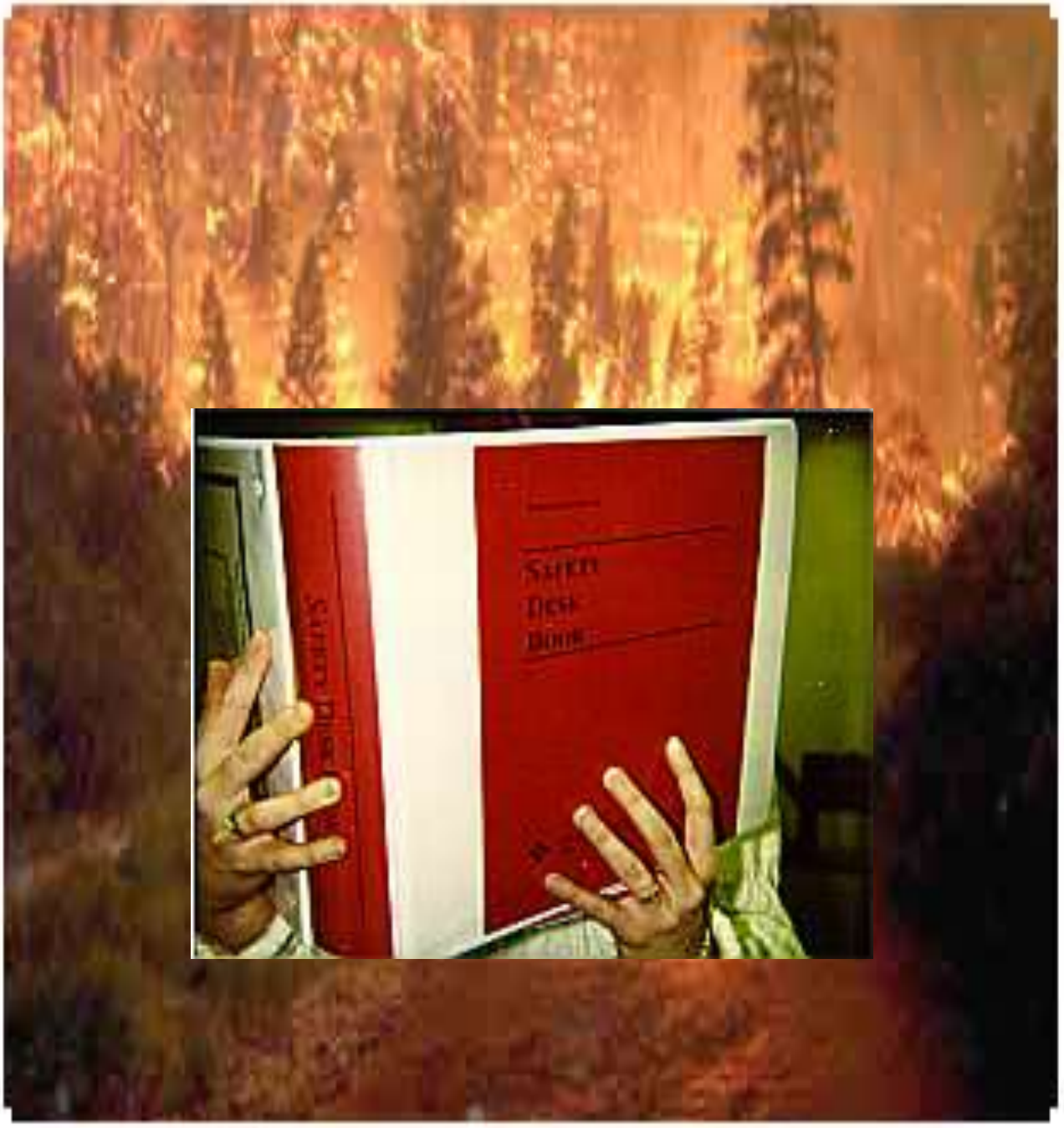
CHEMICAL SCIENCES DIVISION

LABORATORY SAFETY

Laboratory Safety

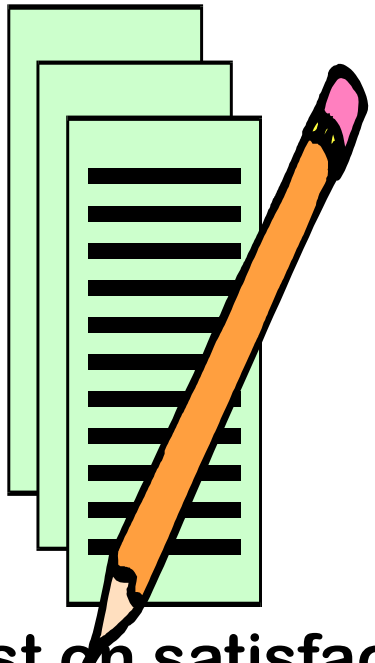


YOUR RESPONSIBILITY

Your safety training as a student is dictated by safety regulations. It is to your advantage to learn and practice safe laboratory practices.

Whenever necessary, you will be given laboratory safety instruction by your supervisor and you are required to read written safety materials given in published papers.

SAFETY QUIZ



Some laboratory classes insist on satisfactor completion of a safety quiz.

http://daphne.palomar.edu/safetyquiz/safetyquiz.htm

If you do not pass this quiz with at least an 80% proficiency you will not be allowed to work in the laboratory.

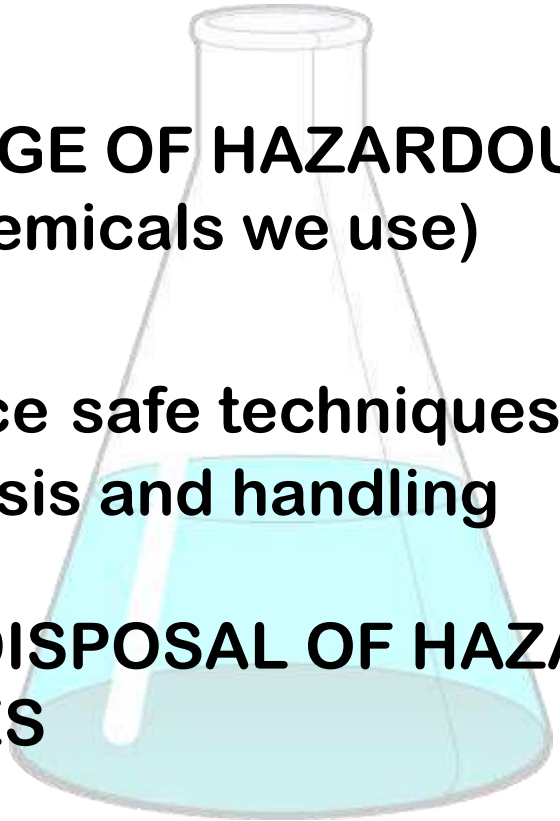
…. study this material very seriously

Aim of the Safety Committee….

- Promote safety awareness.
- Ensure and maintain a safe and healthy laboratory environment.
- Teach / practice “safe work”.
- Develop a laboratory safety program that is appropriate for the department.

SAFETY PROGRAM

TRAINING OF EMPLOYEES



STORAGE OF HAZARDOUS MATERIALS (the chemicals we use)

Practice safe techniques in synthesis and handling

SAFE DISPOSAL OF HAZARDOUS WASTES

DEVISING EMERGENCY PROCEDURES (first aid, fire, earthquake, building evacuation)

Danger!
Real and Imagined

- Danger is there everywhere..
- Where are you safer?
  - On a trip to Mysore and back by train ?
  - Working in the laboratory ?
  - Going to Yeshwantapur by a two wheeler ?

Sources of Danger

- Intrinsic Sources of Danger
  - Chemicals 9
  - Compressed Gas Cylinders 40
  - Liquid Nitrogen Containers 46
  - High Temperature Furnaces 47
  - High Voltage Sources 48-50
- Storage and Disposal 51-65
- Unsafe Practices
  - Personal protection 66
  - Uncharted Paths & Human error 82

Chemicals

- Potential Danger
  - Explosives
  - Flammables
  - Poisons, Carcinogens, Irritants
    Mutagens: CO, C_6H_6, etc..

- Proper Response
  - Appropriate Storage
  - Careful Transport
  - Minimum Usage
  - Correct Disposal

Materials Safety Data Sheets

MSDS

- **MSDS Hyperglossary** Hyperglossary
- **MSDS Demystifier** Demystifier
- **Hypoxia** Your body isn't getting oxygen, you will die.
  - If working in an enclosed space or with an asphyxiant. Move to a well-ventilated area if you become light-headed, weak or disoriented.
- An example of a chemical causing it is CO. Be sure you understand the dangers of carbon monoxide in the home and workplace. This nasty, invisible, odorless, colorless, gaseous poison can cause hypoxia and death!
- Camphor

MATERIAL SAFETY DATA SHEETS MSDS

A Material Safety Data Sheet (MSDS) is a multipage document that contains the following information about a chemical.

- Flammability
- Toxicity
- Exposure Risks (contact, inhalation,ingesti
- Reactivity and Fire Hazards
- Mixing Hazards (with other chemicals)
- Emergency First Aid Procedures
- Spill Handling Procedures
- Disposal Procedures

SOME SPECIAL MSDS TERMS

LD_{50}	Lethal Dose, 50% Mortality mg/kg
TLV	Threshold Limit Value mg/m^3 (ppm)
PEL	Permissible Exposure Limit mg/m^3 (ppm)
STEL	Short-Term Exposure Limit mg/m^3 (ppm)

Carcinogen	a substance shown to cause cancer
Teratogen	a substance shown to cause birth defects

See the Laboratory Safety section of the textbook for a complete discussion of these terms.

- Chemicals
  - Read the label
  - Review hazards of chemicals before starting an experiment. Secure hoses/tubing
  -

Designed to provide complete up-to-date information. On an Aldrich label you will find:

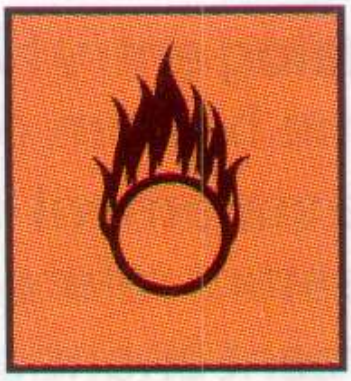
- **A** Product name and description
- **B** Product number
- **C** Package size
- **D** Lot number
- **E** CAS registry number
- **F** Hazard pictogram
- **G** Health and safety information
- **H** Physical properties
- **I** Chemical formula

Dichloromethane, 99.6%
A.C.S. reagent, Inhibited with 50 ppm amylene

May cause cancer. Possible risk of harm to the unborn child. Harmful if swallowed. Irritating to eyes, respiratory system and skin. Avoid exposure - obtain special instructions before use. In case of an accident or if you feel unwell, seek medical advice immediately (show the label where possible). Wear suitable protective clothing, gloves and eye/face protection.
Do not breathe vapor. Readily absorbed through skin.
Target Organ: heart because Methylene Chloride is converted to Carbon Monoxide in the body.
Target Organ: central nervous system because of possible dizziness, headache, loss of consciousness or death at high concentrations.

Handle and store under nitrogen.

Explosive



Oxidizer

Flammable

Toxic

Harmful or Irritant

Corrosive

Environmentally Toxic

Chemical Burns

Hydrofluoric Acid Burn from Trifluoracetic Acid

A laboratory worker picked up a container of trifluoroacetic acid with her ungloved hand to move it. She did not notice that there was a small amount of residue on the glass. Several hours later, she experienced pain in the palm of her hand and thumb. There was a serious burn that required skin grafting. She was not aware that this type of burn could result from handling trifluoracetic acid.

Trifluoracetic acid can form hydrofluoric acid upon contact with moisture. Hydrofluoric acid can cause deep burns that may not be painful for hours.

What should we do ?

-Know the hazards of the chemicals involved before handling them.

-Always assume containers are likely to be contaminated on the outside and wear appropriate gloves when handling chemical containers.

-Keep a hydrofluoric acid burn kit in the laboratory when working with hydrofluoric acid or trifluoracetic acid.

POTENTIAL SHOCK-SENSITIVE CHEMICALS

- Ammonium nitrate
- Ammonium perchlorate
- Ammonium picrate
- Calcium nitrate
- Copper Acetylide
- Cyanuric triazide
- Trinitroanisole
- Trinitrobenzene
- Trinitro*anything?*

POTENTIAL PEROXIDE-FORMING CHEMICALS

- Acetal Ether (Glyme)
- Cyclohexene
- Decahydronaphthalene
  Tetrahydronaphthalene
- Methyl Acetylene
- Dicyclopentadiene
- Isopropyl Ether Diethyl Ether Tetrahydrofuran (all ethers!)
- Diethylene Glycol
- Sodium Amide

Incompatible Chemicals

Ω

Toxic Chemicals

LEVELS

- Phenol (irritant)
- Phosgene, mercury (poison)
- 1-Naphthylamine, benzidine, dimethyl sulfate (carcinogens)
- arsenic compounds, (Mutagens)

Poisons...

- **Mercury Compounds**
  - **1997 The News York Times HANOVER, N.H., June 10** - A Dartmouth College chemistry professor Karen E. Wetterhahn, 48, has died from exposure to a rare form of mercury, first synthesized more than 130 years ago. Dimethylmercury Skin Exposure Fatality

Carcinogens

- Benzene
- CCl_4
- Thiourea
- Saccharin
- Methyl Iodide
- Metronidazole
- Most Dyes..

- Lists are available in the internet
- From Unversity of Bath (local)

Mutagens and Teratogens…….

- Huge list… Priority chemicals are given here local list

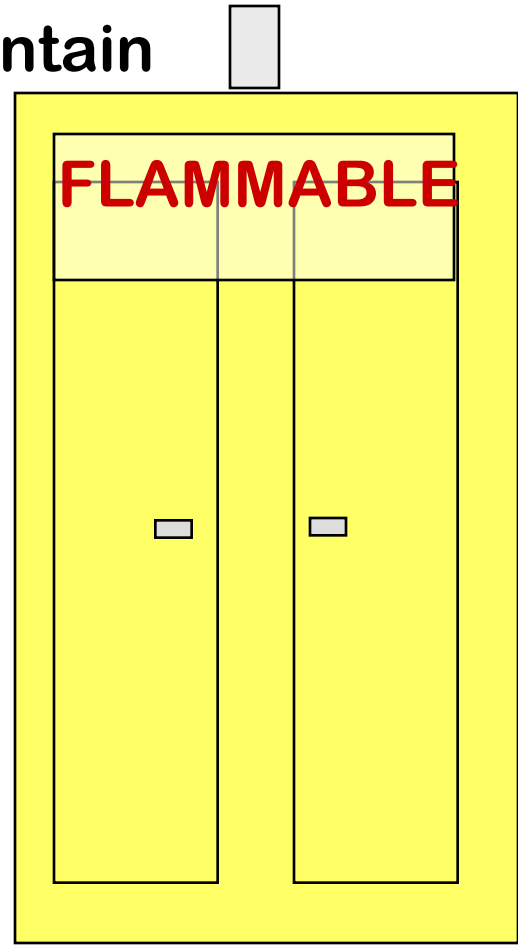
Storage of Chemicals

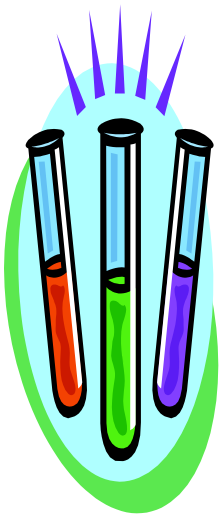
- The principle concern is to achieve / maximize STUDENT safety
- Proper storage will account for
  - chemical compatibility, (Check Chart) Ω
  - spill control
  - fire / explosion control, (Not yet)
  - Temperature
  - provide a "user friendly" system (inventory)

STORAGE CABINETS

Secondary containment is also a requirement for
the storage of volatile liquids.

The ventilated cabinets used to store volatile reagents must have a chamber at the bottom which can contain the entire contents of the cabinet if the reagents should spill.
These cabinets will also contain a fire and prevent serious fire damage.





Flammable Liquids Storage & Handling

- Flammable liquids are stored and used away from ignition sources. (Not to be used as a stand)
- Bulk quantities of flammable liquids (within permissible quantities) are stored in properly labeled storage cabinets.

Flammable Liquids Storage & Handling

- Flammable liquids should be handled in a fume hood to prevent accumulation of vapors.

- Heat guns and other equipment capable of igniting flammable vapors should not be used to heat flammable vapors.

- Expolsions from solvents

CHEMICAL SPILLS

It is your responsibility to clean up any chemicals that you spill. If necessary, ask for guidance.

For acids and aqueous solutions, sponges and paper towels.

If there is a major spill of a volatile or hazardous substance, you may have to evacuate the lab.

Notice how tissue paper is Left lying around near the Balance.

Transport of Chemicals

- Gas cylinders:
  - Use Trolleys
  - Cap it while transporting
- Liquid Nitrogen:
- Corrosive Chemicals

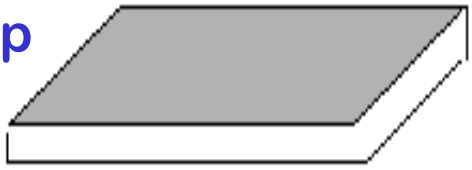
SECONDARY CONTAINMENT

Whenever reagents are moved from one room to another, secondary containment is required.

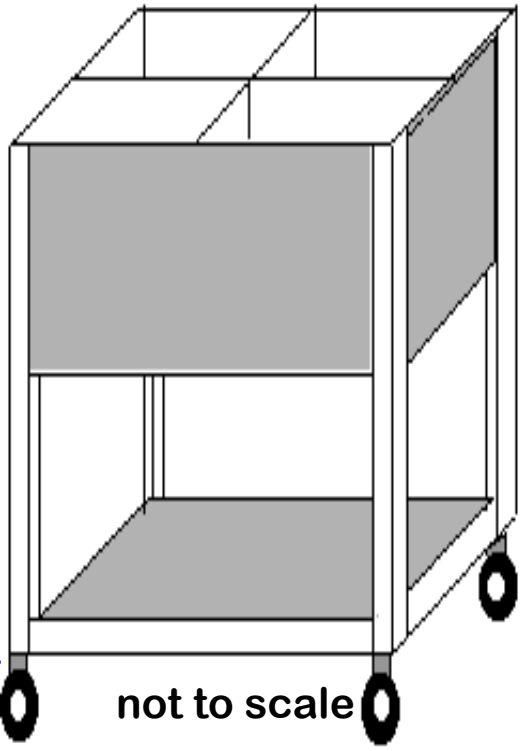
Secondary containment requires that each reagent be placed in an unbreakable container with a lid that will "contain" or hold the contents of the primary container if it should break.

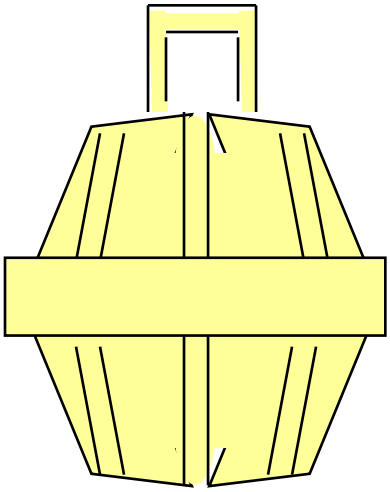
When reagents are brought from the stockroom to our lab, they are either placed in a trolley with containment chambers, or in special hand-carried polyethylene "buckets". *All of these carriers should have secure lids.*

TRANSPORTING CHEMICALS



reagent bottles go inside chambers





bottle carrier

(holds a 5 L bottle)

containment cart

(holds various lab supplies)

safety basket

(holds six 500 mL bottles)

Carrying Chemicals Incorrectly

A laboratory worker placed unsealed centrifuge tubes filled with phenol-chloroform into a styrofoam centrifuge tube shipping container. The styrofoam broke and the phenol-chloroform splashed onto the worker's face and dripped down the chest. The worker immediately flushed the area with a water, but still suffered from second-degree burns to the face, chest and abdomen. *Fortunately, the worker was wearing chemical splash goggles and did not receive burns to the eyes.*

What do we learn ?

- Appropriate eye and face protection helped to minimize the chemical burn.

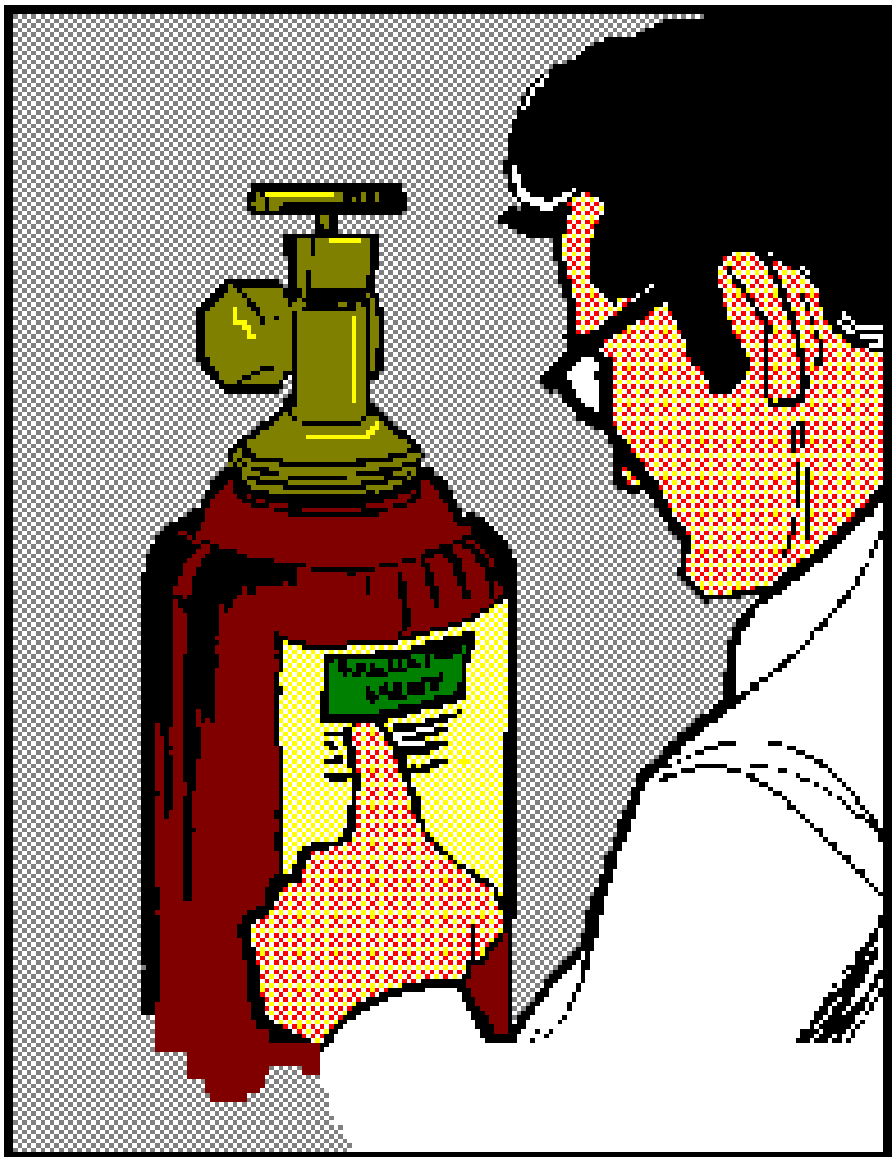
-Wear a closed lab coat when working with hazardous materials.

-Use a plastic centrifuge rack instead of a Styrofoam packing container, particularly when transporting chemicals.

HANDLING GASES

Cylinders

Identification of gases:



Identifying Gases

Gas	US	International
Oxygen	Green	White
Nitrous Oxide	Blue	Blue
Nitrogen	White	White
Air	Yellow	White & Black
Carbon Dioxide	Gray	Gray

Gas	Indian	
	Body color	neck color
Oxygen	Black	White
Nitrogen	gray	
Argon	Blue	
Hydrogen	Red	Red
Acetylene	Black	black

Transportation of Cylinders

Leaks

If leaks are discovered, inform SECURITY.

If the gas is toxic or it is an irritant inform security and cordon off the area.

POST APPROPRIATE SIGNS

Cryogenics, Fire, Electrical….

Control sources of contamination. (ice formation in liquid nitrogen containers

- Be aware of the possibility of pressurization when working with cryogenic liquids

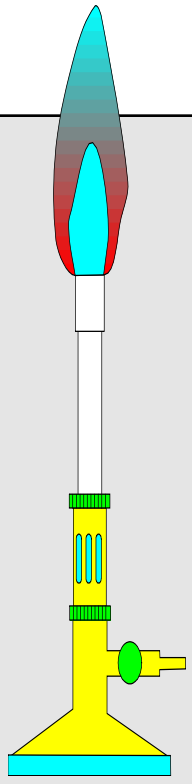
- Consider shielding for operations involving : vacuum or pressurization

-)

FIRE SAFETY

Many of the solvents used in this lab are flammable and will burn. Avoid flames.

GLASSWORKING



A special area is provided in an adjacent room where flames may be used to bend tubing or perform other glass work.

Avoiding Electrical Fires

Do not cascade extension boards

Electrical Safety

Do not put multiple pins on the same socket.

Check the earth to neutral voltage

- **Do not defeat safety locks in any instrument.**
- **Do not work around energized, exposed conductors**
- 
- Equipment
  - Replace worn components

-Carbon dioxide extinguishers should be used around sensitive equipment.

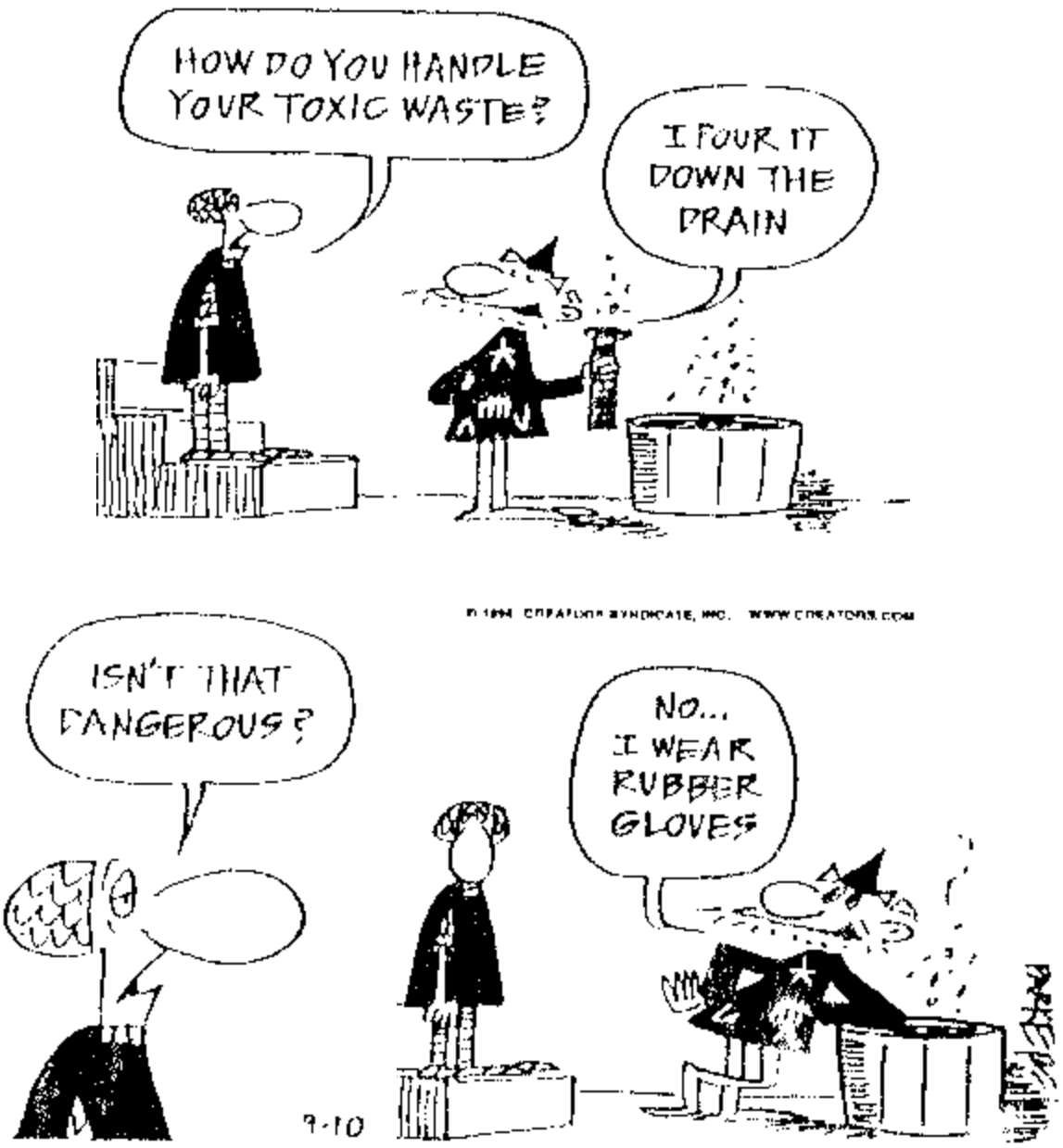
Dry powder extinguishers can damage such equipment.

Laboratory Waste

- Purchase Prudently
- Practice Solvent Recycling
- Accumulate / Dispose waste properly
- Maintain an Inventory

Use Less and Less and Less …

Until recently……



Disposing of waste solvents

Disasters…….

Disposing of waste solvents

- Chemical containers should be triple rinsed and dry before being used for waste accumulation

- Solvent waste cans are labeled properly with: **Name, Contents, Lab #**.

CHEMICAL WASTE DISPOSAL CONTAINERS

Waste containers are found in the waste disposal hoods - one hood at each end of the laboratory.

All wastes are collected in containers located in the waste disposal hoods.

Several types of containers are supplied.

Liquid wastes or solutions fit into one of the following containers.

Halogenated Waste

Non-Halogenated Waste

Aqueous Waste

Heavy Metal Waste

CHEMICAL WASTE CONTAINER LABELING

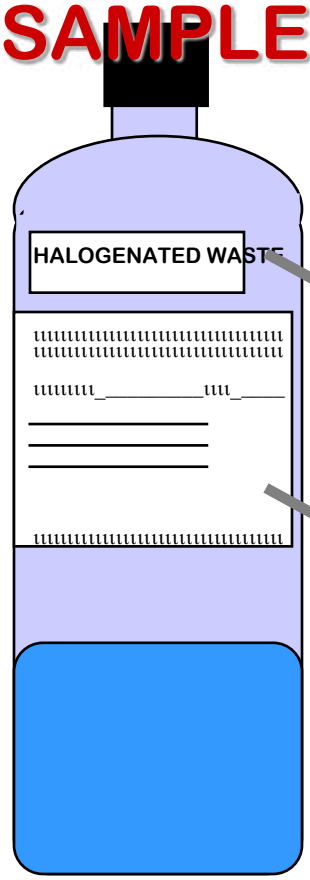
Prepare a waste label before the containers are placed in the waste hood.

Each waste container must be labeled with the complete contents of the container and any known hazards.

When the contents are not known, the disposal procedures must assume that halogens and/or heavy metals may be present. This increases the cost of disposal.

PLEASE USE THE CORRECT WASTE CONTAINERS

SAMPLE WASTE CONTAINER LABELS



HALOGENATED WASTE

Indian Institute of Science
Hazardous Waste

Generator/Contact IPC AGS **Date** 3-3-03
Phone No 2384 **Dept** Chem **Rm No** IPC 123
Chemical Name/Composition

dichloromethane bromobenzene
chlorocyclohexane

Check Hazard(s)

☒ Toxic	☐ Corrosive	☐ Oxidizer
☐ Highly Toxic	☐ Flammable	☐ Solid
☐ Acid	☐ Water Reactive	☒ Liquid
☐ Base	☐ Air Reactive	☐ Gas

Other Hazard(s) _____

*Handle With Care * Don't Mix Waste **
Specify ALL contents

The first label gives the type of waste.
The second label gives specifics: Every chemical needs to be listed by name, and all known hazards must be specified.

Halogenated Waste

F Cl Br I

Any chemical compound which contains any of a Group VII element compound.

Organic liquids (or liquid mixtures) which contain halogenated compounds should be placed in a separate waste container.

Non-Halogenated Waste

C H N O

Organic liquids (or liquid mixtures) which do not contain any halogens may be placed in this container for disposal.

It costs more to process halogenated waste because
more rigorous (and costly) procedures are required to
prevent the formation of acidic gases (HCl, HBr, etc.)

Aqueous Waste

H_2O

Aqueous means it is contaminated water or a water solution containing inorganics. Any water based solutions (except those containing
heavy metals) should be placed in the aqueous waste
container.

Heavy Metal Waste

Cr
Hg
Pb

Heavy metals include the transition metals. Typical heavy metals that might be used in an organic
lab might include Zn, Cr, Cu, Pb, Mn, Fe, Co, Ag, etc. Heavy metal wastes (although usually aqueous) should
be placed special containers designated for this purpose.

Zn

$NaSO_4$

Solid Chemical Wastes

Solid chemical wastes should be collected in separate wide mouth containers, different from the liquid containers.

Halogenated compounds and heavy metal solid wastes should be separated.

Trash (Non-Hazardous Solid Wastes)

Paper, corks, tea leaves, and other non-hazardous
substances may be placed in the trash containers.

Do not, however, place any glass (*broken or not*) in
the trash containers.

Broken Glass Waste

Any glass or broken glass waste must be placed in the
special cardboard box containers provided.

Do not place paper or garbage in these containers.

Do not pick up broken glass with your fingers. Use a dust pan and broom located in a marked
cabinet.

Destroy before disposal

- - Alkyl boranes
- - Aluminum Alkynes
- - Ammonium Nitrate
- - Benzoyl Peroxide
- - Calcium Carbide
- - Chromic Acid
- - Cyanides
- - Ethers
- - Grignard Reagents
- - Hydrogen Peroxide
- - Iron Sulfide
- - Metal Alkyls
- - Metal Hydrides
- - Peracetic Acid Solution
- - Peroxide Forming Compounds
- - Picric Acid
- - Sulfides
- - Water reactive metals (Lithium, Potassium, Sodium, Cesium)

UNKNOWN WASTES

- Identify the contents by asking other researchers if they produced the material or know who did.
- If the original researcher cannot be found, ...contact the group leader.
- If your efforts at identifying the waste are unsuccessful, the contents will have to be disposed at a significant cost!

AVOID CONTAMINATION OF CHEMICALS

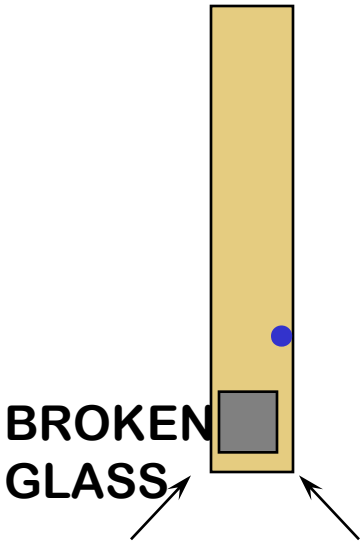
Do not put chemicals back into reagent bottles.

Returning an unused chemical to a container risks contamination.
Take only the amount you need.
Extra material must be placed in the appropriate chemical waste container.

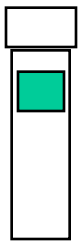
Take only as much as you need.

Whenever possible, share excess material with a neighbor.

TRASH CONTAINERS



Trash containers are to be locate under the sinks on either side.
(positions may be reversed).



cardboard box

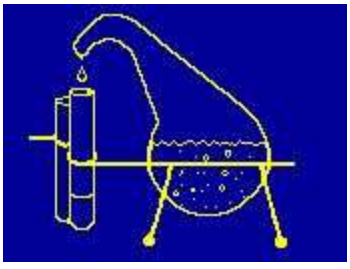
cylindrical metal / plastic container

Not All Trash is the Same

Broken glass must be separated from other types of trash.

Working in the Laboratory..

- Forbidden: Smoking, eating and drinking in the laboratory.
- No food to be stored in chemical refrigerators.
- All work and No play zone!



WHEN CAN YOU WORK ?

For your own safety, you should never work alone in the laboratory.

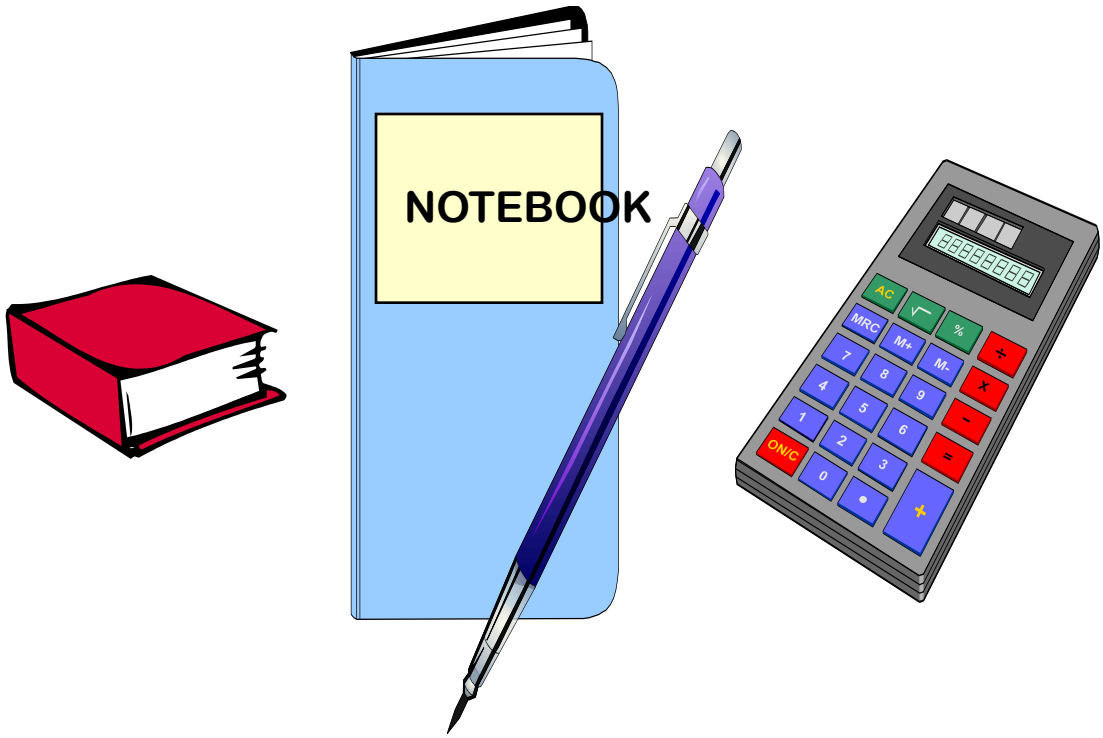
If you are injured there will be no one to help you or to call for emergency help.

YOU SHOULD NEVER WORK ALONE IN THE LAB

Do not work if drowsy or if you are taking medication.

Don't rush

Do your experiments in the hood.



Hood Sinks. The sinks in the hoods are meant to receive the water flow from condensers. Do not pour any chemicals or solutions down these sinks.

Excess chemicals go in waste containers. Only water is placed in the hood or bench sinks.

Proper Attire

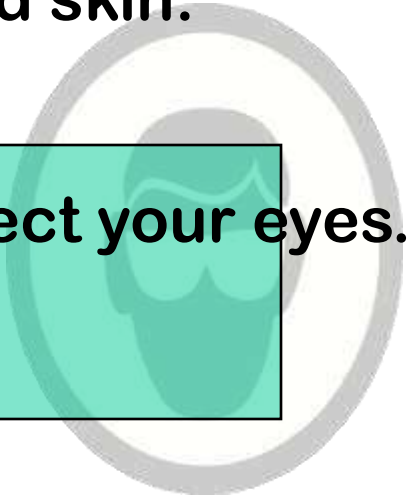
- Require the use of appropriate eye protection at all times -- in a laboratories and areas where chemicals are transported.
- Provide adequate supplies of Personal Protective Equipment -- safety glasses, goggles, face shields, gloves, lab coats, and bench top shields.

PERSONAL PROTECTION

The most common type of exposure in the lab is the inhalation of chemical vapors.

To protect yourself from vapors, always work with chemicals in a hood.

The second most common type of exposure is to the eyes and skin.



Always wear goggles to protect your eyes.

Chemically resistant gloves will prot
you from the most common type of s
exposure.

EYEGLASSES

Ordinary eye glasses
(even if hardened) do not provide adequate protection to your eyes.

If you wear glasses, the goggles will fit over them.

CONTACT LENSES

Contact lenses may be worn in the laboratory, but
you must also wear approved safety goggles.

GOGGLES

GOGGLES MUST BE WORN AT ALL TIMES WHEN WORKING IN THE LABORATORY.

You must wear the type of goggles that seal completely around the eyes and provide splash protection from top, bottom, and the sides, as well as from the front.

12/20/2011

Eye Protection

- At University of X, an investigator was blinded in one eye when a cryotube exploded while being thawed.
- The probable cause was the rapid expansion of liquid nitrogen that had entered the tube through a small crack during storage

Eye Protection

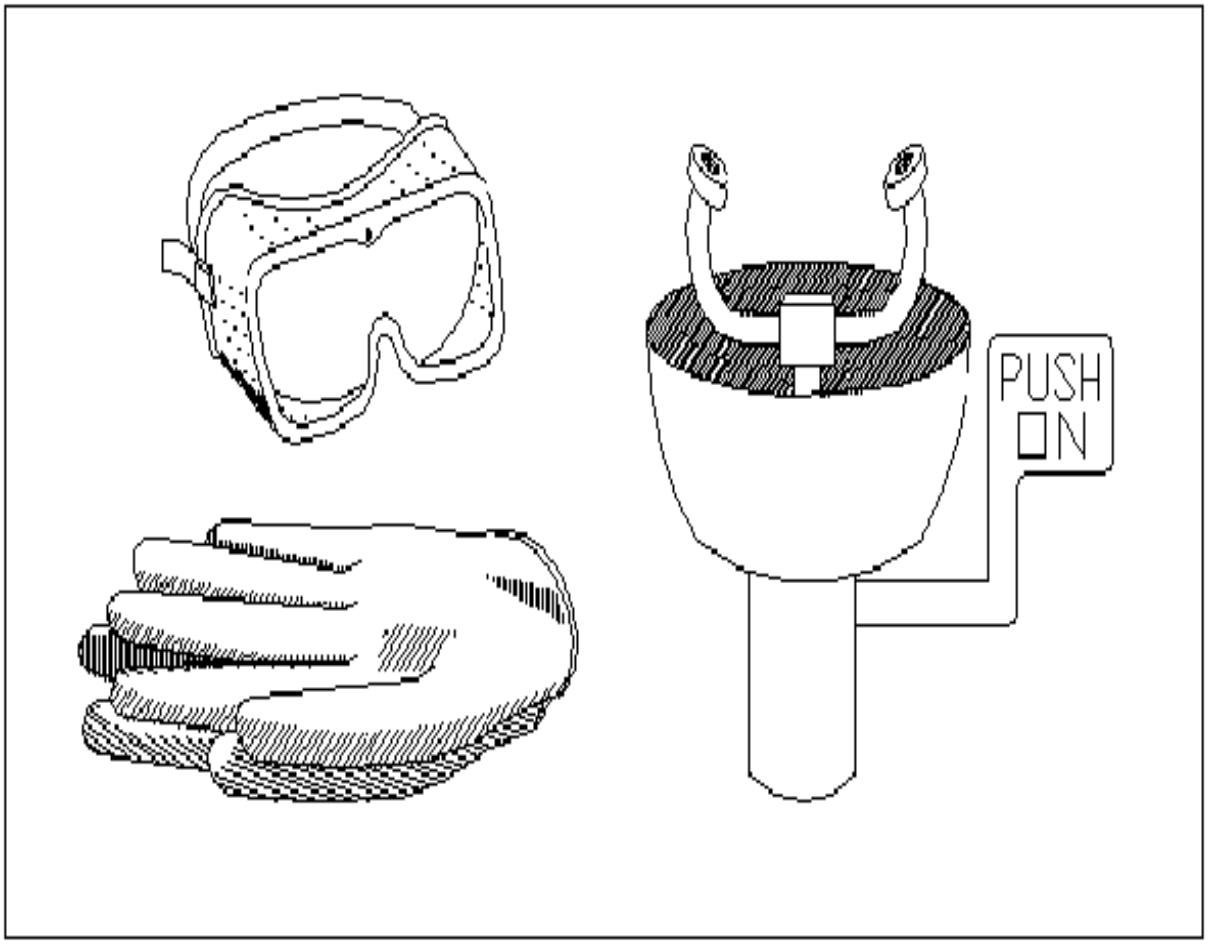


Figure 2. Chemical splash goggles, gloves, and an eye wash station located near the spotting station are all important to protect the health and safety

SHOES

You must wear closed-toe shoes in the laboratory

- open-toed sandals are not permitted.

- bare feet are not permitted

GLOVES

You are advised to use chemically-resistant gloves for use in the laboratory.

The most effective gloves for general use are the “nitrile” gloves.

LABORATORY COATS

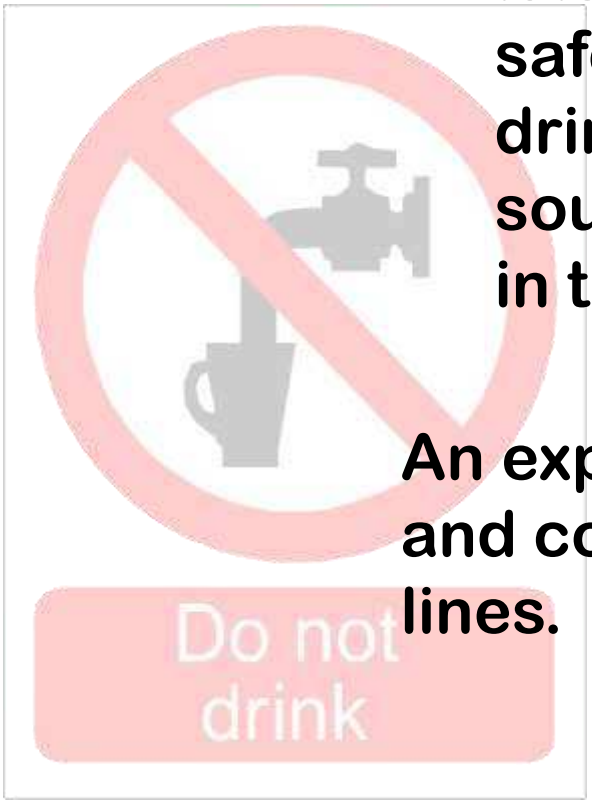
If you wish you may also purchase a white lab coat, or an apron, to protect you from chemical spills.

TOXICITY

NO EATING OR DRINKING IS ALLOWED IN THE LABORATORY

Do not bring any food or drink into the lab, there is always a risk of contamination with toxic chemicals.

12/20/2011



It is not considered safe to
drink water from any source
in the laboratory.

An experiment could back up and contaminate the supply lines.

Be sure you wash your hands well before
eating or drinking, your hands may be
contaminated with chemicals.

NO SMOKING

SMOKING IS NOT ALLOWED IN THE CHEMISTRY BUILDING
- YOU MUST GO OUTSIDE

Outside IISc because, the Institute prohibits smoking in all public

Think before you carry out a reaction

- What are the hazards?
- What are the worst possible things that could go wrong?
- How will I deal with them?
- What are the prudent practices, protective facilities and equipment necessary to minimize the risk of exposure to the hazards?
- Review Risk Assessment when scaling up reactions

Key Points

- Don't leave reactions unattended.
- Use proper PPE.
- Set chemical hood sash to lowest height possible.
- Ensure adequate ventilation

And when it happens...

All accidents (incidents) must be reported, evaluated by the departmental safety committee, and discussed at departmental safety meetings.

TELEPHONES

- Display the phone numbers of the fire department, police department, and local ambulance either on or immediately next to every phone.

- Identify yourself and your location first.

PERSONAL INJURY

- If skin is exposed to moderate concentrations of acid or base or other hazardous chemicals, wash thoroughly with running water.
- Remove any contaminated clothing at once.
- If eyes are infected, flush thoroughly with water for 15 minutes.
- If noxious gas has been inhaled, contact authorities immediately and get to fresh air as soon as possible.
- In the event of injury to yourself or a student in a laboratory, always consider dialing the emergency number DIAL 2227 / 100
- Your own sound judgement and consultation with the victim will guide your decision, but it is better to err on the side of caution when burns, toxic exposure or deep cuts are at issue.

First Aid

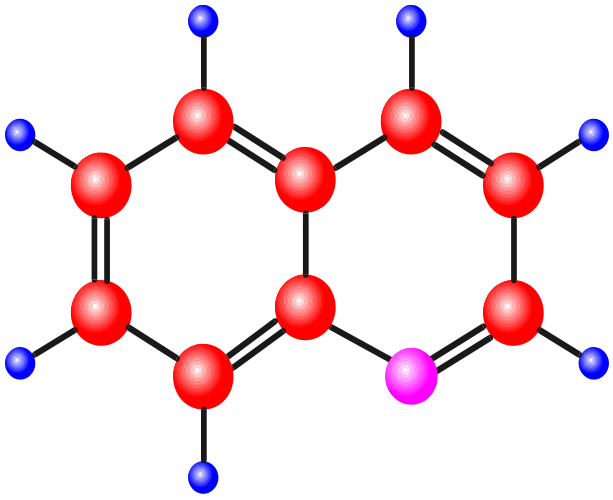
PERSONAL INJURY

Call the HC 2227

- Bleeding; stop bleeding by applying either a bandage or your hand firmly over the wound. If no fractures are suspected, wrap the wound with a firm bandage and elevate the injury. Never use a tourniquet.
- Shock; when victims look pale and say they are cool, elevate the legs 10 to 12 inches and cover them with something.
- Do not move victims unless there is a life and death situation (fire, etc.), otherwise keep them still and as comfortable as possible.

First Aid

- 40 3/4" Plastic Strips
- 2 Eye Pads
- 10 2" x 3" Adhesive Strips
- 1 Scissors
- 1 1/2" x 5 yd Adhesive tape
  5 2" x 3" Non-Adherent Pads
- 1 Antiseptic & Burn Ointment
- 4 Antiseptic Wipes
- 1 1" x 10 m. Gauze Bandage
- 1 Triangular Bandage
- 1 10 gram USP Cotton



YOU SHOULD IMMEDIATELY REPORT ANY UNSAFE WORKING CONDITION TO YOUR ADVISOR

We would like to correct any safety problem in the lab as quickly as possible. If you become aware of any unsafe or potentially unsafe condition in the lab, please let us know.

IN CASE OF A FIRE
OR
A MAJOR SPILL

Future program….

If there should be an emergency such as a fire or a major spill of a hazardous chemical you should evacuate the laboratory.

COMING SOON!!

FIRE EXTINGUISHERS

Learn the location of the fire extingu r(s
nearest to your position in the labora

There is a pin that must be pulled in order to operate the extinguisher.
After pulling the pin, aim the nozzle at the base of the fire.
Squeeze the handle.

If an instructor is nearby, it is best to w them to extinguish the fire.

Once a fire extinguisher has been use , you should report its use, so that it can be recha

- Provide fire extinguishers, safety showers, eye wash fountains, first aid kits, fire blankets and fume hoods in each laboratory and test or check 6-monthly. Make sure it has been refilled in the last 12 months.
- Learn how to use the fire extinguisher in the lab.

-If clothing is on fire, smother the flame by rolling on the ground or use a safety shower to extinguish the fire.

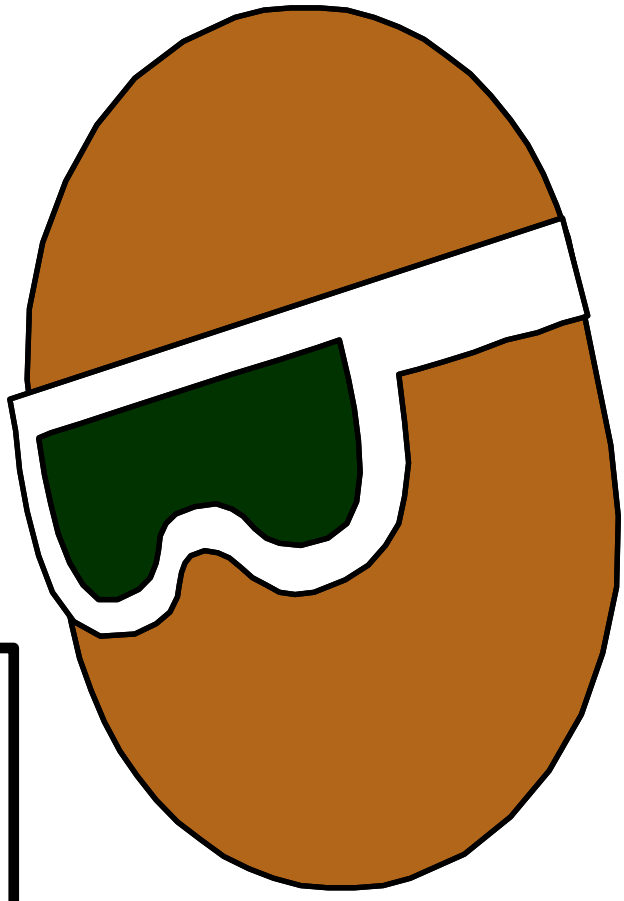
From www.ilpi.com a ppt

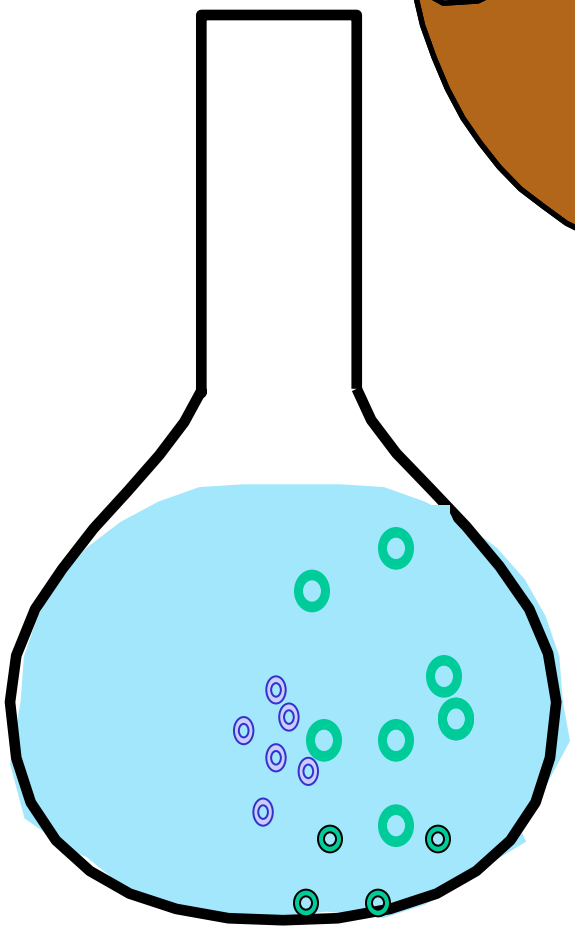
Acknowledgements

This Material has been liberally borrowed from the internet.

…All the pages that come on a Google Search for Chemical Safety

Thanks to the many, many people out there who prepared this…





We wish you all a safe working environment!!