

American University of Beirut
Chemistry Department

Laboratory Safety



Date: 29-04-2011

A Yale University senior was **killed** in an accident in a chemistry laboratory's machine shop **Two weeks ago**.

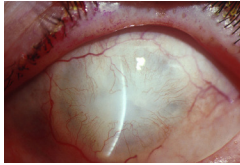
The student's **hair** got caught in a machine while working on a project. **The cause of death was asphyxia due to neck compression.**

- You follow safety at **your home**
- You follow safety on the **roads**
- You make sure everything is safe when it comes to **babies and kids**
- Then why not follow safety in laboratories,
one of the major hazardous places.

Why Lab Safety? Why does it matter?

- Protect **yourself** from laboratory hazards
- Protect **others** from laboratory hazards
- Protect the **environment**
- Comply with the University's lab Safety Policy "Chemical Hygiene Plan"

To avoid such accidents



Laboratory Safety Training Objectives

- Laboratory Safety Recognition and Evaluation of chemical Hazards
- Handling chemicals properly
- Laboratory Emergency Preparedness and Spill Response
- Chemical Storage
- Laboratory Waste Disposal



- Working in a laboratory can be an exciting experience.
- It can also pose many threats and hazards that a traditional classroom does not.
- Such hazards can be physical or chemical and can cause serious injuries.

Know Your Surroundings

Physical Hazards

- Fire
- Bunsen Burners
- Autoclaves
- Compressed Gas Cylinders
- Broken Glassware
- Razorblades and needles
- Electrical Equipment
- Ultraviolet light

Chemical Hazards

- Flammable Chemicals
- Reactive Chemicals
- Corrosive Chemicals
- Toxic Chemicals
- Radioactive chemicals
- Explosive chemicals

Consequences of these hazards

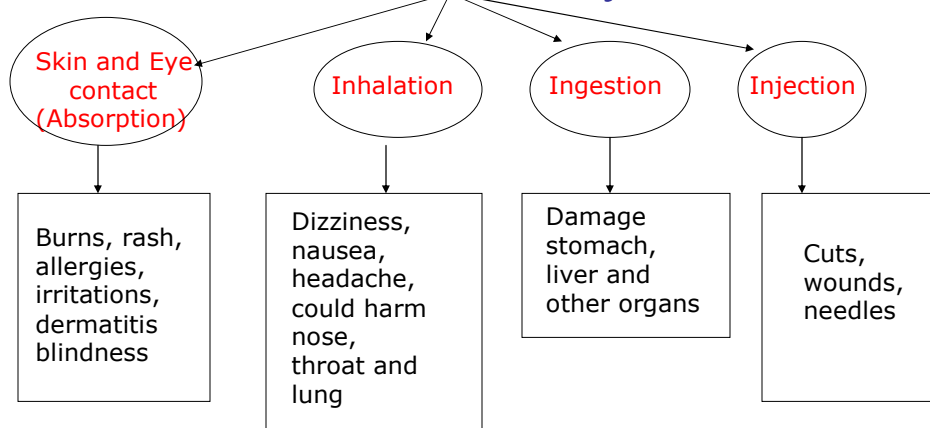
Physical:

- Fires
- Explosions

Chemical:

- Burns
- Poisoning
- Irritation

Ways of penetration of chemicals into our body



Avoiding Hazards

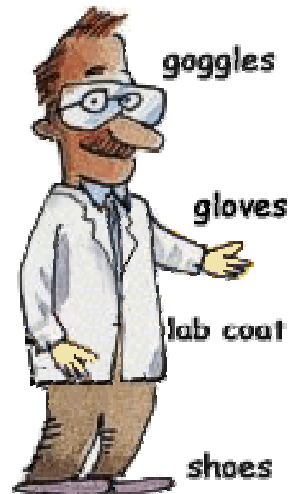
Wearing appropriate Personal Protective Equipment (PPE)

- Reading labels
- Knowing safety symbols
- Reading the MSDS of chemicals
- Knowing the locations of safety equipment
- Knowing Emergency Response Procedures
- Knowing storage procedures
- Knowing proper disposal procedures
- Knowing Emergency Numbers

American University of Beirut Laboratory Safety Manual, Environmental Health, Safety & Risk Management Life Safety & Hygiene Division, APRIL 2006

Wearing appropriate PPE

- Personal Protective Equipment
 - Eye Protection – chemical/splash/impact goggles, face-shields (no contact lenses)
 - Clothing -Labcoats, long pants, closed shoes
 - Gloves - rubber, butyl, latex, nitrile?
 - Respirators



Hazards vs PPE (minimum PPE requirements)

Hazard	Eyes	Face	Body/Hands
Any laboratory or general use of chemicals	Safety glasses (all times in lab)		Normal work/lab attire (no sandals, shorts, etc) with over-garment (smock, lab coat, or coveralls), & gloves
Use of corrosive chemicals, strong oxidizing agents, carcinogens, mutagens, etc.	Chemical splash goggles	Full face shield over goggles (if gallon or more liquid)	Resistant gloves (see glove selection guide), resistant apron or over-garment (full protective suit for work with over 5 gal corrosive liquids)
Sharp objects, glass, insertion of tubes into stoppers	Safety glasses		Heavy cloth barrier or leather gloves
Temperature extremes	Safety glasses (goggles if possible splash)	Recommend full face shield (large quantity gas/liquid or sparking)	Insulated gloves for ovens, furnaces, cryogenics & devices over 100C or below -1C, use over-garment for hot/cold liquids & sparking

Always check the MSDS to find out what PPE you will need.

Avoiding Hazards

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Reading labels

The national fire protection association

NFPA Diamond - used by fire/ rescue personnel

Ex: Cyanide compounds, mercury and merury compounds, benzene, CCL4



Ex: Methanol, toluene, acetic acid, phosphorous, magnesium,

Example



NFPA Diamond for Sulfuric acid



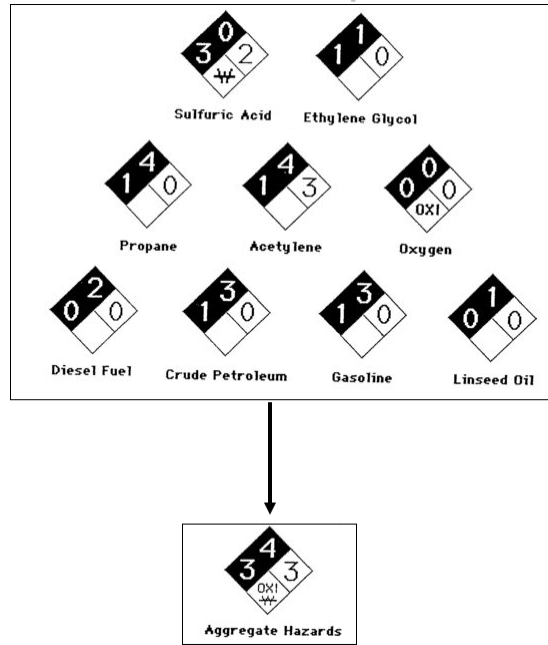
NFPA Diamond for Acetone



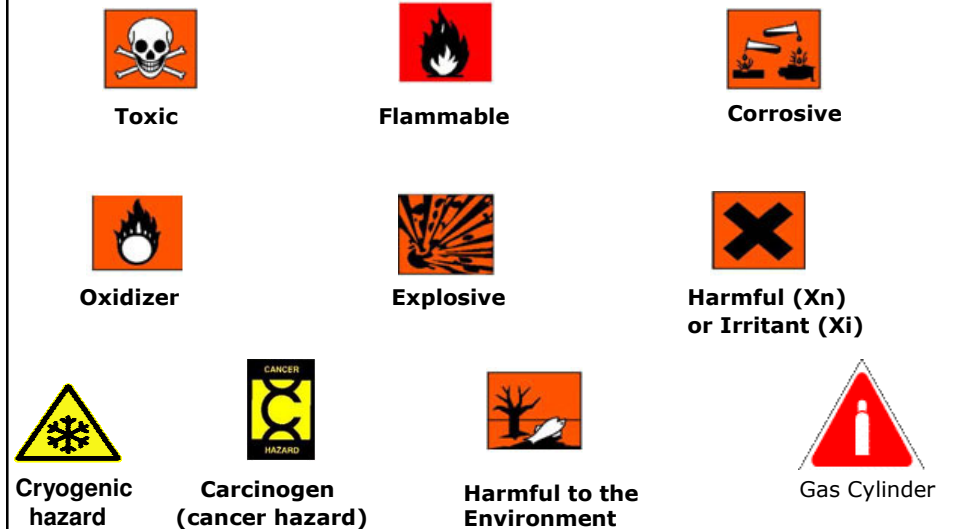
NFPA Diamond for door of room containing Sulfuric Acid and Acetone



Example



Other Common Symbols on Product Labels



Labeling

- Purchased bottles should be labeled by date received and date opened.

Labels on prepared chemicals in labs

- All chemical containers must be labeled completely. Original manufacturers labels should not be obscured.
- Chemicals transferred to other containers or prepared solutions should be labeled clearly with the following information:
 - Complete name of the chemical and concentration
 - Complete name of the solvent
 - Date of preparation
 - Course number/Research lab
 - Name (not initials) of the person preparing the solution/sample

Labels on prepared chemicals in labs

- When a chemical container is emptied the original label should be either removed or defaced completely using indelible ink marker or paint.

This will minimize the possibility of accidentally using the wrong material due to a labeling confusion.



Deteriorated labels



Damage to container labels reduces their usefulness and can lead to mishaps and unknowns.

Reference: Office of compliance, fast facts, safe use and handling of hazardous chemical products (2007)

Have periodic checks on
labels

Avoiding Hazards

- Wearing appropriate Personal Protective Equipment (PPE)
- Reading labels
- Knowing safety symbols
- Reading the MSDS of chemicals
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Reading the MSDS of chemicals

– Types of information typically provided:

- » Chemical name
- » Composition and ingredients information
- » Potential health effects
- » Exposure levels, with specific concentrations and times
- » First Aid Procedures
- » Fire fighting procedures
- » Accidental release procedures
- » Handling and storage procedures
- » Recommended personnel protection
- » Physical and chemical properties
- » Stability and reactivity
- » Toxicological information
- » Environmental impact
- » Disposal Recommendations
- » Transportation information
- » Regulatory information
- » NFPA rating

MSDS Information

Exposure Limits

- There's no guarantee that if your exposure to a hazardous substance exceeds the limits, you'll automatically experience an adverse health effect.
- However, you can't assume that if you're exposed to permissible levels of a substance, you won't suffer adverse effects.

Exposure Limits

- Agencies that publish limits:

- **OSHA**

Occupational Safety and Health Administration (OSHA) sets Permissible Exposure Limits (PELs) for 550 chemicals. These have the power of law.

- **ACGIH**

American Conference of Governmental Industrial Hygienists (ACGIH) has determined Threshold Limit Values (TLVs) for about 850 chemicals. These are advisory only.

OSHA's Permissible Exposure Limit (PEL)

- Maximum daily human exposure to a specific substance allowed in a workroom's air over an 8-hour shift. It is based either on a time weighted average or the maximum exposure limit.
- Time-weighted averages, TWAs. This is an average exposure weighted for an 8 hour work day.
- Ceiling (C) limits, not to be exceeded during any part of the work day. Highest allowable concentration of a chemical to which a worker may be exposed over a period.

U.S. Department of Labor, Occupational Safety and Health Administration (2006)

Example PELs

- Sulfur dioxide has the following OSHA PELs. Notice the units: ppm or mg/m³.
 - 8-hr TWA: 2 ppm (5 mg/m³)

ACGIH's Threshold Limit Values

- Like PELs, TLVs are the allowable limit for an air contaminant to which nearly all workers may be repeatedly exposed day after day without adverse health effects.
- Threshold Time Weighted Average (TLV-TWA) – the average concentration over an 8-hr day and a 40-hr week that a worker can be exposed to without adverse effects

Toxicity Data

- **Lethal Dose (LD50)** – the single dose of a substance that can result in the death of 50% of the exposed population.
- **LD50** is measured in micrograms (or milligrams) of the material per kilogram of the test-animal's body weight
- The lower the amount, the more toxic the material.

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Knowing the locations of safety equipment:

- eyewash station
(flush for 15 minutes)
- body shower
(remove clothing in the shower and
rinse for 15 minutes)
- first aid kit
- Spill kit
- fire extinguisher



Using Safety Equipment

Chemical in the Eye

- Flush the eye immediately with water while holding the eye open with fingers.
- If wearing contact lens, remove and continue to rinse the eye with water.
- Continue to flush the eye and seek immediate medical attention.

Body shower (Used in case of fire or spill on body)

- For spills directly on human skin, do the following:
 - Flush area with copious amounts of cold water from the faucet or drench shower for at least 5 minutes.
- If spill is on clothing, first remove clothing from the skin and soak the area with water as soon as possible.

Acid/Base Spill (Spill kit)

- For a spill not directly on human skin, do the following:
 - Neutralize acids with powdered sodium hydrogen carbonate (sodium bicarbonate/baking soda), or bases with vinegar (5% acetic acid solution).
- Avoid inhaling vapors.
- Sweep up and dispose of as hazardous waste.
- Arrange treatment by medical personnel.

Spills

When a spill occurs, an aerosol can be created which can make the material several times more potent.

- **Minor Spills**

- A minor spill is a small spill that involves less than 500 g solid or 500 ml liquid of non-acutely hazardous materials.

- **Major Spills**

- A major spill is a large spill that involves more than 500 g solid or 500 ml liquid or any amount of an acutely hazardous material.

An acutely hazardous material is any material that is imminently dangerous to life and health.

Spills

- **Minor Spills**

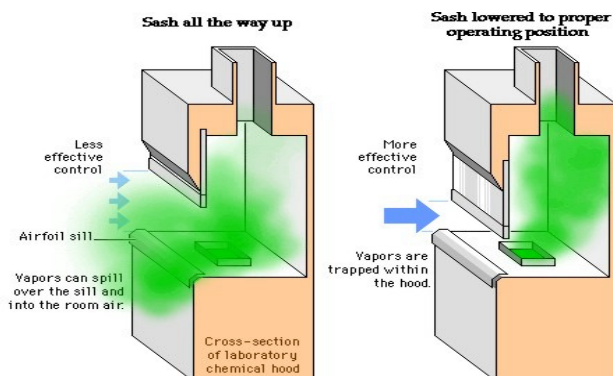
- Notify other laboratory workers, control access to the area, consult MSDS, wear proper PPE, use the spill kit to clean up the mess yourself outside-in (Absorb, collect, dispose), notify Safety & Health Department to remove cleaned-up spill materials.

- **Major Spills**

- Protect people, Remove ignition sources/reactive materials, Evacuate the lab, call University Safety & Health to clean up the mess.

Fume Hood

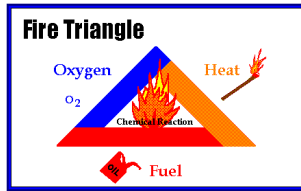
- Ventilated enclosure that protects you from being exposed to chemical fumes, gases and aerosols generated within the hood.
- Lower sash to marked (sash level) position.



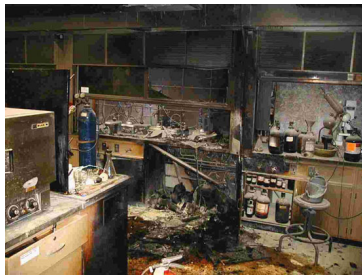
Fume Hood

- Use with materials that can produce harmful gasses or vapors (an example is lachrymators (such as ethyl bromoacetate).
- Air intake velocity must be at least 100 Cubic feet per minute .
- Remember, do not put your face inside the hood!
- The hood is not for storing chemicals.

Fire



- You need oxygen, fuel, and an ignition source to start a fire.
- The key to safety is removing, or otherwise making inaccessible, at least one side of the fire triangle.
- Inorganic acids give off oxygen and flammables act as a source of fuel.



Fire Safety

- If a fire occurs:

– Remember two words:

PASS

REACT

PASS

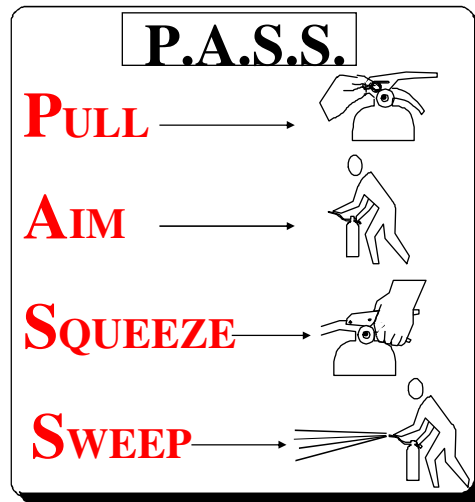
(for small fires and if you are trained)

- **P** (pull) – **A** (aim) – **S** (Squeeze) – **S** (Sweep)

1) *Keep your back to a clear escape route,*

2) *Stand back 6 to 8 feet from the fire,*

3) *Then >>:*



REACT

Remove persons in immediate danger!

Ensure doors are closed! (*confine fire/smoke*)

Activate the building alarm !

Call the Fire Department !

Treat ALL fires as DANGEROUS!

- Continue a complete building evacuation
- Do not attempt to fight a fire UNLESS you are trained in using a fire extinguisher !










or **R** (rescue) - **A** (alarm) - **C** (confine) - **E** (Extinguish/Evacuate)

Fire Safety

- Know locations and types of fire extinguishers!
 - Class ABC - normal combustibles, flammable liquids, electrical fires
 - Class D - Combustible metals

COMMON TYPES OF FIRE EXTINGUISHERS:

- WATER 
- DRY CHEMICAL   or   
- CO₂  

Electrical Safety

Lab fires often start by careless use of electrical equipment

- ✓ Check all equipment for worn insulation.
- ✓ Connect ground wires to clean metal.
- ✓ Keep wires away from water & hot surfaces.
- ✓ Avoid extension cords
- ✓ Avoid homemade/makeshift wiring
- ✓ Never touch a switch/outlet with wet hands



If someone catches fire

- shower
- fire blanket
- *Stop, Drop, and Roll.*

Don't Die for your **Research!**

Live long enough to **publish**

Avoiding Hazards

- Wearing appropriate Personal Protective Equipment (PPE)
- Reading labels
- Knowing safety symbols
- Reading the MSDS of chemicals
- Knowing the locations of safety equipment
- Knowing Emergency Response Procedures
- **Knowing storage procedures**
- Knowing proper disposal procedures
- Knowing Emergency Numbers

Knowing storage procedures

- Storing chemicals
- Storing gas cylinders
- Storing chemical waste

Storing chemicals

- Do not store chemicals in **alphabetical** order.
- Separate **incompatible** chemicals (flammable, corrosive, reactive, cryogenics, pyrophoric) (ex: Nitric acid (ox. agent) and alcohol (red. agent))
- Keep the amount of chemicals in the lab to a **minimum**
- **Never** store chemicals on the **floor**
- Store chemicals below shoulder height when possible
- Use **secondary** containment
- **Do not store food** in a chemical storage

Refrigerator

- Do not store chemicals in hood, on top of cabinet, on high shelves and on the floor.
- Do not store above eye level
- **Old and outdated** chemicals should be **disposed of** through Safety and Health.
- Store on shelves with **raised edges**.
- Keep an **Up-to-date chemical inventory**



Reactive Storage

Segregate:

- Acids from Bases
- Acids and bases from flammables
- Pyrophoric compounds from flammables
- Perchloric acid from reducing agents
- Water from water reactive chemicals
 - Sodium/phosphorus & aqueous material - fire
 - Acid with cyanide compounds - toxic gas
 - Chlorine & ammonia - toxic chloramines
- Store thermally unstable materials in approved refrigerator

Storage Considerations

- Chemical Storage Considerations...
 - Dry chemical storage
 - ✓ May be stored together.
 - ✓ Keep organic and inorganic separated.
 - Liquid chemical storage
 - ✓ Determine major storage groups (acid, base, etc.)
 - ✓ Designate separate storage area for highly toxic chemicals.
- ✓ Store only cleaning materials under lab sink.

Storing cryogenic materials

Cryogenic Materials...

- ✓ Cold (e.g., Ar (-302°F), H₂ (-423°F), N₂ (-320°F), O₂ (-297°F)) vapors can rapidly freeze human tissue
- ✓ Produces large volumes of gas that can displace breathable oxygen
- ✓ Materials can be embrittled
- ✓ Boiling / splashing occurs when charging or filling a warm container
- ✓ Wear face shields during transfers, loose fitting, dry leather or cryogenic gloves and long pants



After Proper Storage

- Chemicals in storage should be examined periodically for:
 - 1- Changes in the condition of the chemical itself
 - 2- Changes in the condition of the container holding the chemical
 - 3- The storage area surrounding the chemical.

Obvious signs of degradation are:

- Split caps
- Formation of deposits on the exterior of bottles or on shelf surfaces in the storage area
- Formation of two phases or a change in physical state
- Formation of crystalline structures within liquids.

Mixtures to avoid

- Acids with cyanide salts or cyanide solution. Generates highly toxic hydrogen cyanide gas.
- Acids with sulfide salts or sulfide solutions. Generates highly toxic hydrogen sulfide gas.
- Acids with bleach. Generates highly toxic chlorine gas.
- Oxidizing acids (e.g., nitric acid, perchloric acid) with combustible materials (e.g., paper, alcohols, other common solvents). May result in fire.

Mixtures to avoid (cont'd)

- Hydrides (e.g., sodium hydride) with water. May form flammable hydrogen gas.
- [Alkali metals](#) (e.g., sodium, potassium) with water. May form flammable hydrogen gas.
- Oxidizing agents (e.g., nitric acid) with reducing agents (e.g., hydrazine). May cause fires or explosions.
- Unsaturated compounds (e.g., substances containing carbonyls or double bonds) in the presence of acids or bases. May polymerize violently.

Storing Gas cylinders

- Gas cylinders must be restrained vertically with a chain or strap between the “waist” and “shoulder” of the cylinder to a wall/bench.
- Remove regulators and cap cylinders before moving.
- Always use a cart & safety chain when transporting cylinder.
- Cap unused cylinders
- Never use grease or Teflon tape on cylinder fittings
- The cylinder (not the cap) must be labeled as to contents.
- Fittings vary between gas types: toxic, corrosive, inert, flammable, oxidizing.
- Never force a fitting. If it has to be forced, it is probably the wrong type.



Using Gas Cylinders

- Mishandled cylinders may rupture violently, release their hazardous contents or become dangerous projectiles.

- If a neck of a pressurized cylinder should be accidentally broken off, the energy released would be sufficient to propel the cylinder to over 3/4 of a mile in height.

-A standard 250 cubic foot cylinder pressurized to 2,500 PSIG can become a rocket attaining a speed of over 30 miles per hour in a fraction of a second after venting from the broken cylinder connection

<http://www.youtube.com/watch?v=pe9gYRXQTTY>

Avoiding Hazards

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Storing waste and disposing it

- Hazardous Waste- This is a waste which contains the characteristics of being any of the following:
 - Toxic
 - Corrosive
 - Ignitable
 - Flammable
 - Oxidizer

Storing waste and disposing it

-All containers must be labeled with "WASTE" or "HAZARDOUS WASTE", contents (full chemical name and approximate percentages), and date started.

-Waste should not be filled to the top.

- No leaking containers or bottles without caps.



Storing waste and disposing it

- Segregation of the chemical waste stream:
 - Aqueous heavy metals
 - Non-halogenated organic solvents
 - Halogenated organic solvents

Thus, the Chemical Hygiene

- It is a method or system to ensure that workers are informed of the hazards associated with exposure to chemicals and chemical products that they work with and how they can protect themselves.
- **Chemical Hygiene Plan is ...**
 - ✓ Standard operating procedures (SOP)
 - ✓ Purchase, distribution, and storage of chemicals
 - ✓ Maintenance, housekeeping, and inspection procedures
 - ✓ Exposure control measures
 - ✓ Fume hood & protective equipment
 - ✓ Information & training
 - ✓ Chemicals that require prior planning & approval
 - ✓ Work with particularly hazardous substance
 - ✓ Medical consultations and examinations

Good Housekeeping

Prudent Laboratory Practices:

- Clean-up and properly store materials
- Don't block access to emergency equipment
- No eating, drinking, chewing, smoking or applying cosmetics
- Remove gloves and wash hands
- Never smell or taste chemicals or pipette by mouth
- Never add acid to water. Always do the opposite.
- Wear appropriate PPE
- Use secondary containers when transferring chemicals
- Remove your gloves before using instruments, telephone, and leaving the laboratory
- Know emergency procedures
- Ensure that all containers are clearly labelled with their contents and a hazard label
- Never work alone – Let someone know where you are

Knowing Emergency Numbers

- EH&SC : 2360
- For Fire: 5555
- Protection Office: 2400

Disasters related to chemicals

- The **Bhopal disaster** is the world's worst [industrial catastrophe](#).
 - It occurred on the night of December 2–3, 1984 at the [Union Carbide India Limited](#) (UCIL) [pesticide](#) plant in, India.
 - A leak of [methyl isocyanate](#) gas from a plant resulted in the exposure of hundreds of thousands of people.
 - The official immediate death toll was 2,259 and the government of India has confirmed a total of 3,787 deaths related to the gas release. Others estimate that 3,000 died within weeks and that another 8,000 have since died from gas-related diseases.

Disasters related to chemicals

- The **Chernobyl disaster** was a [nuclear accident](#) that occurred on 26 April 1986 at the [Chernobyl Nuclear Power Plant](#) in the [Ukrainian SSR](#) (now [Ukraine](#)).
- An explosion and fire released large quantities of radioactive contamination into the atmosphere, which spread over much of Western Russia and Europe.
- It is considered the worst [nuclear power](#) plant **accident** in history, and is one of only two classified as a level 7 event on the [International Nuclear Event Scale](#) (the other being the [Fukushima nuclear incident](#)).

Remember these costly phrases

- “Frequently used chemicals should be ordered in bulk.”
- “Ordering in bulk is the best deal for the money.”
- “Accept any donated chemicals...”
- “Labs will always do the same experiments and demonstrations...”
- “I’ll remember what I put in that jar.”
- “Nothing will happen.”

Remember

- Just because you have gotten away with something 100 times doesn't mean the 101st time is safe.

Ultimately it is up to you the individual laboratory worker who is responsible for his/her safety and the safety of their coworkers- after all it is you who has the most to lose, your health, eyesight, or life.

Penalties

1st offense is a verbal warning.

2nd offense is a written formal warning from the safety committee with the notification of your advisor or supervisor.

3rd offense is is warning from the Chairman/Dean and they will further apply more consequences.

Quiz

- Date: May 6, 2011
- Time: 4pm
- Location: Chemistry department, room 001

Thank you.