

SAFETY IN THE ACADEMIC LABORATORY

David A. Katz

Department of Chemistry
Pima Community College

Laboratory safety is an important part of the chemistry course. In the laboratory, you are working with chemicals in their pure form, not diluted as they may be in household products. Therefore, you should be familiar with safety procedures for working with chemicals and should know what to do in the case of an accident or emergency.

General lab procedure

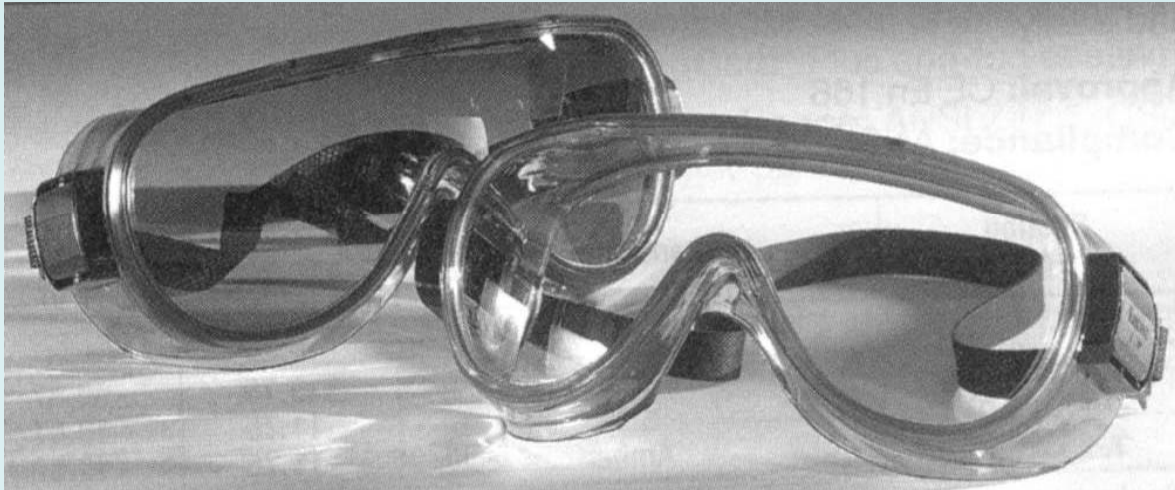
When you come into the laboratory, you should place all books, pocketbooks, book bags, coats, hats, etc... in appropriate locations (lockers, bins, etc...). Avoid putting these items on the floor where you may trip over them or any place where they may come into contact with spills.

Only essential materials such as your laboratory manual and a laboratory notebook should be on the bench top at your work area.

EYE PROTECTION

Goggles or safety glasses must be worn at all times in the laboratory to decrease the likelihood of eye injury.

This includes times when you are just visiting the laboratory or doing calculations.



Eyeglasses/Safety glasses

Normal eyeglasses do not provide protection from splashes coming from the sides, nor are they considered shatterproof by industrial standards.

Safety glasses with side shields may be shatterproof, but do not provide adequate protection from splashes.

Contact lenses

Contact lenses can be worn in the laboratory for most normal procedures provided the individual wears the **proper safety splash goggles** required for laboratory activities.

Contact lenses do not provide any additional protection to the eyes, nor, is there any documentation to prove that contact lenses result in any increased problem of injury due to laboratory vapors over that of an unprotected eye.

In the event of any chemical splash into the eyes of an individual wearing contact lenses, the contact lens must be removed as soon as possible to effectively rinse the chemical from the eyes.

Please inform your laboratory instructor if you will be wearing contact lenses in the laboratory.

For additional information and restrictions see CDC Workplace Safety and Health *Current Intelligence Bulletin 59*, Contact Lens Use in a Chemical Environment, <http://www.cdc.gov/niosh/docs/2005-139/pdfs/2005-139.pdf>

To properly adjust safety goggles, loosen the elastic band so the goggle is loose against the face. Then slowly tighten the elastic band so that the goggle is snug against the face, but not tight. Tight goggles will not be comfortable to wear and may result in headaches.

Clean the goggle lens to prevent eyestrain and blurred vision. Cleaning solution and soft, non abrasive tissues are available at the goggle station in the laboratory.



If something gets in your eye(s)

**go to the nearest
EYEWASH**



**Note the location of the eyewash
in the laboratory**

To use the eyewash, hold the eyelids open and continue to flush with WATER for up to 15 minutes (or until stinging stops).

Obtain qualified medical assistance immediately to inspect the eyes for any chemical residue or damage.



Never use another chemical to rinse or attempt to neutralize a substance in the eye, this may result in further damage.

Only a doctor or qualified medical personnel should inspect and treat the eye and prescribe any further treatment.

Eyewash bottles, or similar type containers are recommended only as a temporary measure since they do not supply a sufficient quantity of water to effectively wash the eye.

Also, the water in such devices may not have been changed at weekly intervals and may contain mold or bacteria.



In case of an accident or injury in the laboratory

Inform others near you and call your
laboratory instructor.

Your instructor should be trained to assist
with emergency first aid until qualified
medical assistance arrives.

Note the location of the nearest telephone, and also, if it is a direct line to the campus police or other emergency service.

Emergency telephone numbers should be posted on the phone or close to the phone.

Write down the telephone number of Campus Police or emergency service in your laboratory notebook.



Never treat a chemical injury with another chemical in an attempt to neutralize the corrosive or caustic effect of the substance.

Neutralization reactions produce heat and can cause additional injury.

Wash the affected area with copious amounts of room temperature water for up to fifteen minutes, never rub the affected area, and get immediate qualified medical assistance.

CHEMICAL SPILLS

Clean up all spills immediately, no matter how small.

Liquid on a bench top can be mistaken for water.



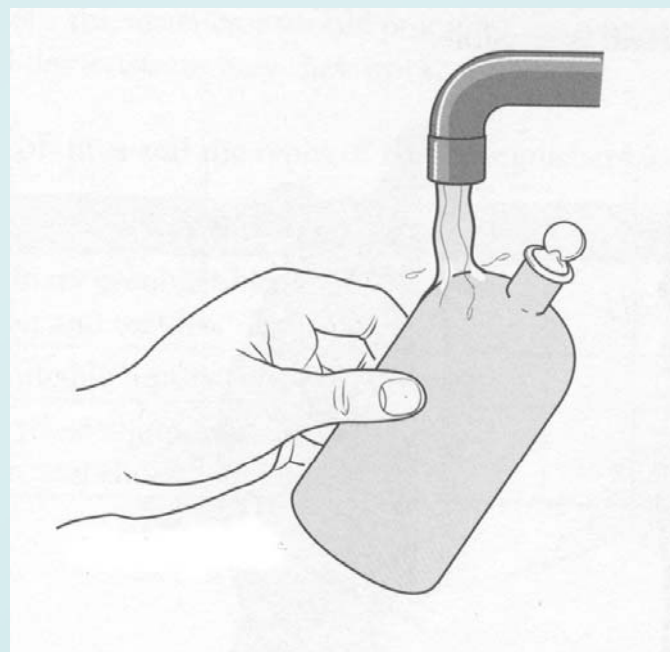
A wet ring around the base of a bottle of a chemical indicates a spill. This may be the result of liquid dripping down the side of the bottle.

Wash any chemical from your hands immediately.

The bottle should be sealed and the body of the bottle rinsed with water.

Do not let the running water come in contact with the bottle top or cap.

If you have any doubts about rinsing a bottle, as illustrated, ask your instructor for assistance.



In the event that there is a large chemical spill, move away from the area quickly.

If large quantities of toxic or irritating vapors are generated, evacuate the room.

Assess the spill and take appropriate action to contain it or clean it up.

A spill can be contained and soaked up using spill control pillows, but this may not result in neutralization of the chemical.

A mixture of sand and soda ash can be applied to acid or alkali spills.

If uncertain how to respond, contain the spill, evacuate the area, and seek qualified help.

If the spill contains any materials not addressed in your pre-laboratory preparation, look up information in reference safety books available in the laboratory.

If chemical is splashed on the skin and clothing, the splashed surface must be drenched with large quantities of water from a **SAFETY SHOWER**.

All contaminated clothing must be removed as drenching will only dilute the chemical absorbed by clothing, not wash it away.

Washing should continue for up to fifteen minutes or until no chemical remains in contact with the skin.

Qualified medical assistance should be obtained immediately to assess any possible injury.



FIRES

In the event of a fire, evacuate the area, close all doors, call for help, and sound local alarms.

If you attempt to extinguish it, keep your back to an exit from the laboratory, do not allow yourself to become trapped or cornered in the lab.

If clothing catches fire, the safety shower may be effective in drenching the flames.

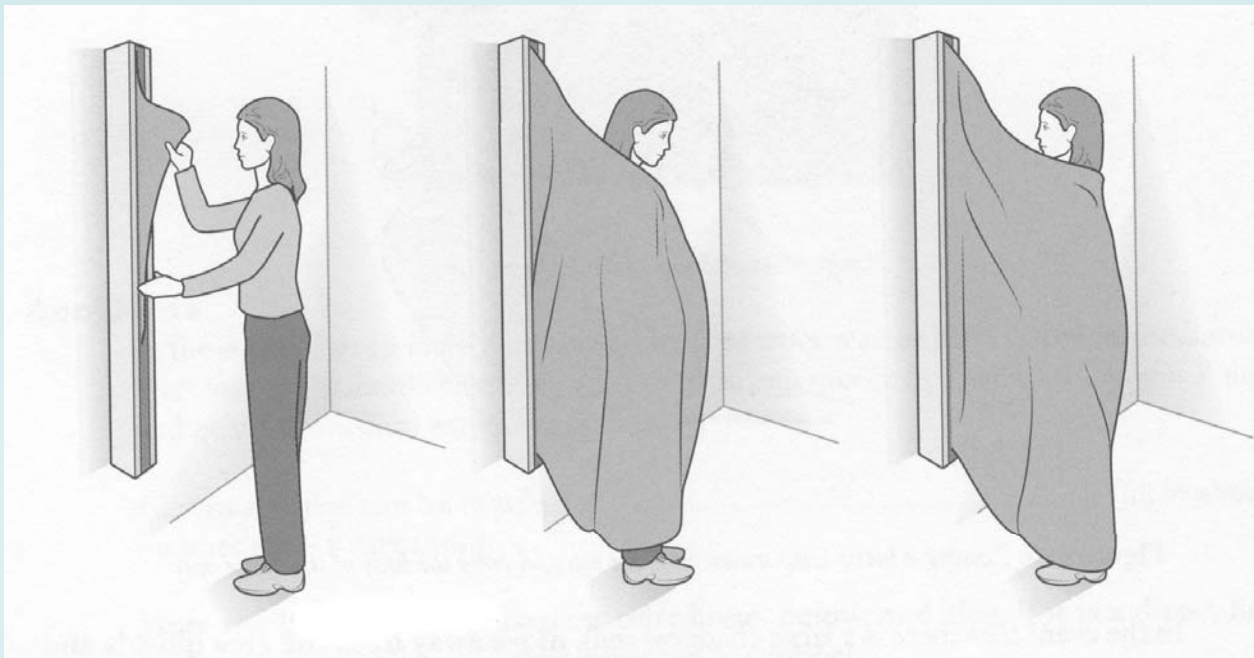
Also recommended is a **FIRE BLANKET**.

Note the location of the fire blanket in the laboratory.



The individual should be wrapped in the fire blanket and rolled on the floor. If the person remains standing, a chimney effect may occur permitting the fire to continue to smolder.

Remove all burned clothing as soon as possible and get immediate qualified medical attention.



A small contained fire in a test tube or a beaker can easily be put out by covering it with a watch glass or beaker to smother the flames.

Do not use papers or towels as they may catch fire.



A fire blanket can also be used to smother a small fire

To extinguish an open fire in the laboratory, use a **FIRE EXTINGUISHER**

The different classes of fires and the types of fire extinguishers used for each are:



Class of Fire	Type of Fire	Extinguisher
A	Ordinary combustibles such as paper, wood and textiles	Water, dry chemical
B	Flammable liquids, oils, and grease	Dry chemical
C	Electrical equipment and danger of electrical shock	Dry chemical

Note the types and locations of the fire extinguishers in the laboratory

To use a fire extinguisher:

- Remove the metal or plastic pin in the trigger handle. (The pin prevents accidental discharge.)
- Aim the nozzle at the base of the flames, and discharge the extinguisher.
- Move it slowly and systematically from side to side in a sweeping type motion.



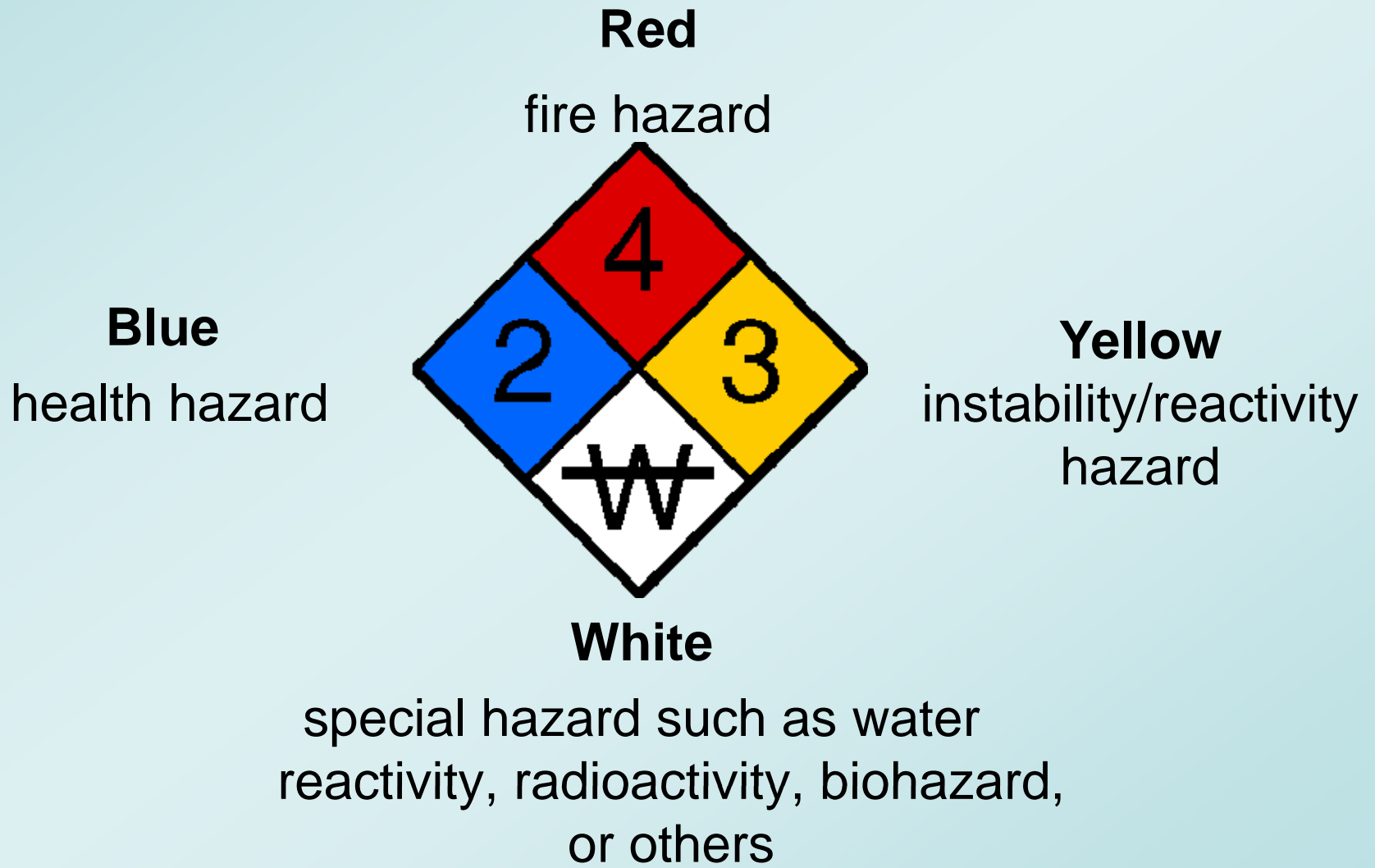
You should have observed a multicolored diamond on the door to the laboratory, the door to any chemical storage area, and all chemical reagent bottles in the laboratory.

This is known as the **NFPA hazard signal system**.

It's purpose is to allow fire fighters and individuals to quickly identify the nature of any chemical hazards.



The NFPA hazard signal system



The NFPA hazard signal system

4 = extreme hazard

3 = severe hazard

2 = moderate hazard

1 = minor hazard

0 = no unusual hazard



The NFPA hazard signal system

No.	Emergency Health Hazard (BLUE)	Fire Hazard (RED)	Instability/Reactivity (YELLOW)
4	Extremely hazardous	Flammable gas or liquid that vaporizes at ambient temperatures and burn readily	Extremely shock sensitive and capable of detonation
3	Toxic or corrosive	Flammable liquid, can be ignited at ambient temperature conditions	Shock-sensitive materials which may detonate under some conditions
2	Moderately toxic	Combustible liquid, must be moderately heated before ignition can occur	Unstable and water reactive materials
1	Irritating	Combustible, must be heated before ignition can occur	Materials that may become unstable under heat or pressure
0	No unusual hazard	Noncombustible	Not reactive

Examples of Hazard Signals for Common Laboratory Reagents

Chemical	Emergency Hazard Signal			Special Hazards
	Health (blue)	Fire (red)	Instability (yellow)	
Acetic acid	2	2	1	
Acetone	1	3	0	
Ethanol (ethyl alcohol)	0	3	0	
Diethyl ether	1	4	1	
Hydrochloric acid	3	0	0	
Hydrogen cyanide	4	4	2	
Picric acid	1	4	4	
Sodium hydroxide	3	0	0	
Sulfuric acid	3	0	2	water reactivity
Toluene	2	3	0	

Laboratory attire

When working in the laboratory, do not wear clothing that is frilly or flared or has loose flowing sleeves.

Remove bulky sweaters, especially those with a brushed finish.

Generally, clothing which is not torn or raveled, composed of non-synthetic material is best. Synthetics tend to burn and melt, sticking to your skin.

Laboratory aprons and lab coats should be worn to protect clothing and bare arms from minor splashes that occur in boiling liquids and other laboratory procedures.



Long hair or beards must be confined

Hair burns, especially if covered with hair spray.

Keep long hair tied back so it cannot fall near a burner flame or into chemicals.

If you are wearing a scarf or necktie, remove it or confine it in such a way as to prevent it from extending into your laboratory work area where it could catch fire, get into chemicals, or get caught in apparatus.



Proper footwear is required

Proper footwear should have a low heel and be composed of leather or equivalent material.

Shoes should have no open spaces to prevent spills from getting on your feet.

Canvas shoes tend to absorb liquids.

Sandals and flip-flops offer no foot protection and are not permitted in the laboratory.



Working with burners and flames

Open flames in the laboratory are discouraged because of a potential fire hazard, especially when working with flammable materials.

If you use a Bunsen burner:

It is dangerous to leave a lit Bunsen burner unattended.

The blue flame of a properly adjusted burner is not visible and can result in a burn if you reach over it on the lab bench.

Never reach across a lab bench, either near or over a lighted burner, for any materials you may need for the experiment.



Incorrect flame adjustment



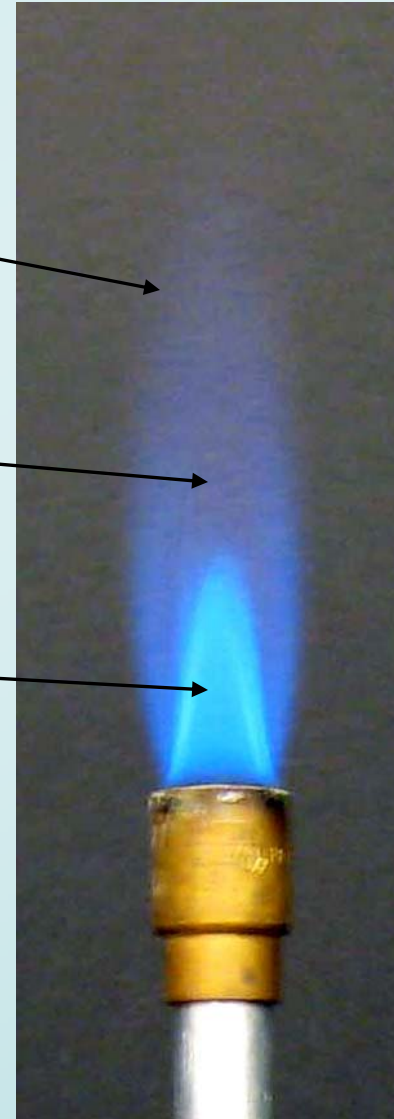
Properly adjusted flame

The Bunsen burner flame

Pale blue-violet outer flame
(oxidizing flame, temperature about
1550°C)

Hottest part of flame
(temperature about 1560°C)

Bright blue inner cone
(reducing flame ranging from about
300°C near bottom to 500°C near top of
cone)



Working with hotplates

Hotplates should be positioned away from any flammable materials, such as alcohol, acetone, and toluene, and bottles of reagents.

Hotplates can spark, unseen by your eyes, and ignite flammable liquids or vapors.

Hotplates retain heat for a while after they have been used and turned off. Once they have been used, hotplates are to be treated as if they are hot, even after you have disconnected them from the power supply.

Give a hot plate sufficient time to cool before moving it and putting it away. If you need to leave the laboratory, please inform your coworkers and your instructor that the hotplate, left on the lab bench, is still warm.



Food and drinks

Smoking, chewing, eating and drinking are not permitted in the laboratory due to the possible ingestion of chemicals.

One should always take the precaution of washing the hands, with soap, upon leaving the laboratory.

At the end of a laboratory session, it is also recommended that both hands and face be washed. There is a possibility that the individual may have touched their face with contaminated hands during the laboratory experiment.

Working with chemicals

Assume that all chemicals used in the laboratory are harmful.

Although the substances you encounter in the laboratory have different degrees of safe exposure, you should not treat anything as safe unless you know for certain that it is.

Every substance in the laboratory must be treated with respect to insure that all exposure is kept at a safe level.

Prior to coming to the laboratory, look up information and hazards about each chemical to be used on their **Manufacturer Safety Data Sheet (MSDS)**, available online or in the laboratory.

A Manufacturer's Safety Data Sheet, or MSDS, is a federally required hazard communication to employees or users of a hazardous chemical that must be placed in a location where users can have access to the information.

The information that must be contained on an MSDS is:

1. The **identity of the product** including the chemical and common names, chemical formulas, and product codes of all the ingredients that contribute to any health hazards that constitute 1% or more of the composition
2. The **physical and chemical properties** of the hazardous chemical such as vapor pressure, flash point, autoignition temperature, explosion mixture with air, etc.

The MSDS (continued)

3. The **physical hazards** of the hazardous chemical including the potential for fire, explosion, and reactivity.
4. The **health hazards** of the hazardous chemical, including signs and symptoms of exposure, and any medical conditions that are recognized as being aggravated by exposure to the chemical.
There are two classifications of health hazards, acute (immediate), and chronic (from prolonged exposure)
5. The **primary route(s) of entry into the body**. This includes inhalation, ingestion, skin contact, and eye contact.

The MSDS (continued)

6. **The OSHA** (Occupational Safety and Health Administration) **permissible exposure limit** (PEL), the ACGIH Threshold Limit Value (TLV) and any other exposure limit.
7. **Toxicological information** on whether the chemical has been found to be a potential carcinogen (a substance that is know to cause cancer in humans or laboratory animals), mutagen (cause genetic changes) and/or teratogen (can induce a genetic malformation in a developing embryo or fetus).
8. Any generally applicable **precautions for safe handling and use** of the chemical including appropriate hygienic practices, protective measures, and procedures for clean-up of spills and leaks.

The MSDS (continued)

9. Any generally applicable **control measures** such as appropriate engineering controls, work practices, or personal protective equipment such as wearing of gloves or other skin protection, eye protection, and breathing apparatus such as respirators.
- 10. Emergency and first aid procedures.**
11. The **date of preparation** of the MSDS or the last change to it.
12. The name, address, and telephone number of the party preparing or distributing the MSDS, who can provide additional information on the hazardous chemical and appropriate emergency procedures.

Pregnant women and women planning to become pregnant should be aware that some chemicals may be **teratogens**, that is, they may cause genetic malformations in a developing embryo or fetus.

Known teratogens are not used in laboratory experiments, however, your instructor should be aware of pregnancy so that he/she may advise you of any laboratory chemicals or specific experiments to avoid.

Read each label on reagent bottles carefully to note the names of the chemical, its formula, and its concentration.

It is a good idea to **read the label twice** to make sure you have the correct material at the correct concentration.

Many chemicals have similar names such as sodium sulfate and sodium sulfite.

If you are not sure as to the identity of a substance, ask your instructor.



Liquids should be dispensed from a small reagent bottle

If it is necessary to obtain a small amount of liquid from a large reagent bottle, pour the approximate amount called for into a smaller container such as a beaker. The liquid can then be easily poured into a measuring device such as a graduated cylinder.

If the bottle has a glass or plastic stopper, hold it between your fingers, as shown.

Do not lay the top on the lab bench as it may pick up contamination



Solid chemicals are best dispensed from a small reagent bottle.

Solid chemicals can be poured from a small bottle directly into a weighing boat or weighing paper on a balance.

Never place chemicals directly on the balance pan.

If necessary, a clean spatula can be used to withdraw small amounts of chemical from a container.

To dispense a small amount of solid from a spatula, tap your hand gently as shown



Chemicals should never be returned to their containers

Once removed from a container, a chemical is considered to be contaminated.

If you have taken too much material, ask a coworker in the laboratory if they can use it. If no one needs the excess, dispose of it in the proper waste container.

Disposal

Procedures for the disposal of chemical wastes vary from locality to locality. What may be acceptable in a large city may not be acceptable in a small town or rural area. Your instructor will advise you on the procedures for each experiment.

Appropriate waste containers for solids and for liquids should be available in the laboratory.

Disposal of liquid chemicals and solutions

There should be separate, labeled containers for flammable liquids, corrosive materials, oxidizers, heavy metals, and other materials that you are likely to use in an experiment.

Be certain to use the correct waste container for each substance to avoid potential hazards resulting from mixing non-compatible waste chemicals.

Drain Disposal

Drain disposal of liquid chemicals and solutions is limited to those that are soluble in water, nontoxic, and not malodorous. Even then, only small quantities should be poured down a drain with copious amounts of water before, during and after drain disposal.

Always consult your instructor about drain disposal if an appropriate waste container is not supplied in the laboratory.

Disposal of solid chemicals

Solid chemical wastes should be placed in the appropriate containers in the laboratory.

Familiarize yourself with the types and location of waste containers.

Do not throw solids into the trash cans unless specifically directed to do so.

DISPOSAL OF GLASS

Broken glass should be disposed of in containers marked for glass only.

When filled, glass disposal containers are sealed and disposed of along with their contents. This will prevent injury to persons handling this type of waste.



Storing chemicals between experiments

Chemicals should never be stored in a desk drawer or locker. There is always the possibility of fumes given off or spilling of the material. This could result in another individual becoming contaminated with an unidentified chemical.

Your instructor will direct you on proper storage of chemicals between experiments.

Do not remove any chemicals from the laboratory environment. Even if properly labeled, outside of the laboratory an individual unfamiliar with the chemical may mishandle or misuse it and become injured.

Removal of chemicals from the laboratory is prohibited and will result in appropriate actions against the individual.

When working at the balance, clean up spilled materials from the balance and surrounding work area immediately.

This not only protects the balance, but it protects the next person from becoming contaminated with an unidentified chemical.

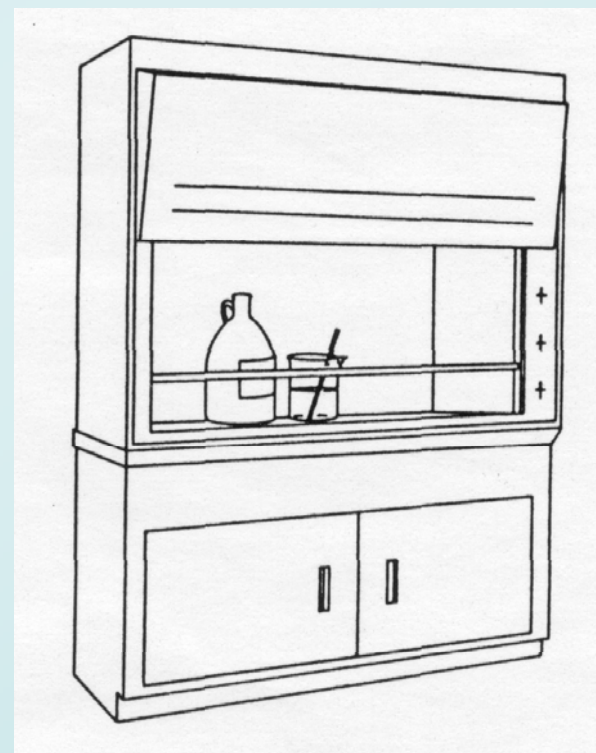


Fume Hoods

If a chemical or a reaction generates any irritating or potentially toxic gases or vapors, it should be used in a **FUME HOOD**.

If fumes are generated unexpectedly, turn off any heating device and move the apparatus under the hood as quickly as possible.

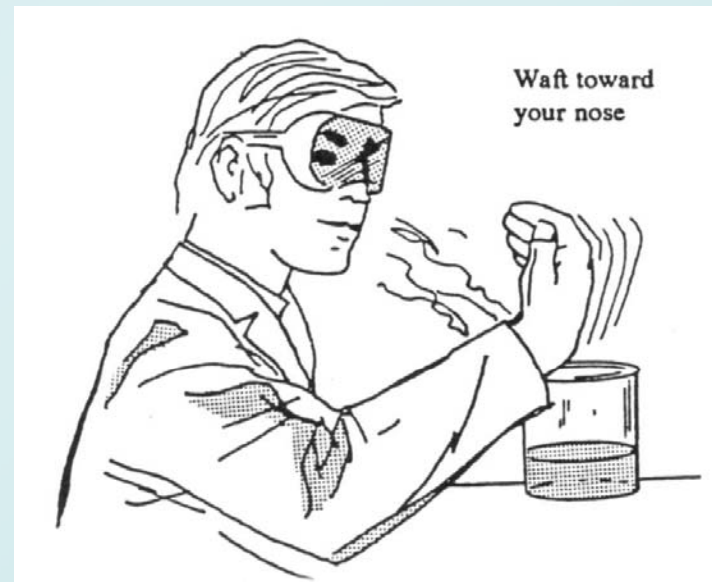
If exposed to the vapors, get fresh air immediately.



Noting odors of substances

When noting the odor of a substance, cup your hand and waft vapors toward your nose.

Do not sniff the material at the mouth of the container as the odor may be too strong and may overcome you.



Chemical reactions

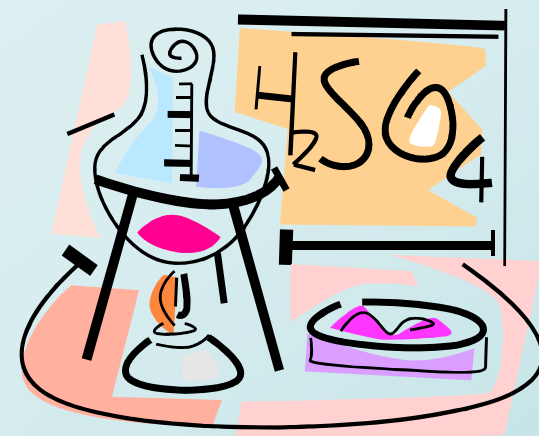
When adding chemical reagents to a reaction, always add the material slowly with stirring. This will help to keep the reaction under control and minimize or prevent splattering or foaming.

Chemical reactions

It is dangerous to leave a reaction unattended while heating it.

An untended reaction is a potential bomb. Material can splatter from the container at any time. If a reaction is heated to near dryness, it can splatter from its container.

Also, a flask, beaker, or evaporating dish heated to dryness can shatter.



Chemical reactions

Never heat a closed system.

Any flask, beaker, reflux set-up, distillation, or other system must be open to the atmosphere so excess pressure does not build up inside the system. Heat will cause the gases and liquids inside the system to expand until the container breaks, or at the worst, explodes.

Diluting concentrated solutions

When diluting acids, or any concentrated solution, with water, **always pour the acid, or concentrated solution, into water.**

Dilution of concentrated solutions is often accompanied by heat and splattering may occur if liquids are mixed in the wrong order.

Never mix a concentrated acid with a base. The neutralization reaction produces heat in addition to the heat of dilution and splattering will occur.

Heating liquids

Boiling chips or stones should always be added to liquids to promote smooth boiling and prevent bumping and splattering.

Add boiling stones when the liquid is cold or only slightly warm. If a boiling stone is added to a hot liquid, it may boil over the sides of the container.

Heating a test tube

Use a water bath.

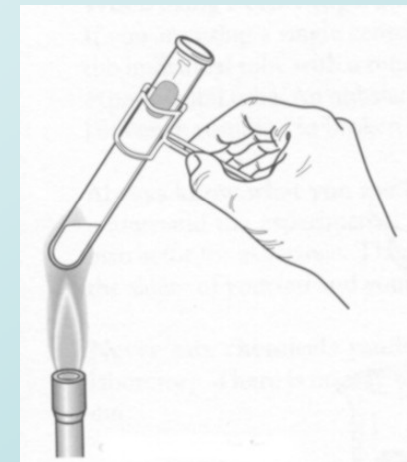
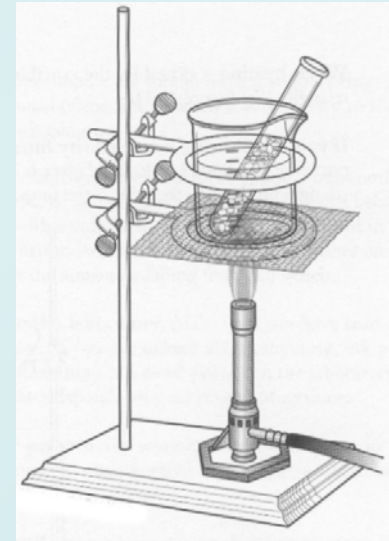
For direct heating:

Use a test tube clamp or holder.

Never point the open end of the test tube toward yourself or other individuals.

Hold the test tube at an angle of about 45 degrees and heat it from top to bottom moving the test tube in and out of the flame.

An improperly heated test tube can result in hot liquid being splattered a distance of several feet.

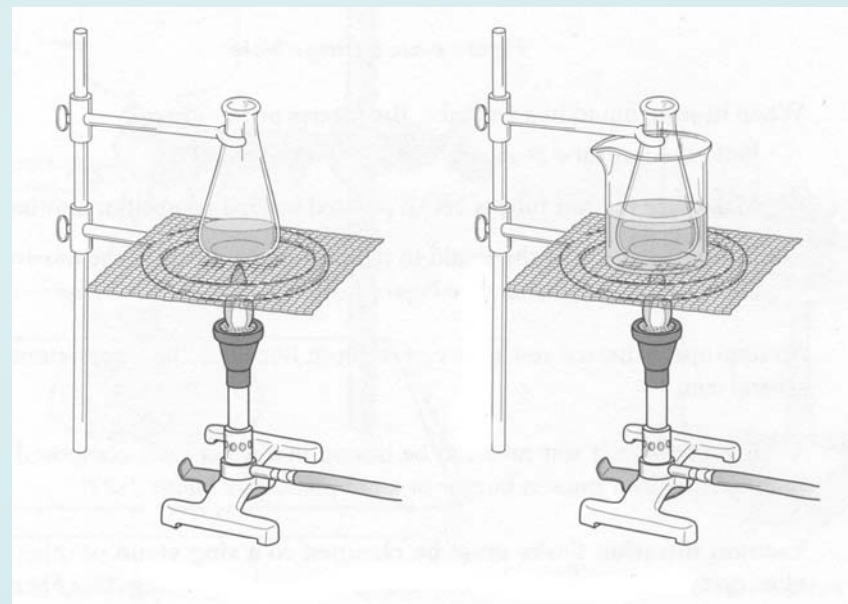


Heating a flask

When heating a flask on a ring support, **always clamp the flask to the ring stand** to prevent the flask from falling off the ring support.

Use a wire gauze to distribute the flame over the base of the flask or beaker.

Caution, the clamp will get hot during the heating of the flask.

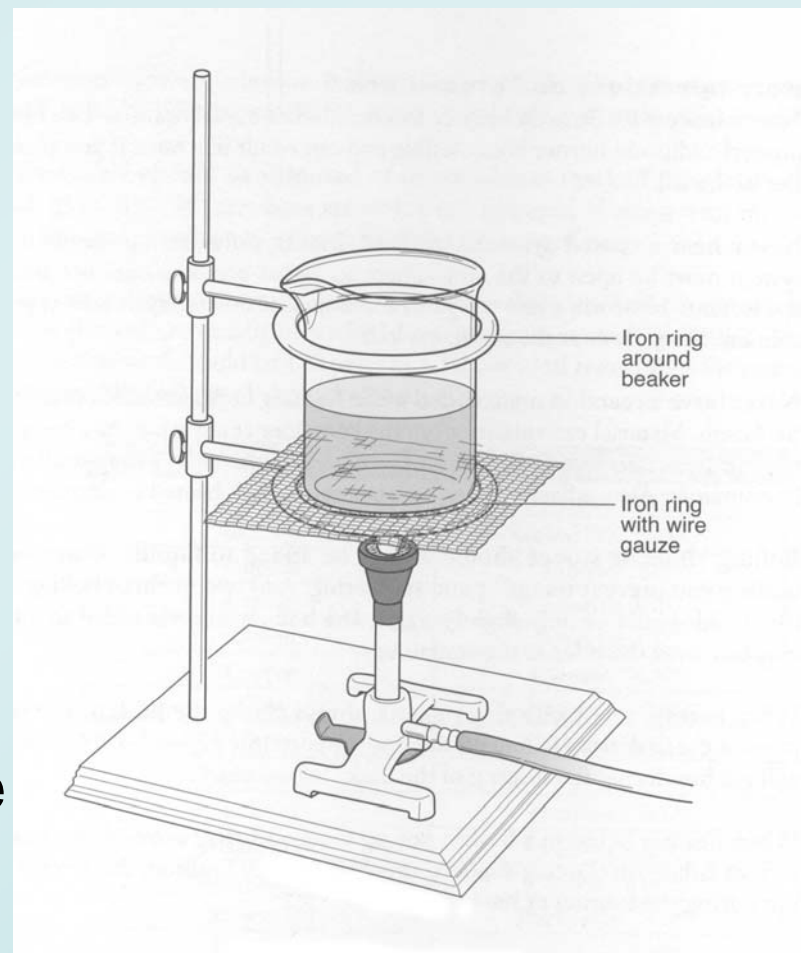


Heating a beaker

When heating liquid in a beaker, **set up a second ring around the beaker** to keep it from falling off the ring support.

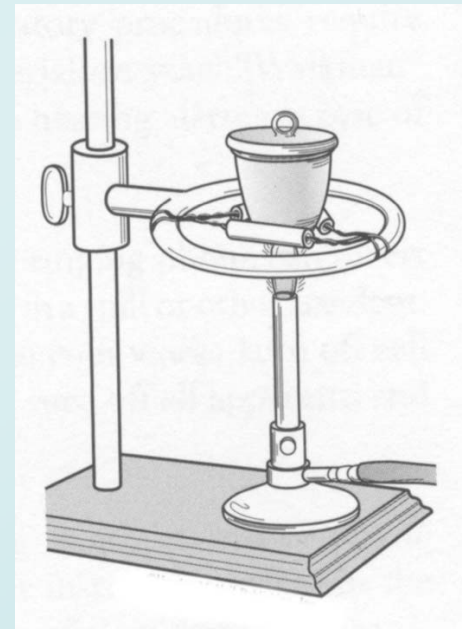
Caution, the second ring will get hot during the heating of the beaker.

Use a wire gauze to distribute the flame over the base of the beaker.



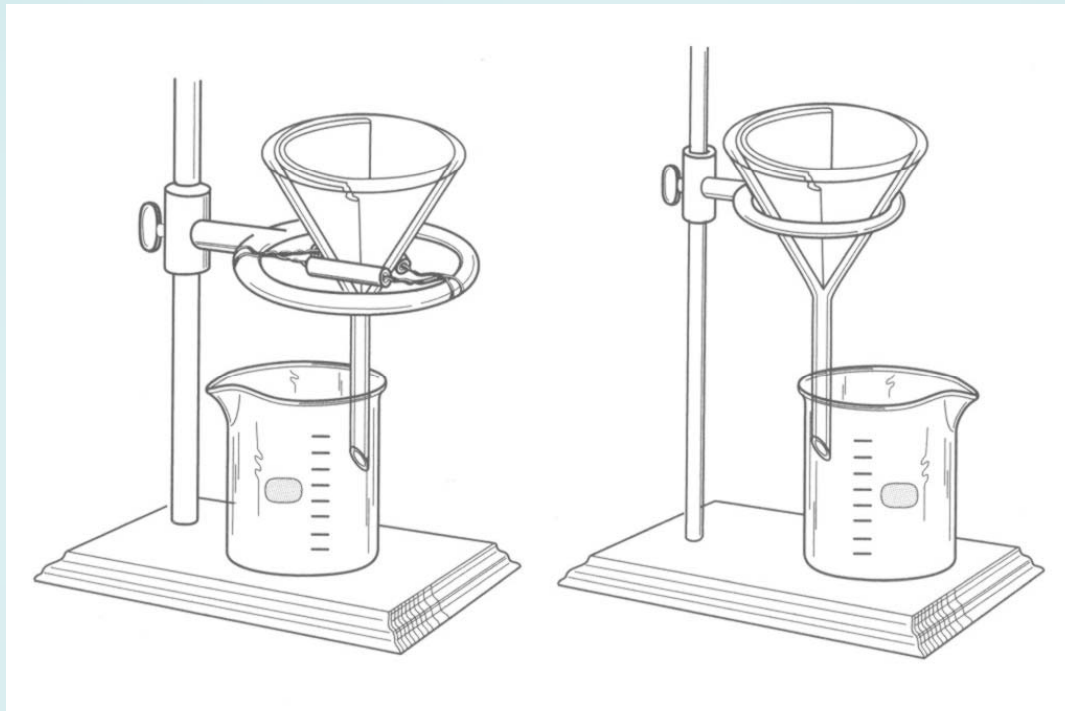
Heating a crucible

When heating a crucible,
the crucible is supported
on a support ring using a
clay triangle



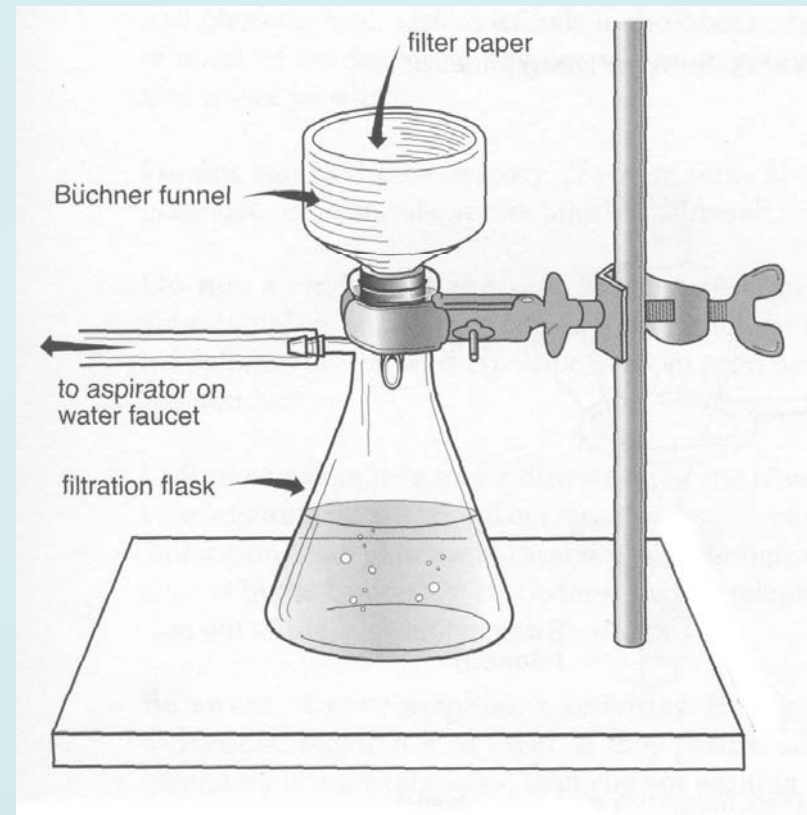
Gravity filtration

If you are filtering using gravity filtration, always support the funnel using a support ring or a funnel rack. If the support ring is too large, place a clay triangle on the ring to support the funnel.



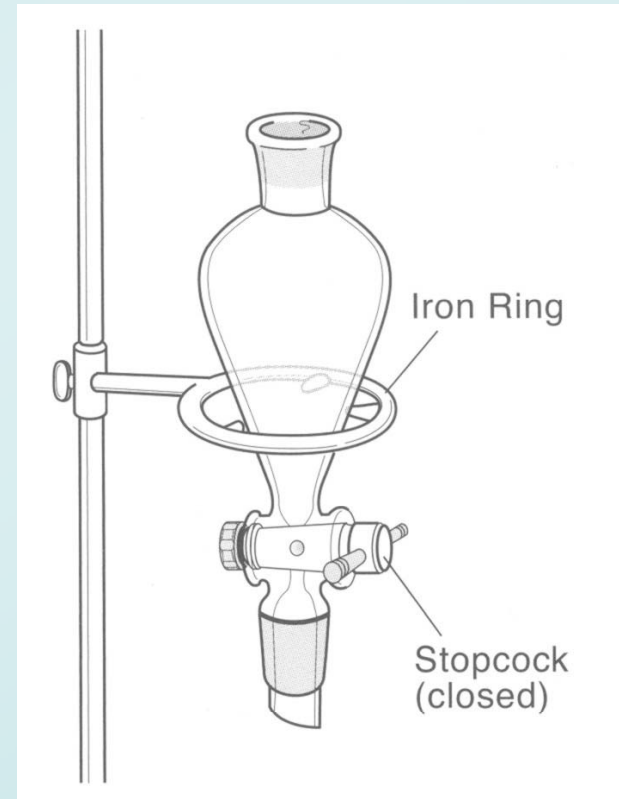
Vacuum filtration

Vacuum filtration flasks should be clamped to a ring stand when filtering to prevent the flask from falling over and imploding.



Separatory funnels

When using a separatory funnel, always support the funnel using a support ring. This will allow easy removal of the funnel when it is necessary to shake the contents as part of the separation procedure.



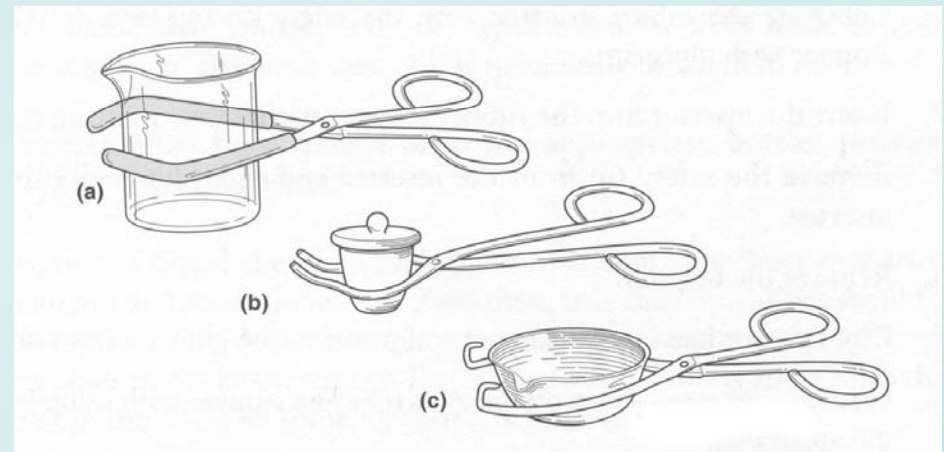
Use the appropriate apparatus to handle lab ware.

Beaker tongs, not crucible tongs, should be used to hold beakers.

Flask tongs are designed for holding flasks.

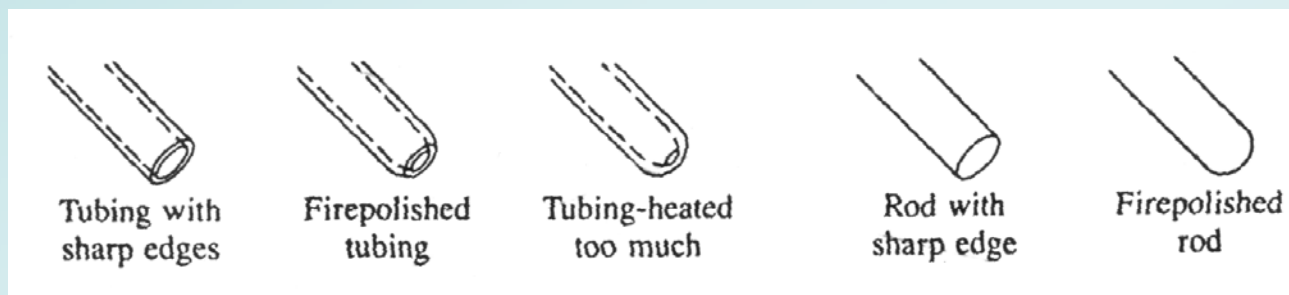
Crucible tongs are designed to hold crucibles.

Dish tongs are used to hold evaporating dishes.



To insert glass tubing or a thermometer into a cork or rubber stopper

Make sure that the ends of the glass tube are firepolished.



Lubricate the glass tubing and the hole in the stopper with glycerin.

Hold the tube with a towel and insert it into the stopper with a slow twisting motion - NEVER PUSH HARD.

Use extra glycerin if needed.

Wash the glycerin off the glass tube and stopper with water before assembling the apparatus.

To remove glass tubing or a thermometer from a cork or rubber stopper

Hold the tube or thermometer with a towel and pull out the tubing slow twisting motion - NEVER PULL HARD.

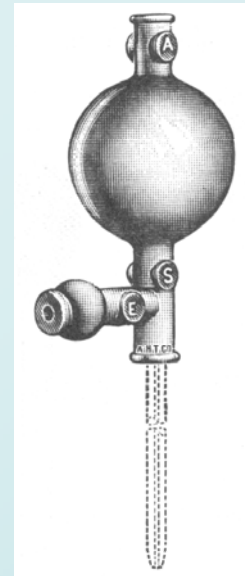
If the tube or thermometer does not move easily, ask your instructor for assistance.

In some instances, the cork or stopper may have to be cut to remove the tube or thermometer.

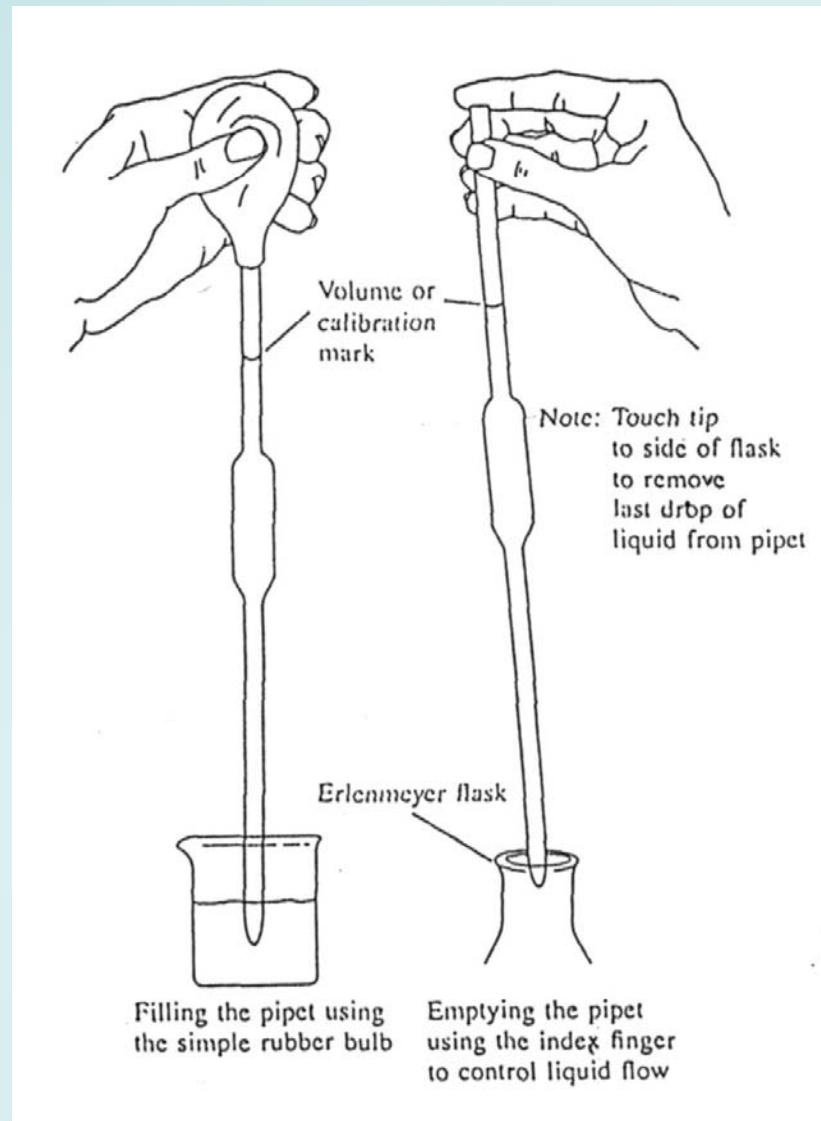
Under some circumstances, it may be safer to discard a glass tubing-stopper assembly.

PIPETTING LIQUIDS

When pipetting liquids or solutions, use a pipette safety bulb or a pipette pump to draw the liquid into the pipette. Never pipette by mouth.



PIPETTING LIQUIDS



Always know what you are doing in the laboratory. Make sure you have read and understand the experimental procedure. If you are unsure about anything, ask your instructor for assistance. There is no such thing as a *dumb question* in the laboratory as the safety of yourself and your classmates depends on your proper procedures.

Never work in the laboratory without proper supervision

It is important to have someone present who can help out in the event of difficulties or an accident.

Proper behavior is expected in the laboratory.

Each student is expected to maintain a wholesome, businesslike attitude in the laboratory. Horseplay, pranks, and other acts of mischief are dangerous and cause harm to yourself, as well as others. Violators will face severe penalties.

Be aware of your neighbor's activities. If they are using improper and/or unsafe techniques, mention it to them. If they persist, advise your instructor. Safety in the laboratory is more important than you not wanting to report a fellow student's hazardous behavior.

Do not wear headphone sets in the laboratory.

Laboratory procedures require your complete attention. Listening to music or other material on your “I-Pod” headphones diverts your attention and can prevent you from hearing alarms in case of any accident.

Cell phones can be a major distraction in the laboratory.

A ringing phone can divert your attention from a critical operation or procedure resulting in a spill or other accident. Talking on a cell phone also diverts your attention away from your work. Turn off cell phones in the laboratory. If you must make a telephone call, turn off all apparatus and step out of the laboratory to make the call.

Unauthorized experiments are not permitted

Without the information or experience, there is no way of knowing if an unauthorized experiment is safe to carry out.

Cleaning up

Always clean up your work area after completing each part of an experiment, as well as at the end of the laboratory experiment. Minimize the apparatus and materials on the bench top to eliminate sources of accidents.

Always clean up around the laboratory balances before taking chemicals back to your work area. This prevents contact with unidentified laboratory chemicals. If the person in front of you does not clean up spilled chemicals at the balance, ask him/her to do so. Please report any infractions to your instructor.

Cleaning up

Clean your glassware. Brushes are available in your apparatus drawer and detergent is located on each lab bench. This includes any special equipment used for the experiment. Rinsing with water does not remove all residues from glassware.

At the end of the laboratory session, **clean up your bench area.**

Wash and wipe down your bench top.

Be sure that the gas and water valves are turned off and any electrical equipment, with the exception of instrumentation such as pH meters and Spectronic 20's, are turned off.

Return any special equipment to the location from which you received it, with the exception of any equipment that is still hot to the touch, such as hot plates and iron ring supports.

CONSTRUCT A SAFETY MAP SHOWING LOCATION OF SAFETY EQUIPMENT AND EXITS IN THE LABORATORY

- Show the location of all laboratory benches, desks or other furniture in the laboratory.
- Identify all exits from the laboratory and write **EXIT** next to each doorway.
- Mark the location of all fire extinguishers with the words **FIRE EXTINGUISHER**.
- Mark the location of the fire alarm with the words **FIRE ALARM**.
- Mark the location of the eye wash station with the word **EYEWASH**.
- Mark the location of the safety shower with the words **SAFETY SHOWER**
- Mark the location of the fire blanket with the words **FIRE BLANKET**
- Mark the location of the first aid kit with the words **FIRST AID KIT**
- Mark the location of the waste hood with the words **WASTE HOOD**
- Mark the location of the glass disposal box with the words **GLASS DISPOSAL**
- Mark the location of each of the fume hoods with the word **HOOD**
- Mark the location of the emergency telephone with the word **TELEPHONE**