal of wastes was of major importance in the preparation of this edition. Concern for the protection of both students and the environment from hazardous materials prompted several of the revisions.

The problems presented at the end of the exercises are new for this edition.

An *Instructor's Manual and Storeroom Guide* is available. In addition to listing required supplies for each exercise and detailed descriptions for reagent preparation, it provides solutions for all problems (about 100).

The authors take great pleasure in acknowledging the contributions and suggestions of their colleagues and friends to the various editions of this manual: N. S. Bowman, J. Q. Chambers, J. A. Dean, F. A. Grimm, C. W. Keenan, D. C. Kleinfelter, C. A. Lane, L. J. Magid, R. M. Magid, R. M. Pagni, J. R. Peterson, F. M. Schell, G. K. Schweitzer, W. A. Van Hook, E. L. Wehry, and C. Woods, III, of the University of Tennessee; E. D. Calloway, Birmingham-Southern College; David Y. P. Chou, Lenoir-Rhyne College; R. G. Gaunder, University of North Alabama; R. L. Hudson, Eckerd College; R. A. Paysen, Wofford College; A. A. Reidlinger, Long Island University; A. F. Saturno, State University of New York at Albany; J. C. Stallings, Sam Houston College; James A. Stanfield, Georgia School of Technology; and D. B. Stone, University of Tennessee (Martin).

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# *Instructions to the Student*

• Your Attitude Occasionally a student takes the position that his or her laboratory work consists solely of filling in an answer sheet. If this is your attitude, then ask yourself why you should come to the laboratory at all, for you can find the answers to all the descriptive questions in textbooks, and you or your instructor can supply hypothetical data that will enable you to make the calculations called for. The questions at the end of each exercise represent only a few of those that could be asked and that you should be able to answer if you have done the exercise properly.

It is important that you regard the laboratory as a place where you will do a good deal of observing and studying. Chemistry is not an abstract science, but much of its subject matter may seem unreal because it is new to you. For example, solving the problem "What weight of carbon dioxide can be obtained by the decomposition of 100 g of limestone?" involves no different mathematical procedure from solving the problem "How much sugar can you buy for $100?" But many students who take general chemistry never become proficient in doing problems like the first one.

A prime objective of the laboratory work is to emphasize the realistic nature of chemistry so that, in the end, the facts, laws, and theories will be better understood. You will do well in your work if you think of each exercise as being designed to extend your understanding of certain phases of the science. As you do the work and fill in the Data/Report Sheet, consider what other questions are answered by your work; be sure that you know the aims of the exercise and that you observe how these aims are achieved. Not infrequently your instructor will ask you what you are doing; if you have to refer to your manual to answer, you are not qualified to be doing the exercise.

Sometimes students have the mistaken idea that their answers must be the "correct" ones, irrespective of what they observe as they do the experiments. The answers you write in your manual should be based on your own observations. If your observations differ from the known facts, repeat the experiment or try to account for your contradictory observations. In any event, cultivate originality and self-reliance in your work. Even if you can predict the outcome of an experiment, do the work carefully. *When you hand in your Data/Report Sheet, your instructor will accept it with the understanding that you have performed the experiments as directed and that your answers are based on your own observations.* You may, of course, use your textbook at any time to help you interpret your work.

You can save valuable laboratory time by studying the assignment before coming to the laboratory.

• Laboratory Behavior Conduct in the laboratory is more informal than in the classroom. However, whistling, loud talking, singing, and so on are not appropriate.

Do not pester your neighbor for information. If you cannot get the answer from your observations and your books, see your instructor.

Do not throw solids in the sink.

Solids and liquids that are spilled anywhere in the laboratory must be cleaned up immediately.

Before leaving the laboratory make sure that (1) your equipment has been stored in your locker, (2) borrowed or community apparatus has been returned to the proper place, (3) your tabletop and hood area are clean, (4) the sink is free of trash, (5) gas and water are turned off, and (6) reagent bottles are in proper order and are free of adhering liquid (flush off the bottle with water if necessary, making sure that the stopper is tightly inserted). After all this has been done, tell your instructor that your area is ready for inspection.

• **Safety** Certain elements of danger are associated with many of the experiments you perform. Usually, your attention is called to this when the exercise is described. Pay strict attention to all warnings about safety.

Cuts resulting from inserting glass tubing into stoppers probably account for the greatest number of injuries. Burns caused by picking up hot glass or by the spattering of hot liquids are not uncommon. Injuries from corrosive chemicals such as acids and bases are usually infrequent, but they can be the most serious. Hot acids and bases are especially dangerous and must be handled cautiously. Acid burns are more often than not caused by the carelessness of a neighbor. Observe the methods of the students who work near you. If one of them pays no attention to where you are working when he or she is heating a liquid in a test tube or carrying on other dangerous procedures, speak to that student about it or, if necessary, to your instructor.

Remember that corrosive acids and bases are very soluble in water and can usually be washed off the skin before much damage is done. Haste is important. Familiarize yourself with the location of the showers and do not hesitate to use them if the occasion arises. Do not attempt to neutralize acids on your skin with strong bases, or vice versa. After flushing the material off with water, report to your instructor. (The weakly basic sodium bicarbonate may be used to neutralize residual acids, and very dilute acetic acid may be used to neutralize bases.)

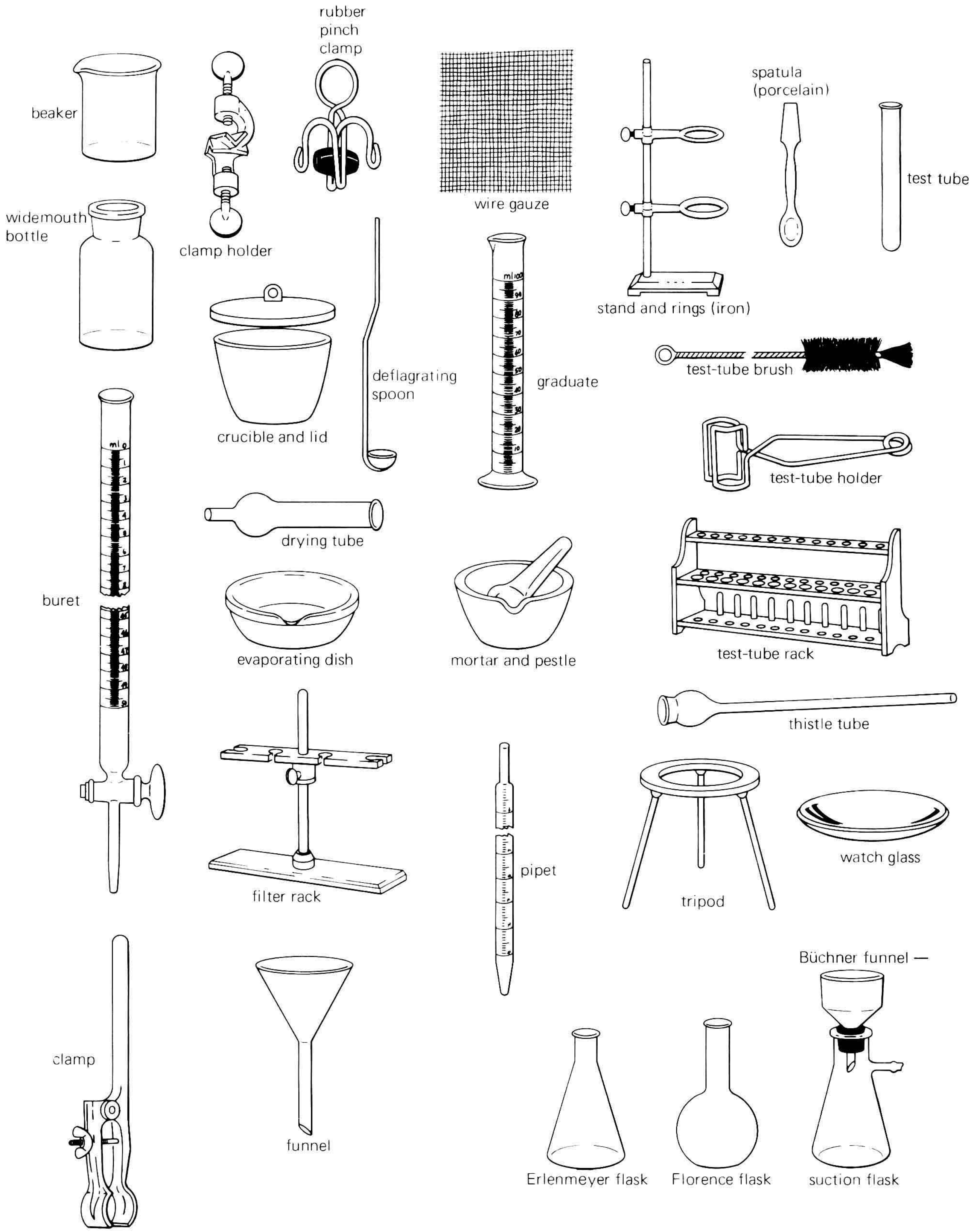
*Safety goggles must be worn at all times during the laboratory period.*

Directions often call for doing an experiment under the hood. A hood is a place in the laboratory where the air is vented by means of an exhaust fan. A good rule to remember is that all experiments that produce noxious fumes and gases must be done under the hood.

• Data/Report Sheet At the end of each exercise is a Data/Report Sheet organized to save your time in writing up your observations and your instructor's time in evaluating your work. Numbers enclosed in brackets that appear in the description of the experiment indicate the places on the Data/Report Sheet for your answers. Base your answers not on the abbreviated question on the Data/Report Sheet but on the full discussion in the description of the exercise.

While you are asked to study the experiment before coming to the laboratory, *you are not to fill in any part of the Data/Report Sheet that depends on laboratory observations.* These are to be filled in only after you have done the work.

• Calculations The solutions to all problems must be put on the Data/Report Sheets or on work sheets attached to the Data/Report Sheets. Units must always be specified except in the case of dimensionless answers.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evaporating dish
mortar and pestle
test-tube rack
thistle tube
filter rack
pipet
tripod
watch glass
Büchner funnel —
clamp
funnel
Erlenmeyer flask
Florence flask
suction flask

# *Special Safety Rules*

1. *Wear approved eye protection in the laboratory at all times.* This means eye covering that will protect both against impact and splashes. (If you should get a chemical in your eye, wash with flowing water from sink or fountain for fifteen to twenty minutes. The wearing of contact lenses, even under safety glasses, is forbidden because it restricts the washing out of chemicals in the eye.)
2. *Perform no unauthorized experiments.*
3. In case of fire or accident, call the instructor at once. (*Note location of fire extinguisher and safety shower so that you can use it if needed.* Wet towels are very efficient for smothering small fires.)
4. You must go to the infirmary for treatment of cuts, burns, or inhalation of fumes. Your instructor will arrange for transportation if needed.)
5. Do not use the laboratory as an eating place; do not eat or drink from laboratory glassware.
6. Exercise great care in noting the odor of fumes, and avoid breathing fumes of any kind.
7. Do not use mouth suction in filling pipets with chemical reagents. (Use a suction bulb.)
8. Do not force rubber stoppers onto glass tubing. (Lubricate the tubing and protect your hands with a towel when inserting tubing into stoppers; keep your hands close together.)
9. Confine long hair when in the laboratory. Also, a laboratory apron is essential when you are wearing easily combustible clothing. (Such an apron affords desirable protection on all occasions.) Shoes must be worn.
10. Never work in the laboratory alone.

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(Detach and return signed statement to your instructor. The instructions should be retained for later reference.)

I have read the general laboratory instructions and the special safety rules, and I will observe them in my chemistry course.

Date ______________ Signature ________________________________________

# Contents

# Basic Laboratory Procedures and Techniques

Exercise

# 1

Students who have had a year of high school laboratory work in biology or chemistry will be familiar with much of the material in this experiment. Accordingly, the experiment is written largely as a review exercise, with suggestions for laboratory work. Students need not do suggested work when they and their instructors decide that past training is adequate. Students who have had little or no training in laboratory work should do the suggested work carefully and may require two laboratory periods for completion.

## • The International System of Units

Scientists throughout the world are being urged to use the International System of Units, known as **SI units**. The SI system represents a revision and extension of the metric system in which seven basic units are defined (see Table A.1 in the Appendix). All physical measurements can be expressed in terms of these seven units. For example, volume can be expressed in cubic meters, thus relating the measurement to the SI unit of length, the meter. A standard set of prefixes indicating fractions of the base unit, such as 1/10 or 1/1000, or multiples of the base unit are listed in Table A.3. *Deka-*, *kilo-*, and *mega-* indicate units in which the original unit is multiplied by 10, 1,000, and 1,000,000, respectively. Examples are dekameter, kilometer, and megameter. Thus, the defined units are related to other units by some factor of ten, which makes interconversions quite easy.

Although the SI system does not include the traditional metric system unit of volume, **liter**, we will use the unit, liter (abbreviated L), in this manual. Few equipment items are presently available with SI calibrations for volume measurements.

Memorize the more common units of length, volume, and mass. Practice using them until you can estimate simple distances, volumes, and masses in centimeters, milliliters, and grams as readily as you can estimate in inches, pints, and pounds (see Table 1.1). (It is a matter of choice whether abbreviations of the units are followed by a period; we will not use periods in this manual.)

**Table 1.1.** Units of Measurement

| |
|---|
| **Units of length** |
| 1 meter (m) = 100 centimeters (cm) = 1,000 millimeters (mm) |
| 1 kilometer (km) = 1,000 m = 0.6214 mile (mi) |
| 1 m = 39.37 inches (in.) = 1.094 yards (yd) |
| 1 in. = 2.540 cm |
| **Units of mass** |
| 1 gram (g) = 1,000 milligrams (mg) |
| 1 kilogram (kg) = 1,000 g |
| 1 g = 0.03527 ounce (oz) |
| 1 oz = 28.35 g |
| 1 kg = 2.2046 pounds (avoirdupois) (lb) |
| 1 lb = 453.6 g |
| **Units of volume** |
| 1 liter (L) = 1,000 milliliters (mL) = 1,000 cubic centimeters ($cm^3$) |
| 1 mL = 1 $cm^3$ |
| 1 L = 1.056 liquid quarts (qt) |
| 1 gallon (gal) = 3.785 L |
| **Units of amount** |
| 1 mole (mol) = $6.02 \times 10^{23}$ atoms, molecules, or ions of the substance |

## • Precision of Measurements

**• Decimal Estimation** The distance between two graduations on a ruler, a thermometer, or a graduated cylinder can usually be subdivided into tenths, two tenths, or five tenths by estimation. For example, suppose that you are measuring the diameter of a piece of filter paper with a 15-cm scale. Let us imagine that one end of the diameter is at the zero point and the other end falls between the divisions representing 11.0 cm and 11.1 cm. If this end appears to be exactly midway between these two divisions, the length is recorded as 11.05 cm; if it is slightly short of the halfway point or extends slightly beyond, the diameter might be recorded as 11.04 cm or 11.06 cm, respectively. If the end is barely beyond the 11.0 cm division, the diameter might be recorded as 11.01 cm or 11.02 cm.

**• Recording Data; Significant Numbers** In recording measurements, it is desirable to put down enough numbers to indicate the precision of the measurement. When this is done, the last number recorded is significant but somewhat doubtful.

For example, expressing the diameter of a piece of filter paper as 11 cm implies that the diameter is nearer to 11 cm than it is to 10 or 12 cm. Expressing the diameter as 11.00 cm implies that you have made a precise measurement and that you are certain of all the figures except the last one. The diameter lies somewhere between 11.01 cm and 10.99 cm if your decimal estimation is considered to be correct to plus or minus one hundredth of a centimeter.

**• Rounding Off Answers** The need for rounding off answers is illustrated by the following example. A quantity of oxygen has been collected, and its volume has been measured as accurately as possible as 82.2 mL (the last figure is somewhat doubtful). You now desire to calculate the weight of the oxygen. A handbook gives the density of oxygen as 0.001429 g/mL. Multiplication (82.2 $\times$ 0.001429) gives 0.1174638 g as the answer. To say that the 82.2 mL of oxygen weighs precisely this amount is absurd, because the product of a multiplication (or any other mathematical manipulation) cannot be more precise than the *least* precise measurement used in the calculation. Since the volume contains only three significant figures (the density has four), the answer should be rounded off to three significant figures (0.117 g).

In rounding off numbers, if the figure following the last significant figure is less than 5, discard all but the significant figures; if more than 5, add 1 to the last significant figure. Thus, if three significant figures are to be shown in this answer, 0.11746 is rounded off to 0.117, but 0.11782 is rounded off to 0.118. If the figure following the last significant figure is 5, the last significant figure is rounded off to the nearest even number. For example, with three significant figures, 0.1175 is recorded as 0.118, but 0.1165 is recorded as 0.116.

**• Precise Quantities Versus Approximate Quantities** In laboratory work, measuring out an exact quantity of material is often unnecessary. In these cases, a quantity convenient to work with is specified, but you do not need to measure it precisely. Conversely, in quantitative experiments, a convenient quantity is also indicated, but this amount must be measured as accurately as possible. For example, the statement "Weigh about 2 g of $KClO_3$ to the nearest 0.01 g" implies that you will place on the balance pan enough $KClO_3$ for the weight to be about 2 g, and that you will then proceed to weigh that quantity with a precision of ±0.01 g. Five students doing this weighing might use five different amounts with weights such as 1.91, 1.94, 2.08, 2.12, 1.88 g. It is necessary to know the weight actually used to within ±0.01 g, but it is not necessary to use exactly 2.00 ±0.01 g.

## • Measurements

**• Length** The units most commonly used in laboratory work to express diameters, radii, wavelengths, and other linear dimensions are meters (m), centimeters (cm), millimeters (mm), and micrometers ($\mu$m). Figure 1.1 shows a 15-cm scale, which you may use in measuring ordinary lengths. Usually, meter sticks are available in the laboratory for measuring larger distances. Note that the major divisions of the 15-cm scale or of a meter stick are centimeters. Note also that each centimeter is divided into ten equal divisions, that is, millimeters.

**• Volume** Beakers and flasks are marked to indicate approximate volume only. Usually, the actual volumes are somewhat larger. In laboratory work, the graduated cylinder (Fig. 1.2), the buret (Fig. 16.1), and the pipet are used to measure the volumes of liquids. The graduated cylinder is most commonly used. As a general rule, the

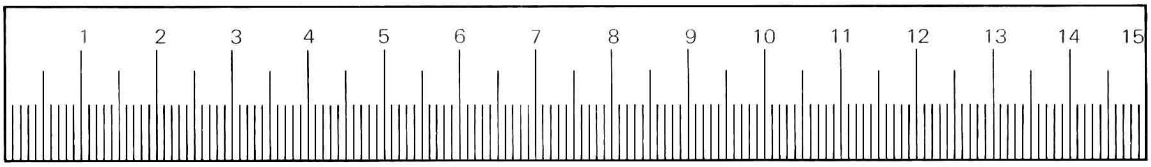


Figure 1.1.

cylinder chosen for measuring should not have a volume more than ten times the volume to be measured (an accuracy of about 0.5 percent is possible). The point on the graduated scale that coincides with the bottom of the curved surface of the liquid (the *meniscus*) is read as the volume (Fig. 1.2).

• Weight or Mass Pictured in Figs. 1.3–1.5 are three different types of balances. For the balance

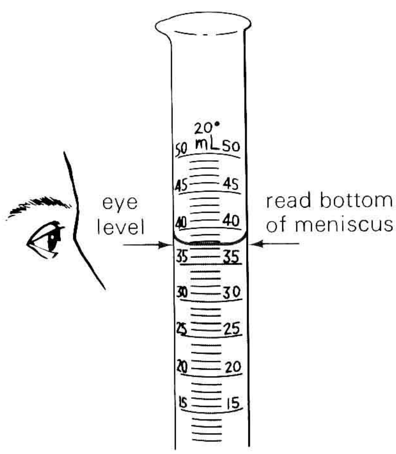


Figure 1.2.

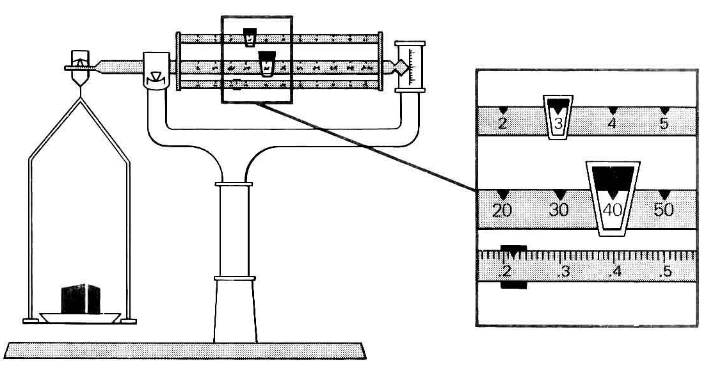


Figure 1.3.

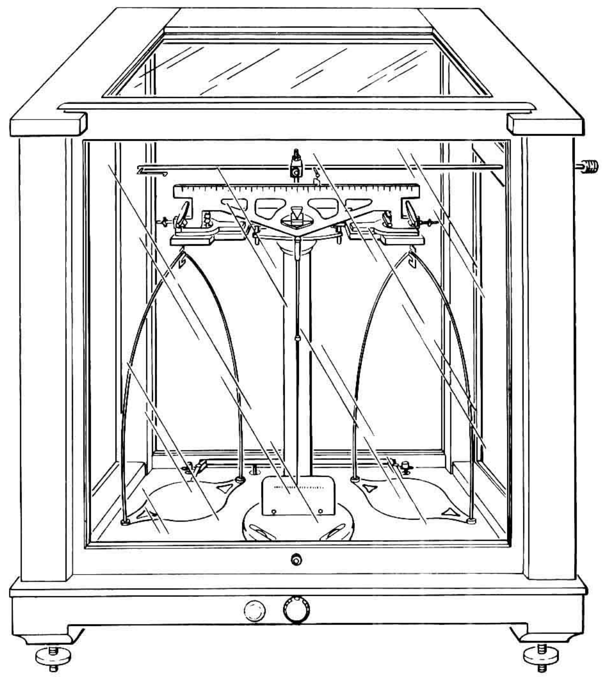

Figure 1.4.

shown in Fig. 1.3, the object to be weighed is placed on the pan and then the weights are moved to the right on the beam until they just balance the weight of the object. For example, the weight of the object pictured on the triple-beam balance in Fig. 1.3 is 43.22 g. Weighing on an analytical balance, Fig. 1.4, follows the same plan except that weights, which have been carefully calibrated, are placed on the right pan until the object is nearly balanced. A small rider weight is then moved along the beam at the top until the pointer shows that a balance between the weights and object has been obtained. A more recent type of balance, and a relatively expensive one (Fig. 1.5), automatically records the weight on a dial, after one has added (by turning a knob) enough 10-g weights to come within 10 g or less of the weight of the object.

Since there are several varieties of each

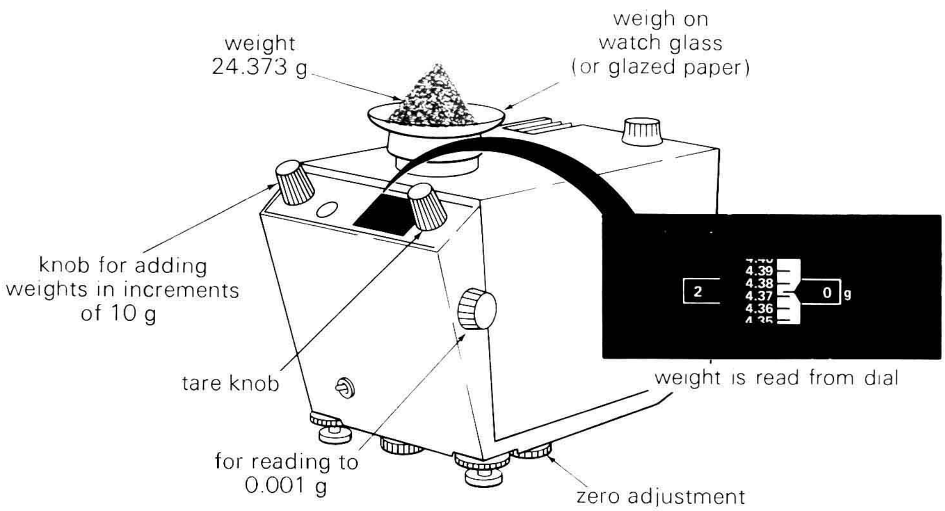


Figure 1.5.

type of balance pictured here, as well as of other types, a fuller description of how to use and care for a specific balance is left to the laboratory instructor. However, some general guidelines that are applicable to the care of all types are as follows:

1. Treat the balance as a delicate, expensive instrument. For example, the balance shown in Fig. 1.5 costs about $1,800.
2. Do not subject the balance to shock by dropping weights and objects on the pans. Place them gently.
3. Powders, granular solids, and liquids are not to be placed directly on the pan. Use a container such as a watch glass, filter paper, or wax paper. Of course, two weighings must be made: weigh the container first and then the container and the object.
4. Usually, when the balance is out of adjustment, notify the instructor. Do not attempt an adjustment unless authorized to do so.
5. After completing a weighing, return weights to the zero position or to their container. Perform all other tasks necessary for leaving the balance in a state of rest.
6. If by chance some spillage has occurred, clean up the balance and area.

• Choice of Balance The magnitude of the weight to be measured and the accuracy desired should determine the type of balance used. Automatic recording balances (similar to that shown in Fig. 1.5) are available in models that have a maximum capacity ranging from 10 g to several kilograms, with an accuracy of ±0.00001 g to ±0.5 g, respectively. Triple-beam balances like that shown in Fig. 1.3 can be used to determine weights of less than 10 g with an accuracy of ±0.01 g. Standard analytical balances (Fig. 1.4) are reliable to ±0.0001 g. Seldom, however, is this degree of precision needed in general chemistry experiments. In order that the probable error due to weighing be no more than the probable error of other measurements made in a given quantitative experiment—for example, volume and temperature measurements—one usually needs to weigh with a probable error of one part in a hundred. This means that the weight should be determined to the nearest 0.01 g for objects with masses of about 1 g and to the nearest 0.001 g for objects with masses of about 0.1 g. Either the analytical balance, Fig. 1.4, or the top-loading balance, Fig. 1.5, permits this kind of precision.

• Suggested Work

• Length Using a 15-cm scale (Fig. 1.1) or a meter stick, determine the length of this sheet of paper, your height, and the surface area of your work space.

• Volume Using a graduated cylinder, determine the capacity of a test tube, an evaporating dish, and a medium-sized beaker.

• Mass Weigh a piece of filter paper and a small beaker on a balance (or balances) designated by your instructor.

• Gas Burners

The Bunsen and Tirrill burners are most often used in laboratory work to provide elevated temperatures. These are shown in Fig. 1.6. They allow nearly complete combustion of gaseous fuels since they give the correct ratio of fuel to air and the correct mixing of these gases in the barrel of the burner. Since a gas burner will be used in many of the experiments you perform, it is important for you to understand how it operates and how to adjust the air and gas to obtain maximum temperatures.

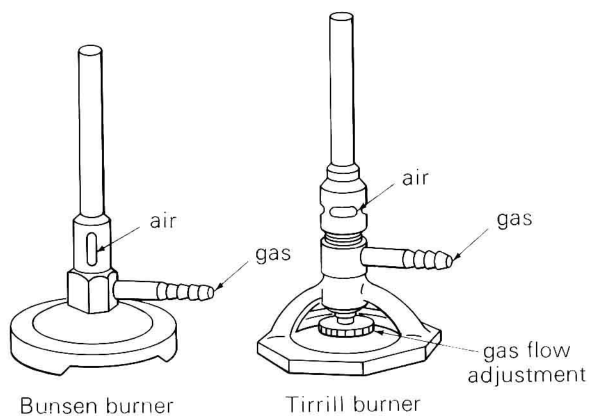


Figure 1.6.

• Glassworking

To cut glass tubing, place the glass tube on the table and make a single deep scratch with a triangular file or tubing scorer. Next, grasp the tube firmly in both hands, thumbs almost touching and opposite the scratch (Fig. 1.7), and break the tube with gentle pressure of the fingers.

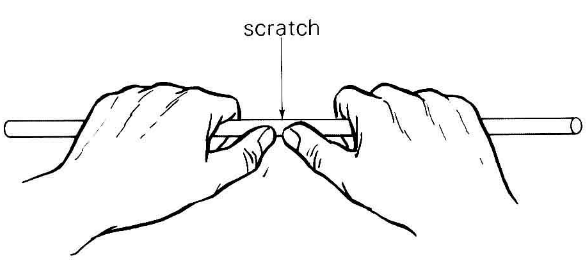


Figure 1.7.

To bend glass tubing, hold the tube lengthwise in a wing-top flame (Fig. 1.8) of the burner so that about 6 cm of the glass will be heated uniformly (Fig. 1.9). Rotate it slowly so that all sides are heated equally. When the tube softens (do not let it sag), remove it from the flame and make the desired bend. The bend should be uniformly curved, with no flat places or kinks (see Fig. 1.10).

To make a glass nozzle, remove the wing top from the burner and rotate a short piece of glass tubing in the flame until the glass is thoroughly soft. Remove the tubing from the flame and draw it out with a firm pull. It should be


Figure 1.8.

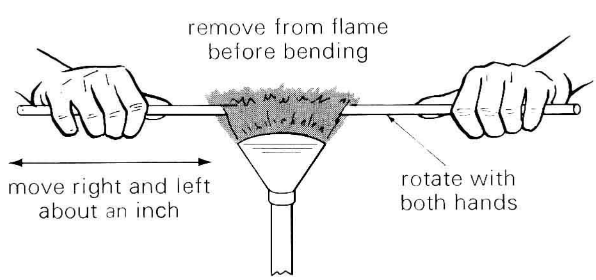


Figure 1.9.

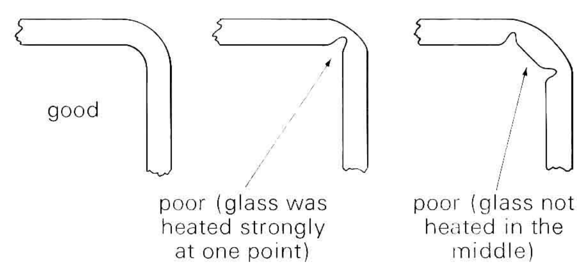


Figure 1.10.

drawn to the desired size in one movement. The constricted glass tube is then cut to give a nozzle of the desired diameter.

Fire-polishing the ends of glass tubing makes a sharp and jagged end smooth. To fire-polish, hold the tube almost vertically in the flame and rotate it slowly till the glass softens and becomes smooth (Fig. 1.11). Do not hold the tubing in the flame too long, because the opening will become smaller. The ends of all glass tubes must be fire-polished.

To close the end of a piece of tubing, proceed just as you did in fire-polishing, but keep the end of the tube in the flame until it is completely sealed.

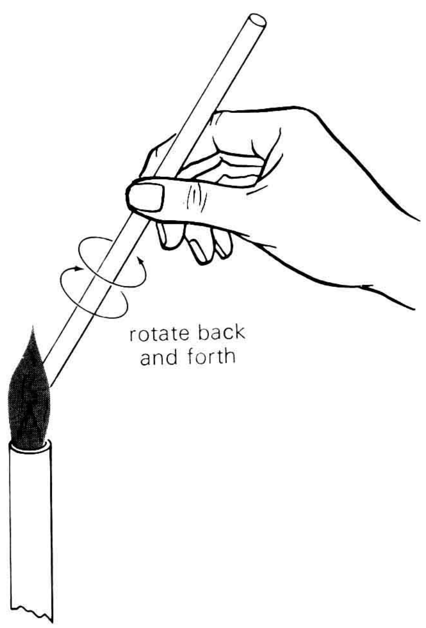


**Figure 1.11.**

• Insertion of Glass Tubes

To insert a glass tube in a rubber stopper, lubricate both the tube and the stopper. Glycerol is excellent for this purpose and should be used if the fit of glass into rubber is to be a tight one; water may be used for less tight fits. *Work the glycerol into the hole of the stopper with a splint or match, making sure that the wall is well covered.* Protecting your hands with a towel, insert the tube by applying a gentle rotary pressure. *Proceed with care, and keep your hands close together.* If your hands are several inches apart and the glass tube breaks, you will almost surely be cut when your hands move toward each other.

• Suggested Work

• Burner Begin to study your burner by cleaning it if it is dirty. When lighting the burner, turn on the gas and bring a burning match to the top of the burner from the side rather than from above. This prevents the match from being blown out by the gas. Light the burner and keep it lit for the following experiments.

Find out how to alter the flow of air and gas into the barrel. Close the air intake at the bottom of the burner completely and adjust the gas flow so that the flame is about 5 in. high. Note that the flame is luminous. With the air intake completely closed, hold a cool evaporating dish with forceps or tongs in the flame near the top until a deposit other than moisture can be seen. What condenses on the evaporating dish? Account for the luminosity of the flame.

Gradually open the air intake until the flame forms two major cones. Determine the hot and cool regions of the cones by holding an iron wire (the end of the deflagrating spoon will serve) in various parts of the flame and noting the time required for the wire to become red hot. Thrust a wooden splint quickly into the center of the inner cone. Does the wood in the inner cone char or burn? From your observations, diagram the flame and indicate the hotter and cooler regions.

• Glassworking Your instructor will ask you to make one or more of the following items. In order for them to pass inspection, all bends must be well rounded; the ends of open glass tubing must be fire-polished; and the dimensions must be approximately as shown. Obtain your instructor's approval of the apparatus.

1. Make the wash bottle shown in Fig. 1.12.
2. Make two stirring rods, one suitable for stirring liquids in small beakers, the other long enough for stirring liquids in large beakers. Do this by sealing off both ends of pieces of glass tubing.

• Handling Liquids

When pouring liquids from a beaker, you can prevent splashing by holding a stirring rod against the edge, as shown in Fig. 1.13. To pour from a bottle, hold the stirring rod vertically against the

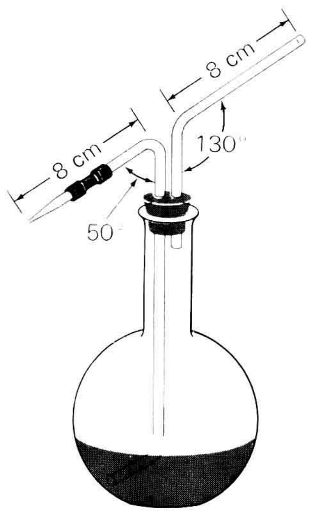


Figure 1.12.

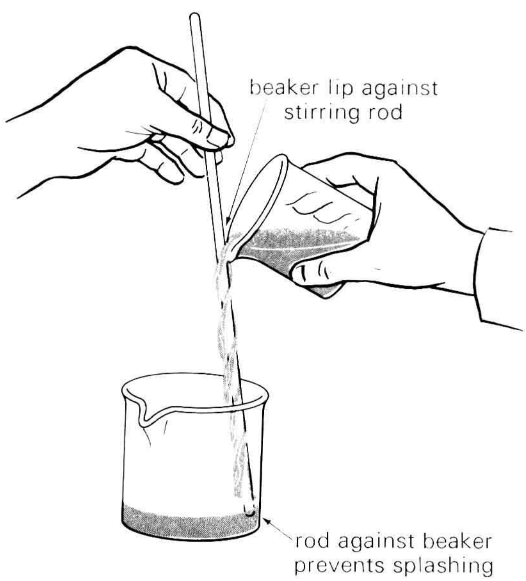


Figure 1.13.

mouth of the bottle. This directs the flow of the liquid into the container and prevents it from running down the side of the bottle.

Remove stoppers from bottles and hold them while pouring, as shown in Fig. 1.14. Never lay stoppers on the tabletop.

The top of a bottle often becomes encrusted with salts, or some liquid is left on the rim after pouring. When either happens, flush off the bottle by holding it, with stopper firmly inserted, under a stream of water.

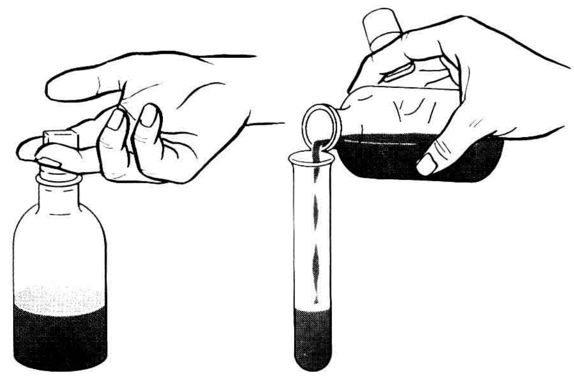

Figure 1.14.

Occasionally, a procedure calls for the dropwise addition of a liquid. This is best done from a pipet or a glass tube that has been drawn to a nozzle at one end. Do not fill the glass tube or pipet by inserting it in a reagent bottle; instead, pour approximately the amount of liquid needed into a test tube and then insert the glass tube and let it fill by gravity, or use a rubber bulb like that on a medicine dropper to pull the liquid into the tube. *Never fill a glass tube with a corrosive liquid by sucking the liquid into the tube with your mouth.* If you take more of a reagent than you need, discard the excess; do not put it back in the reagent bottle. Make every effort to avoid contaminating stock chemicals.

Small amounts of a liquid may be heated in a test tube (Fig. 1.15). Bring the water to boiling by holding the tube at a 45° angle and passing it back and forth over the tip of the flame so that the flame strikes the tube some-

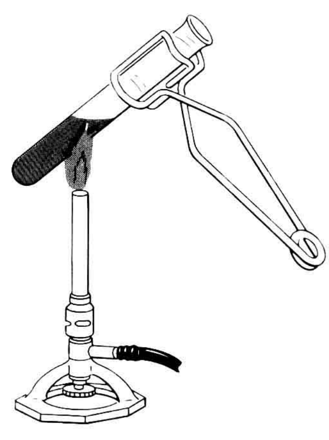

Figure 1.15.

what below the surface of the liquid. Be careful that the flame does not strike the glass above the surface of the liquid. Do not apply heat to the bottom of the test tube, because the formation of steam may cause the liquid to be expelled suddenly and forcefully. For this reason, never point a tube toward anyone.

- Handling Solids

Remove solids from containers as directed in Figs. 1.16 and 1.17. *Make sure that the spatula you use is thoroughly clean and dry.* After the solid has been removed, replace the stopper (or screw cap) tightly to prevent dust and moisture from getting into the contents. *Be very careful to avoid changing stoppers or lids.* In weighing chemicals, place them on paper or glass, never directly on the balance pans.

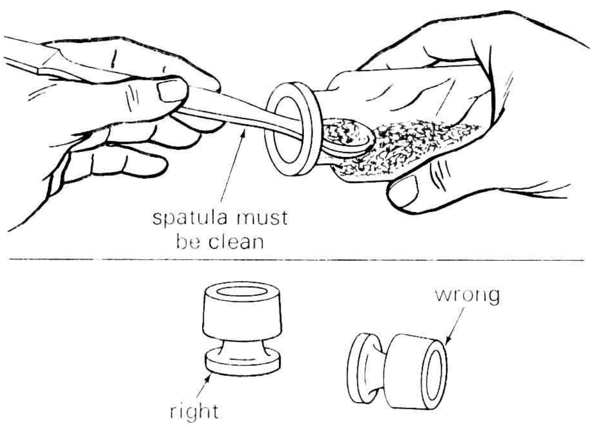


**Figure 1.16.**

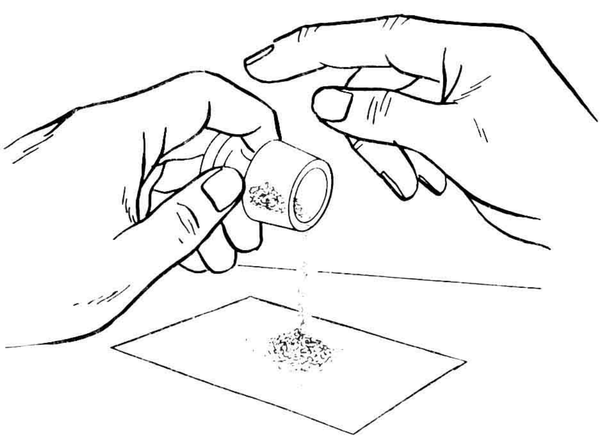

**Figure 1.17.**

**Figure 1.18.**

- Filtration and Decantation

- Filtration  Filtration is the process of removing solid particles from a liquid by pouring the mixture on a filter paper (Figs. 1.18 and 1.19). The liquid passes through the filter paper, leav-

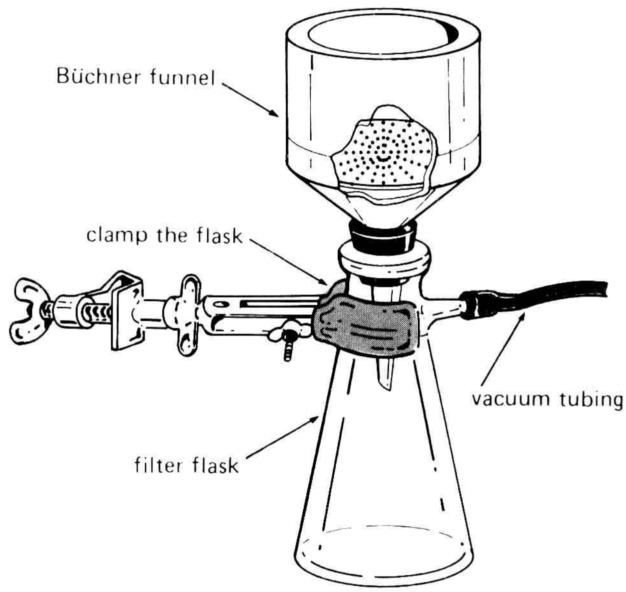


**Figure 1.19.**