

3. **Cleaning**

Keep glassware clean.

- a. Clean immediately after use. The longer glassware sits, the harder it is to clean.
- b. Use laboratory-grade detergents for cleaning glassware. Chromic Acid (dichromate/sulfuric acid mixture) should never be used to clean glassware.
- c. Be sure to rinse glassware well.
- d. When using brushes, make sure the metal part of the brush does not scratch the glass.

4. **General Cautions**

- a. Use glassware that is without defect and has smooth edges.
- b. Glassware should have no cracks, chips, or scratches. In particular, be wary of “star cracks” that can form on the bottom of beakers and flasks. Any glassware with such cracks should be properly disposed of immediately.
- c. All glass tubing should be fire-polished.
- d. Never set hot glassware on cold surfaces or in any way change its temperature suddenly. Even a Pyrex® or Kimax® beaker will break if cold water is poured into a hot beaker.

5. **“Frozen” Glass**

Be careful with glassware that is “frozen.” Only teachers, wearing goggles and gloves, should try to release the “frozen” glassware. If this fails, discard the glassware. Some common cases of “frozen” glassware are:

- a. nested beakers that have been jammed together.
- b. stoppers that cannot be removed from bottles.
- c. stopcocks that cannot be moved.

6. **Hot Glass**

- a. Use care when working with hot glass. Hot glass looks exactly the same as room temperature glass.
- b. Do not leave hot glassware unattended, and allow ample time for the glass to cool before touching.
- c. Check the temperature of the glassware by placing your hand near, but not touching, the potentially hot glass.
- d. Have hot pads, thick gloves, or beaker tongs available for grasping hot glassware.

7. Glass tubing

- a. Breaking. Use gloves or towels to protect hands when breaking glass tubing. Use goggles to protect the eyes. Here are the steps for properly breaking glass tubing.
 - (1) Scratch the glass once with a file or score.
 - (2) Wrap the glass in a towel.
 - (3) Place the thumbs together opposite the scratch.
 - (4) Pull and bend in one quick motion.
 - (5) Fire polish the broken ends: hold the glass so that the sharp end is in the top of the flame of a gas burner. Rotate the tube so all sides are heated evenly, causing the sharp edges to melt and become smooth. Place the glass on insulating material to cool.
- b. Bending. Bending glass tubing is often necessary. Follow these procedures:
 - (1) Place a wing-top attachment on a gas burner and heat the area of the glass to be bent while holding it with one hand on each end, rotating to ensure even heating.
 - (2) When the glass is soft and pliable, remove it from the flame and quickly bend to the desired shape. Results will improve with practice.
 - (3) Place on insulating material until cool.

8. Disposal

Defective glassware should be disposed of correctly.

- a. Glassware should be disposed of in a separate container from normal trash. Such container should be clearly labeled *BROKEN GLASSWARE ONLY*.
- b. When handling broken glassware, wear gloves or use a dustpan and broom. Do not pick up broken glass with bare hands.

B. Corks and Stoppers

1. Proper Stoppers

- a. Use corks for sealing organic solvents.
- b. Use rubber stoppers for sealing aqueous solutions.

2. Inserting Thermometers and Glass Tubing

- a. Check that the hole is the correct size.

- b. Protect your hands with leather gloves.
- c. Lubricate the hole with glycerin or soapy water before inserting thermometers or glass tubing.
- d. During the insertion process, keep a short distance between the stopper and the hand holding the glass.
- e. Use a rotary motion to guide the glass through the stopper.
- f. Remove thermometers immediately after use. If they are difficult to remove, carefully cut away the cork or stopper.

C. Thermometers

1. Alcohol Thermometers

If glass thermometers are being used, it is highly recommended that they be alcohol filled. Mercury thermometers should be phased out as quickly as possible. If mercury thermometers must be used for purposes of higher accuracy, it is recommended that Teflon® coated thermometers be used.

►See Chapter VIII.B.4, Mercury Spills.

2. Resistance Thermometers

Resistance thermometers, or temperature probes, should be considered as alternatives to glass thermometers.

3. Rules for Using Thermometers

- a. Never use a thermometer as a stirring device.
- b. Never swing or shake down a thermometer.
- c. Never use an open flame on a thermometer bulb.
- d. Use extreme care when inserting or removing a thermometer from a rubber stopper.
- e. Mercury thermometers should not be used in heated ovens where breakage might easily occur.
- f. Don't place thermometers where they are likely to roll or be knocked off a table. All thermometers should have anti-roll devices.
- g. Make sure you choose a thermometer with an appropriate temperature range. Overheating a thermometer can cause breakage of its reservoir.

D. Heat Sources

Where possible, use electric hot plates in place of gas burners (Bunsen, portable propane, and butane). Alcohol burners should never be used as a heat source.

1. Safety Rules for Using Gas Burners

- a. Make sure you know the location of the master gas shut-off valve.
 - b. Match the type of burner to the type of gas available.
 - c. Make sure all students know how to operate the burner safely.
 - d. Make sure there are no leaks in rubber hoses connecting the source to the burner.
 - e. Keep rubber hoses away from the flame
 - f. A soft rubber hose connection from a gas burner to the gas outlet is better than a semi-rigid, woven cover type connector, as this lessens the danger of tipping.
 - g. Use a ceramic-centered (not asbestos-centered) wire gauze under the object to be heated to distribute the heat evenly.
 - h. Use matches or lighters instead of strikers for lighting burners. Light matches or lighter before turning on the gas. Bring flame to the side of the top opening of the barrel while slowly turning on the gas.
 - i. Turn off the gas if the gas “flashes back” or burns at the burner base.
 - j. Do not lean toward or reach across a flame.
 - k. Never leave anything unattended while it is being heated or is reacting rapidly.
 - l. Remember that the gas burner barrel remains hot long after use.
 - m. If wing tops (flame spreaders) are used, allow time for these to cool before removing them from the gas burner.
 - n. Turn off gas valves before leaving work area.
2. **Safety Rules for Using Electric Hot Plates**
- a. Use a hot plate with a smooth, clean surface.
 - b. Hot plates appear exactly the same whether hot or at room temperature. Always assume they are hot and act accordingly.
 - c. Keep the electrical cord of a hot plate away from water and the heating surface.
 - d. The cord of the hot plate should be checked periodically for frays and faults. Any hot plate with faulty wiring should not be used. It should be repaired or replaced immediately.
3. **Safety Rules for All Heating Processes**
- a. Never heat a closed container.
 - b. Never point the open end of a test tube toward anyone.
 - c. Never look into the open end of a heated test tube.
 - d. Test tubes should be held with a test tube holder and heated gently along

- the side, not at the bottom, to minimize superheating.
- e. Any set-up should be designed to allow for fast removal of the heat source.
 - f. Do not clamp test tubes or flasks more tightly than necessary to hold them in place when heating. Expanding glass may break if clamped too tightly.

E. Refrigerators and Freezers

1. Refrigerators and freezers used for the storage of chemical reagents and/or biological materials should never be used for the storage of food.
2. Flammable materials should be stored in the flammable material cabinet and not in the refrigerator.
3. A sign should be placed on the refrigerator as a warning not to store flammable and other inappropriate materials inside.

F. Electrical hazards

1. Treat all circuits as though they were energized.
2. Make sure power is off when connections are made.
3. All electrical equipment should be grounded through three-prong plugs.
4. Use ground fault circuit interrupters (GFCIs) throughout all laboratories.
5. Test all electrical receptacles and emergency cutoff switches annually for correct wiring and functioning.
6. Test all electrical apparatus annually for voltage leaks.
7. Inspect all electrical cords annually for defects and damage.
8. Keep work areas dry when working with electrical apparatus.

G. Pipets

Pipets are useful for measuring and dispensing liquids. The following rules apply to all types of pipets, including volumetric pipets, graduated pipets, Pasteur pipets, micro-pipets, and automatic dispensing pipets.

1. Never put a pipet in your mouth.
2. Draw the liquid into the pipet using a rubber bulb or pipet pump.
3. Never withdraw a liquid from a near-empty container. If you attempt to fill a pipet under conditions where air can enter the pipet, the liquid will shoot up into the bulb or pump.
4. Never lay a pipet flat on a table or turn upside down with the bulb or pump attached. The liquid will flow into the bulb/pump, contaminating the bulb/pump.

5. Dispose of broken pipets in the appropriate glass-disposal container.

H. Vacuums

Vacuums occur in the laboratory usually in two situations: using a vacuum pump or by condensing vapors in a closed system (e.g., “crushed soda can” demonstration).

1. Place guards around glass containers in which a vacuum might be created.
2. Always design a relief device such as a stopcock into any vacuum system. The device should allow the slow infusion of air into a system under vacuum.
3. Avoid reactions or procedures in completely closed systems.
4. Any glassware that will be subjected to a vacuum should be specifically designed with heavy walls.
5. Properly handle and maintain vacuum pumps:
 - a. change the oil on a regular basis;
 - b. always have a trap attached;
 - c. have belt guards around belts and pulleys.

I. Centrifuges (Macro and Micro)

The centrifuge should always be securely anchored by use of suction cups or wheel brakes. The centrifuge should have a safety shield and a top disconnect switch. Other safety procedures include the following:

1. Inspect glass tubes for cracks.
2. Inspect the metal centrifuge cups for roughness.
3. Position test tubes opposite each other with the same weight in each tube to balance the centrifuge. Use water-filled tubes as necessary for balance. An unbalanced centrifuge can “walk” off the table.
4. If the centrifuge has a lid, make sure it is closed during operation.
5. Keep hair, loose clothing, and body parts away from the centrifuge while it is operating.
6. A spinning centrifuge should not be touched for any reason. Do not try to stop a centrifuge by grabbing it. Make sure the centrifuge is completely stopped before removing test tubes from it. *Note:* Schools should only purchase centrifuges equipped with a safety feature that does not allow the devices to be opened until the spinning has stopped.
7. Make sure that the centrifuge operates vibration-free at the top speed.
8. Never leave a running centrifuge unattended.

9. Keep rotors and buckets clean.

J. Cryogenics

Nonflammable cryogenics (e.g., liquid nitrogen and dry ice) can be educational but are dangerous and should be handled only by the teacher. Liquid nitrogen requires special ventable flasks or Dewars (to minimize risk of an explosion). Such flasks can break easily if handled carelessly. Use chemical splash safety goggles at a minimum (complete face shield is better), thick gloves and long sleeves when working with either of these substances. It is important that students observing demonstrations wear eye protection and be seated at a safe distance from the demonstration.

K. Compressed Gases

Compressed gases can present dangers through toxicity, reactivity or flammability of the gas, or because the gas is pressurized. Even a normally “safe” gas, such as nitrogen, can become a safety hazard when compressed. An improperly used gas cylinder is a potential bullet or rocket.

1. Have proper carts available for transporting gas cylinders. Do not roll large cylinders around.
2. Use the proper tank and fittings designed for each gas. Your gas supplier will be able to help you with this.
3. Asphyxiation is the most subtle danger of working with compressed gases. Always use compressed gases in a well-ventilated area.
4. Always make sure tanks are secure. No compressed gas tank should be allowed to stand free. All tanks should be strapped or tightly chained to a rigid support to prevent accidental toppling.
5. Keep electrical lines away from compressed gas tanks.
6. Keep gas tanks away from heat sources.

L. Microcomputers

1. Electric Shock.

The use of microcomputers in the science laboratory is increasing at a rapid rate. Although the programming and use of software with computers is not hazardous, many applications that require electrical connections to the computer may involve the risk of electrical shock. Below are guidelines for working with computers.

- a. When the internal electronics must be exposed to make connections, unplug the computer. Most computer circuitry operates on low voltage direct current, but higher A.C. and capacitors are present in the power

supply as well as the VDT (Video Display Terminal).

- b. Whenever possible, students should only make connections to external connection ports (i.e., game paddle connectors, exposed edge connectors). Often it is possible to use low voltage extension cables from inside the computer to an outside location to reduce the risk of accidental shock while making connections.
- c. Some applications require use of 110 volt relays, heaters, etc., and all normal precautions for use of these devices should be followed. Be aware that the computer may remotely turn these devices on unexpectedly.

2. **Ergonomics**

Some study should be given to the physical arrangement of the keyboard, video display, and lighting. Muscle fatigue and eye strain can be reduced by the appropriate positioning and adjustment of these components.

M. Sharps

Care should always be taken when dealing with sharp objects. Scissors, needle probes, and knives should be used with extreme care. Sharps to be discarded – and any other items having sharp edges or points – should be placed in a separate, rigid container labeled *SHARPS ONLY*.

N. Other General Laboratory Safety Concerns

1. Always keep your work space free of clutter.
2. Apparatus attached to a ring stand should be positioned so that the center of gravity of the system is over the base and not to one side.
3. Apparatus, equipment, or chemical bottles should not be placed on the floor.
4. Whenever hazardous gases or fumes are likely to be evolved, the operation should be confined to a fume hood.
5. Any problems with glassware, equipment, chemicals, etc. should always be reported immediately to the instructor.
6. High/low pressure situations (e.g., pressurized systems for specialized reactions, or vacuums) can present hazards. Only sound glassware should be subjected to such situations.

► See Chapter III, Safety Concerns and Emergency Laboratory Equipment, and Chapter V, Safety Strategies in the Classroom, for related ideas on safety practices.