Laboratory Measurements, Equipment, and Safety

Section 1.2
Laboratory Equipment

Most of the time, conducting scientific experiments requires the use of one or more types of equipment. The following is a review of the most common types of equipment and their uses.

Glassware for Measuring and Dispensing Liquids

When accurate measurements are needed for liquid volume, scientists use glassware that are marked with graduations.

Graduated Cylinder

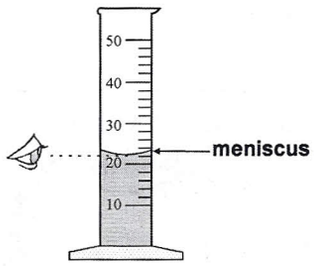


Fig. 1-4

A **graduated cylinder** (figure 1-4) is used to accurately measure the volume of liquids. The most common measurement for volume is milliliters, abbreviated mL. In figure 1-4, each mark or "graduation" represents 2 mL.

When measuring liquid in a graduated cylinder, you read the amount of liquid from the center of the **meniscus**. The meniscus is the curve at the surface of the liquid. The meniscus of most liquids curves down, but the meniscus of mercury curves up. The volume of liquid shown in figure 1-4 is 22 mL.

Graduated cylinders are not the only pieces of glassware used for measurements. For very small liquid measurements, you can use a **pipette** (figure 1-5), **burette** (figure 1-6), or **syringe** (figure 1-5). These pieces of equipment are usually used for *dispensing* liquids in measured amounts.

Pipette

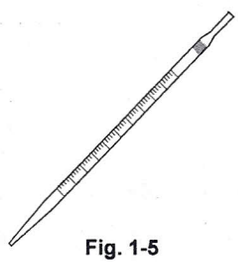


Fig. 1-5

Burette

Fig. 1-6

Syringe

Fig. 1-7

Dropper

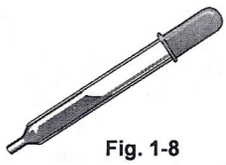


Fig. 1-8

Droppers similar to the one in figure 1-8 are used sometimes for dispensing and measuring small amounts of liquids, but they must be used carefully to make sure that the drops are the same size. As a general rule of thumb, 20 drops equal 1 mL.

Glassware for Storage, Handling, and Observations

Not all glassware is used for measuring and dispensing liquids. Some types are used for holding, mixing, or storing liquid.

For small amounts of liquids, **test tubes** (figure 1-8) can be used for mixing and handling. Some have caps that allow them to be used for storage as well.

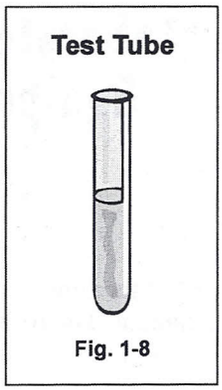


Fig. 1-8

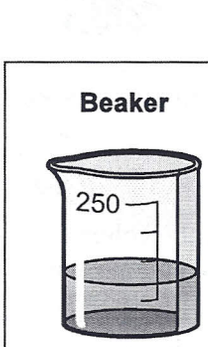


Fig. 1-9

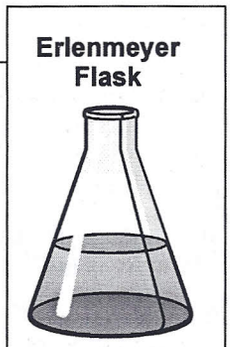


Fig. 1-10

Beakers (figure 1-9) and **Erlenmeyer flasks** (figure 1-10) are commonly used for storing and mixing liquids. Some have measurement markings, but these containers ***do not*** give accurate measurements. A 250 mL beaker or Erlenmeyer flask will hold 250 milliliters of liquid, but you wouldn't use the beaker or the flask to accurately measure 250 mL.

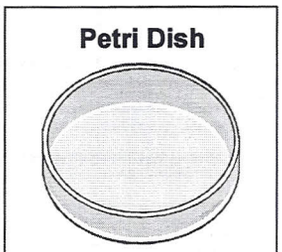


Fig. 1-11

A **petri dish** (figure 1-11) has several uses. It is commonly filled with an agar and nutrient solution and then used to grow and observe bacteria cultures. It can also be used to observe seed germination or small animal behaviors.

Equipment for Measuring Mass

To find the mass of an object, a **scale balance** is used. The most common types of scale balances are the triple beam balance (figure 1-12) and the electronic balance (figure 1-13). Both types of balances measure mass in grams.

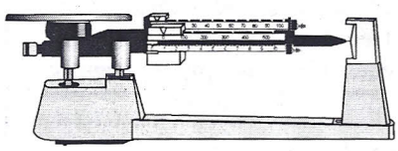


Fig. 1-12

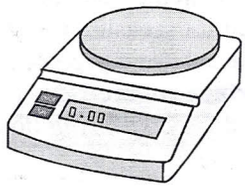


Fig. 1-13

Equipment for Measuring Weight or Force

Remember, mass and weight are not the same thing. **Weight** is a measurement of the force of gravity on an object, and it is measured in **newtons**. (The newton is the SI unit for force.) If you went to the moon where the gravity is only about 20% of the earth's gravity, your mass would not change since your body would contain the same amount of matter, but your weight would be less on the moon than on earth due to gravity.

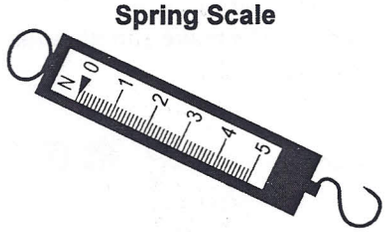


Fig. 1-14

Weight or force is measured using a **spring scale**. Your bathroom scale is a spring scale although it does not look like the one in figure 1-14. Some scales have a dial readout, and others have a linear scale as shown in figure 1-14. To find the weight of an object using this spring scale, you would hold the scale up and attach the object to be weighed to the hook at the bottom. The spring will stretch, and the pointer will move along the scale and point to the number that shows the object's weight.

Equipment for Heating

Many scientific experiments use a heat source as part of the lab equipment. While the heat source may be as simple as a light bulb, it is more often a Bunsen burner or a hot plate burner.

A **Bunsen burner** (figure 1-15) uses gas to produce a flame. The flame of a Bunsen burner can reach temperatures up to 1500°C. That's hot! Bunsen burners are commonly used to heat liquids in test tubes or to heat solid objects that can be held by tongs.

Bunsen Burner

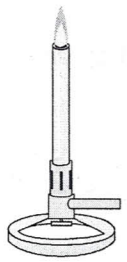


Fig. 1-15

Hot Plate

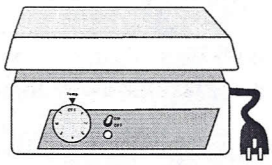
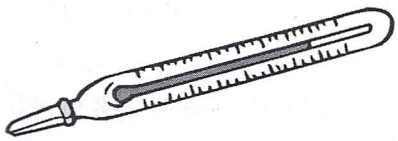


Fig. 1-16

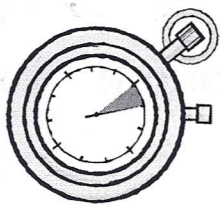
Hot plates (figure 1-16) may be used for some experiments. Even though they do not produce an open flame, they must be used with caution. They should never be left unattended. Hot plates are commonly used to heat liquids in beakers and flasks, especially when the liquid needs to be stirred. (Many hot plates have built-in stirrers that will spin magnetic stir bars when these bars are placed in the liquid on top of the hot plate.)



The **thermometer** is the most common piece of equipment used in the laboratory to determine temperature. Most laboratory thermometers are marked in degrees Celsius, but they may be marked with degrees Fahrenheit as well.

Equipment for Measuring Time

The SI Unit for time is the **second**. When an experiment requires time to be recorded, the most often used piece of equipment is the **stopwatch**.



Optical Equipment

Many times, scientists need to observe either very small objects or objects that are far away. In these cases, different types of optical equipment are used.

Probably the most widely used piece of optical equipment is the **microscope**. Most people can't see details clearly on anything much smaller than 0.1 mm, so scientists may use a microscope to study smaller objects. The units of length usually used for microscopic measurements are the **micrometer, µm**, which is only one thousandth (1/1,000) of a millimeter, and the **nanometer, nm**, which is one millionth (1/1,000,000) of a millimeter.

A **light microscope** (figure 1-17), the most common type, focuses light rays that pass through the specimen to produce a magnified image. A light microscope can be used to view cells and some cell organelles. The light microscope is sometimes called a *compound microscope*. To view objects under a light microscope, the objects must be thin enough for light to pass through them. Objects to be viewed are mounted on **slides**, special pieces of glass that fit under the microscope's lens. Temporary slides called **wet mount slides** are made by placing a specimen in a drop of water and then covering the specimen with a cover slip.

Light (or Compound) Microscope

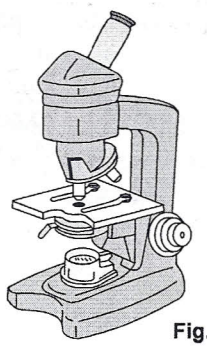


Fig. 1-17

Electron microscopes focus beams of electrons instead of light rays. Electron microscopes have much better **resolution** — that is, they magnify objects more and get clearer details at higher magnification than light microscopes. They can be used to view objects as small as a strand of DNA, which cannot be viewed by a light microscope. Electron microscopes cannot be used to view living objects though.

Laboratory Equipment

To view objects that are far away, scientists use binoculars or a telescope.

Binoculars (figure 1-18) can be used to view everyday objects that are too far away to be seen clearly.

A **telescope** (figure 1-19) is commonly used to view objects in outer space, such as planets, moons, stars, asteroids, etc.

Binoculars

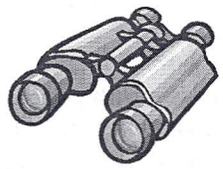


Fig. 1-18

Telescope

Fig. 1-19

Practice

Answer the following question on laboratory equipment.

Ⓐ Ⓑ Ⓒ Ⓓ 1. Which of the following pieces of optical equipment would you use to view a wet mount slide?
A. compound microscope
B. electron microscope
C. binoculars
D. telescope

Ⓐ Ⓑ Ⓒ Ⓓ 2. Which of the following would be the BEST choice to mix and store a small amount of a liquid?
A. beaker
B. syringe
C. pipette
D. capped test tube

Ⓐ Ⓑ Ⓒ Ⓓ 3. In a chemistry experiment, Tyson needs to measure exactly 10 mL of chemical. Which of the following pieces of equipment would be MOST appropriate for him to use?
A. beaker
B. graduated cylinder
C. Erlenmeyer flask
D. test tube

Ⓐ Ⓑ Ⓒ Ⓓ 4. A scientist needs to determine the exact mass of a residual powder. Which of the following pieces of equipment should be used?
A. scale balance
B. thermometer
C. spring scale
D. compound microscope

Ⓐ Ⓑ Ⓒ Ⓓ 5. A laboratory experiment requires students to find the change in temperature of several liquids over time as the liquids are heated. Which of the following pieces of laboratory equipment would MOST likely be used in the experiment?
A. hot plate, petri dishes, spring scale, thermometer
B. petri dish, Bunsen burner, thermometer
C. test tubes, slides, microscope, stop watch
D. beakers, hot plate, thermometer, stop watch

Ⓐ Ⓑ Ⓒ Ⓓ 6. A physical science experiment requires students to find the average velocity of a rolling ball as it travels down a ramp at different slopes. If velocity is calculated by dividing distance over time, which of the following pieces of equipment would be MOST appropriate for the experiment?
A. stop watch and graduated cylinder
B. tape measure and stop watch
C. tape measure and binoculars
D. scale balance and stop watch

Laboratory Measurements, Equipment, and Safety

Section 1.3
Laboratory Procedures and Safety

Safety Equipment

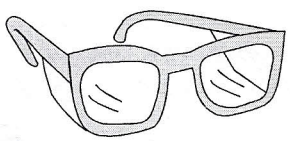
Before you start your first lab activity, you should know the location of the safety equipment in the room and when and how to use it. Most laboratories include the following safety equipment:

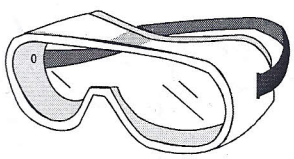
- An **emergency eyewash station** should be used only when needed to rinse away chemicals that have gotten into your eyes. Instructions for using the eyewash are on the eyewash. They will include holding your eyes open in the stream of water for 5 to 15 minutes.
- A **safety shower** is used only when necessary to rinse off chemicals that are splashed or spilled onto your skin or clothing.
- **Absorbent material** is used to contain small spills.
- A **biohazards container** is used for disposal of living tissues, cells, or any other biohazard.
- A **broken glass container** should be used instead of a trash can to get rid of broken glassware.
- A **fire extinguisher** is used to put out small fires. You should read the directions before an emergency occurs. Most fire extinguishers work by using "PASS" —

  P – pull the pin
  A – aim the nozzle
  S – squeeze the handle to release the foam/chemical
  S – sweep the nozzle from side to side, always pointing at the base of the flames

Some personal safety equipment is used routinely in a lab for your protection.

Safety Glasses/ Safety Goggles

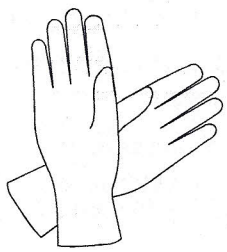




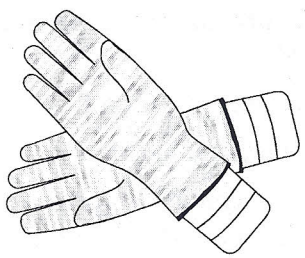
Safety glasses or goggles must be worn if any chemicals or glassware is used.

Lab Apron

Lab aprons help protect your skin and clothing from chemicals.



Latex or nitrile gloves may be needed to protect your hands against biohazards or chemicals.



Asbestos gloves may be needed to protect your hands from heat.

General Laboratory Procedures and Safety Rules

Your teacher may provide you with a specific list of safety rules. Here are some safety rules that everyone should know:

- Do not attempt any unauthorized experiments. Do only what your teacher has approved and told you to do.
- Read all directions before you begin every lab activity and follow the instructions carefully.
- If you are not sure what you should do during the activity, stop and get help from the teacher.
- If you get confused during an activity and are not sure of what you have done, dispose of the materials you were using and start over.
- Your teacher will tell you how to dispose of chemicals correctly. Never pour them down the drain unless told to do so.
- In case of a spill or broken glass, follow your teacher's instructions. Broken glass is usually put into a broken glass container and NOT in the trash can.
- Tell your teacher about any accidents — even little ones that you think don't matter.
- Clean up your area after finishing the activity. Clean the laboratory table and equipment thoroughly.
- Return all materials to their proper places.
- Wash your hands before you leave the classroom.

Biohazard and Chemical Safety

Many chemicals or materials used in the laboratory can be harmful if used improperly. The following is a list of safety procedures that should be followed when using certain chemicals and biohazards. **Biohazards** are materials that can transport disease or illness. Examples of biohazards are human and animal blood, animal tissues, viruses, bacteria, fungi, and cultured cells.

- Never bring food or drinks into the laboratory when performing an experiment.
- Always wear safety goggles or glasses to protect the eyes and a laboratory apron to protect skin and clothing when working with chemicals or biohazards.
- Never inhale fumes from chemicals unless directed to do so. If an experiment calls for a chemical to be smelled, it should be wafted to the nose by holding the chemical away from the nose and gently moving the fumes towards the nose with the hand. See figure 1-20.
- Do not allow chemicals to come into contact with skin or clothing. In case of skin or eye contact, rinse with water immediately. In some cases, immediate medical attention may also be needed.
- Keep flammable chemicals away from open flames or sparks.
- Keep poisonous chemicals under a fume hood.
- Dispose of unused chemicals according to your teacher's directions. Do not pour down the drain unless directed to do so. NEVER put unused chemical back into the original bottle.
- Dispose of biohazards as directed by your teacher. These materials are usually placed in a biohazards container.

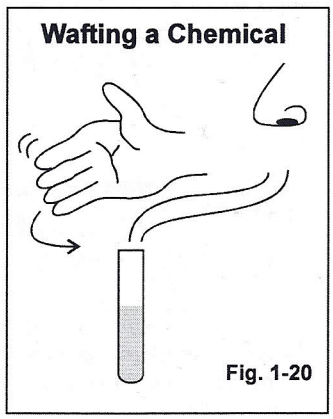


Fig. 1-20

Heat Safety

- Open flames and hot plates should never be left unattended.
- Keep all flammable and combustible materials away from open flames.
- Use appropriate equipment to handle hot glassware. Use test tube holders for test tubes (figure 1-21); use tongs for beakers, flasks, or crucibles (figure 1-22); or use heat-resistant gloves (often made of asbestos) when handling hot glassware (figure 1-23).
- *Hot glassware looks the same as cold glassware!* You cannot tell if glassware is hot by looking at it. If in doubt, handle the glassware as if is too hot to touch by using the appropriate clamps, tongs, or gloves.

Test Tube Clamp

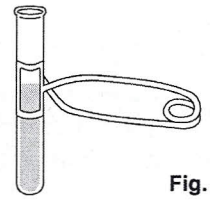


Fig. 1-21

Crucible/Beaker Tongs

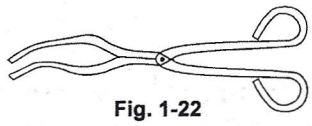


Fig. 1-22

Asbestos/Heat Resistant Gloves

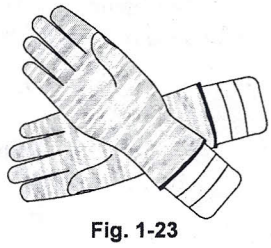


Fig. 1-23

When you heat materials in a test tube over a Bunsen burner, you should remember these special rules:

- Always use a test tube clamp to hold the test tube by the body, not the rim. Tongs and holders not designed to hold test tubes can easily break the glass, so use only test tube clamps specifically made to hold test tubes. See figure 1-21.
- Do not cap or plug the tube while you are heating it.
- The open end of the test tube should always be pointed away from others.
- Do not fill the test tube all the way to the top.
- Do not put the test tube in the hottest part of the flame. Keep the test tube moving in and out of the flame so one part doesn't overheat.

Practice 1

Match each of the following pieces of safety equipment to its correct description.

_____ 1. eyewash station	A. used to protect the hands from heat
_____ 2. absorbent material	B. correct way to dispose of living material
_____ 3. fire extinguisher	C. protects the eyes from chemicals and broken glass
_____ 4. safety shower	D. used in an emergency to rinse chemicals from eyes
_____ 5. biohazards container	E. in an emergency, will rinse away chemicals on skin and clothes
_____ 6. broken glass container	F. used for small fires
_____ 7. safety goggles	G. helps contain small spills
_____ 8. lab apron	H. used to protect skin and clothes from chemicals and biohazards
_____ 9. asbestos gloves	I. used for cracked, chipped, or broken glass

Practice 2

Answer the following questions about laboratory procedures and safety.

Ⓐ Ⓑ Ⓒ Ⓓ 1. If chemicals or glassware are used during a lab activity, you should always wear
A. asbestos gloves.
B. safety glasses.
C. a lab apron.
D. nitrile gloves.

Ⓐ Ⓑ Ⓒ Ⓓ 2. Latex and nitrile gloves help protect your hands from
A. chemicals and biohazards.
B. heat and chemicals.
C. broken glass and radioactivity.
D. heat and biohazards.

Ⓐ Ⓑ Ⓒ Ⓓ 3. The foam or chemical from a fire extinguisher should be sprayed
A. at the top of the flames.
B. as close to the flames as possible.
C. in a circle around the flames.
D. at the base of the flames.

Ⓐ Ⓑ Ⓒ Ⓓ 4. Mrs. MacDonald's class is doing an experiment to determine the most effective anti-bacterial soap. The students are to use the following materials: glass pipette, cotton swab, petri dish with agar solution, bacteria culture, microscope slides with coverslips, microscope. Which list of safety equipment is most appropriate for this experiment?
A. safety glasses, apron, biohazards container, broken glass container, nitrile gloves
B. safety glasses, fire extinguisher, asbestos gloves
C. safety shower, broken glass container, fire extinguisher, nitrile gloves
D. safety goggles, apron, safety shower, asbestos gloves

Ⓐ Ⓑ Ⓒ Ⓓ 5. When any accident occurs during a lab activity, you should
A. always report it to the teacher.
B. notify the office.
C. include it in your lab report.
D. tell the students in the next class.

Ⓐ Ⓑ Ⓒ Ⓓ 6. If you are not sure about what to do during a lab activity, you should
A. ask someone else at your table.
B use your best judgment.
C. ask the teacher.
D. watch to see what everyone else is doing.

Ⓐ Ⓑ Ⓒ Ⓓ 7. Leftover chemicals should be disposed of by
A. pouring them down the drain.
B. following the teacher's directions.
C. putting them in the trash can.
D. leaving them for the next class.

Ⓐ Ⓑ Ⓒ Ⓓ 8. The correct way to heat a test tube over a Bunsen burner is to
A. hold the tube directly into the hottest part of the flame.
B. securely plug the tube before placing it in the heat.
C. use test tube tongs to move the tube in and out of the flame.
D. point the test tube towards a lab partner so he or she can make observations.

Ⓐ Ⓑ Ⓒ Ⓓ 9. A lab activity instructs you to smell a substance in a test tube. Which of the follow describes what you should do?
A. Ignore the instructions since chemicals should never be smelled.
B. Place your nose directly over the test tube and inhale.
C. Waft the aroma towards your nose using your hand.
D. Place your nose about two inches above the test tube and sniff.

Ⓐ Ⓑ Ⓒ Ⓓ 10. Which of the following is true about hot glassware?
A. It looks the same as cool glassware.
B. It should be cooled in ice.
C. It looks slightly reddish.
D. It can usually be handled with bare hands.