LABORATORY SAFETY

Center for NEMS and Nanophotonics
Electrical Engineering Department
IIT – M

SAFETY

- The state of being safe; freedom from the occurrence or risk of injury, danger, or loss.

- The quality of averting or not causing injury, danger, or loss.

- Dictionary.com

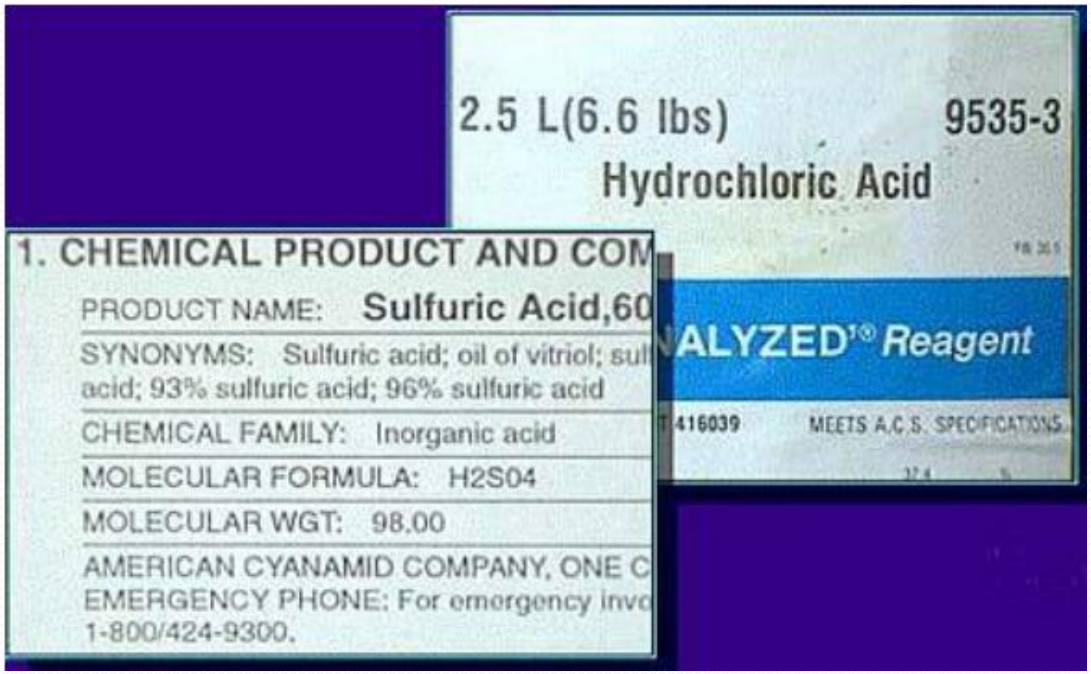
How to be Safe?

Be AWARE…

- Know what you are working with
- Identify the Hazards
- Take necessary precautions
- Post labels around work area/Inform lab mates
  - Helps others know you are working with hazardous materials
  - Good for them AND you

What am I working with?

- Read the LABELS!



Still… What am I working with?

Material Safety Data Sheet (MSDS)-

Provides information about the materials such as

- Manufacturer information
- Characteristics
- Hazards
- Storage
- Spill Response
- Personal Protective Equipment (PPE)

You have the right to know. If a supplier does not provide an MSDS, ask for it!

Or just go online….

The 16 Sections of an MSDS

- Product Information
- Information on Ingredients
- Hazards Identification
- First Aid Measures
- Fire Fighting Measures
- Accidental Release Measures
- Handling and Storage
- Exposure Controls/Personal Protection
- Physical and Chemical Properties
- Stability and Reactivity
- Toxicological Information
- Ecological Information
- Disposal Considerations
- Transport Information
- Regulatory Information
- Other information

** How to read and interpret an MSDS.doc to be sent **

The 16 Sections of an MSDS

1. Product Information

- Synonyms
- CAS No. (Chemical Abstract Service)
- Molecular Weight
- Chemical Formula
- Product Code (manufacturer codes)

2. Composition

- Ingredients
- Percents by weight
- Carcinogen(?)
- References

The 16 Sections of an MSDS

3. Hazards Identification

- Emergency Overview
  - –Health Rating
  - –Flammability Rating
  - –Reactivity Rating
  - –Contact Rating
- Lab Protective Equipment
- Storage Color Code
- Potential Health Effects
  - Inhalation
  - Ingestion
  - Skin Contact
  - Eye Contact
  - Chronic Exposure
  - Aggravation of Pre-existing Conditions

The 16 Sections of an MSDS

4. First Aid Measures

- Inhalation
- Ingestion
- Skin Contact
- Eye Contact

5. Fire Fighting Measures

- Fire
  - Flash point
  - Auto-ignition temperature
  - Flammable limits in air % by volume
    - lel and uel
- Explosion
- Fire Extinguishing Media
- Special Information

The 16 Sections of an MSDS

6. Accidental Release Measures

- What to wear, what to do

7. Handling and Storage

- Proper procedures, materials and techniques.

8. Exposure Controls / Personal Protection

- Airborne Exposure Limits
  - OSHA Permissible Exposure Limits (PEL)
    - ppm
  - ACGIH (American Conference of Governmental Industrial Hygienists) Threshold Limit Value (TLV)
    - ppm
- Ventilation system
- Personal Respirators
- Skin Protection
- Eye Protection

The 16 Sections of an MSDS

9. Physical and Chemical Properties

- Appearance
- Odor
- Solubility
- Specific Gravity
- pH
- %Volatiles by volume
- Boiling Point
- Melting Point
- Vapor Density
- Vapor Pressure
- Evaporation Rate

10. Stability and Reactivity

- Stability
- Hazardous Decomposition Products
- Hazardous Polymerization
- Incompatibilities
- Conditions to avoid

The 16 Sections of an MSDS

11. Toxicological Information

- Acute Effects
- Chronic Effects
- Toxicity
- Investigations into other items
  - Tumorigen
  - Mutagen
  - Reproductive effector
  - Target Organ Data

12. Ecological Information

- Environmental Fate
- Environmental Toxicity

The 16 Sections of an MSDS

13. Disposal Considerations

- Correct procedures

14. Transport Information

- Domestic
  - Proper Shipping Name
  - Hazard Class
  - Information for product size
- International
  - Proper Shipping Name
  - Hazard Class
  - Information for product size

The 16 Sections of an MSDS

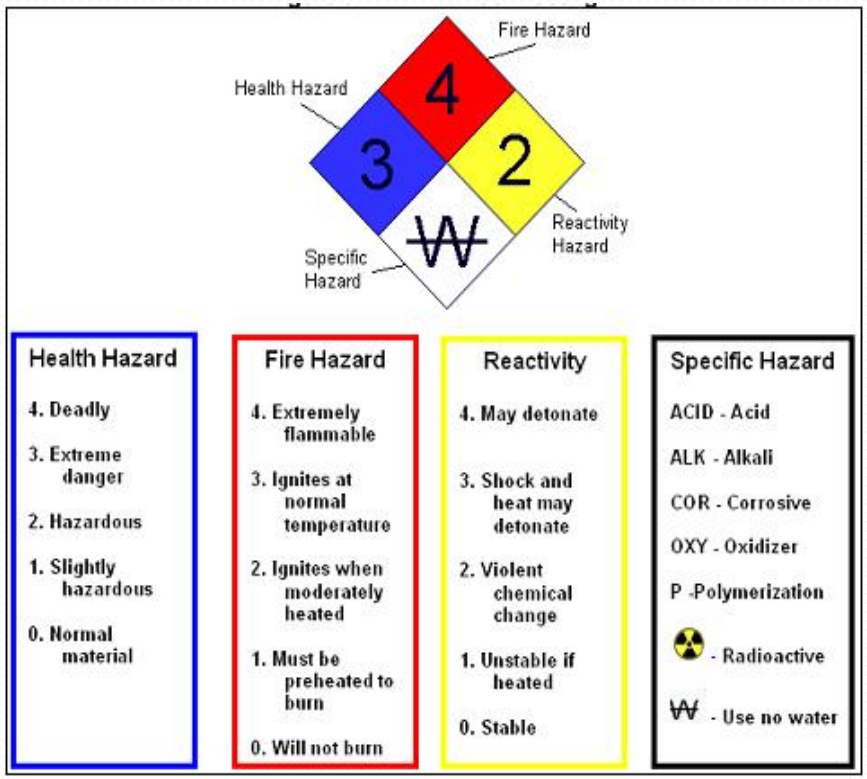
15. Regulatory Information

- Regulations and Status information by state and country as required.

16. Other Information

- Ratings
- Hazards
- Other warnings
- First Aid
- Use
- Disclaimer!

MSDS - Reading the Signs



Health (Blue)

- 4 – Danger - May be fatal on short exposure. Specialized protective equipment required
- 3 – Warning - Corrosive or toxic. Avoid skin contact or inhalation
- 2 – Warning - May be harmful if inhaled or absorbed
- 1 – Caution - May be irritating
- 0 - No unusual hazard

Flammability (Red)

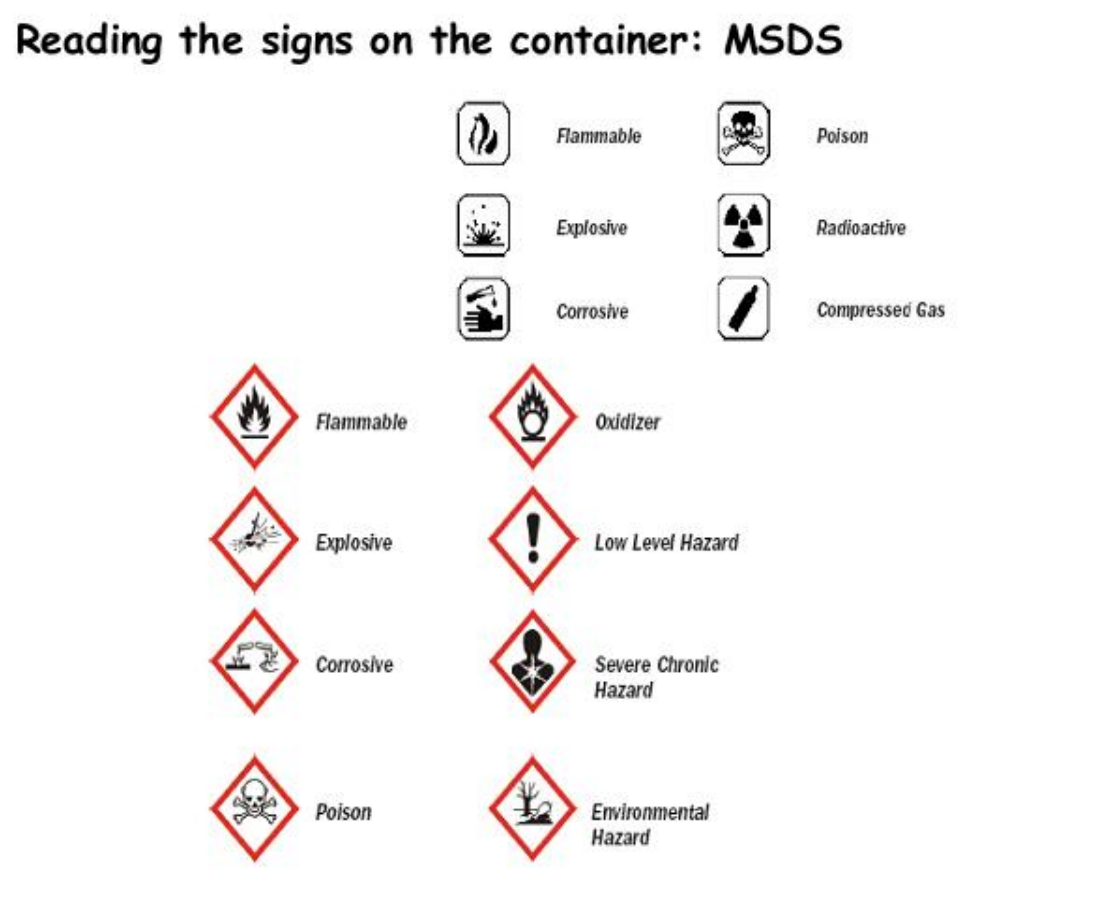
- 4 – Danger - Flammable gas or extremely flammable liquid

  Flashpoint < 73^{o}F
- 3 – Warning - Flammable liquid flash point below 100°F
- 2 – Caution - Combustible liquid flash point of 100°to 200°F
- 1 – Combustible if heated
- 0 – Not combustible

Reactivity / Instability (Yellow)

- 4 – Danger - Explosive material at room temperature
- 3 – Danger - May be explosive if shocked, heated under confinement or mixed with water
- 2 – Warning - Unstable or may react violently if mixed with water
- 1 – Caution - May react if heated or mixed with water but not violently
- 0 – Stable - Not reactive when mixed with water

Reading the Signs (contd…)



Types of Hazards

- Chemical Hazards
  - Health
    - Poison
    - Corrosive
    - Radioactive
    - Biological
  - Physical
    - Fire
    - Compressed Gas
    - Temperature
- Other Types –Noise, Ergonomics, Vibration etc..

PHYSICAL HAZARDS

- Compressed gas cylinders
- Flammables
- Cryogens
- Electrical and high voltage systems
- Vacuum systems
- High pressure systems
- High temperature systems
- Glassware

HEALTH HAZARDS

- Toxicology is the study of the effects of chemicals in living systems.
- Toxicity is the relative degree to which a chemical is harmful.

- **Acute:** Harmful effects through a single or short term exposure. Example: Cyanide, nitrogen dioxide
- **Chronic:** Harmful effects over an extended period, usually upon repeated or continuous exposure.

  Example: Lead or mercury

Paracelsus (~1567): "All substances are poisons, there is none which is not a poison; the right dose differentiates a poison from a remedy"

Acute Toxicity

- Highly Toxic - LD50 <50 mg/kg, oral, rat
  - Botulinum toxin-oral: 200 picogm/kg
  - Sodium Azide: 27 mg/kg (oral, rat)
  - Osmium tetroxide: 14 mg/kg (IP)
- Moderately Toxic – LD50 >50 & < 500 mg/kg, oral, rat
  - Acrylamide – 124mg/kg (oral, rat)
  - Phenol – approx. 400mg/kg (oral, rat)
  - Beta-mercaptoethanol - 244 mg/kg (oral, rat)
- Consider Toxicity of all other Chemicals/Gases to be Chronic

Some Specific Health Hazards

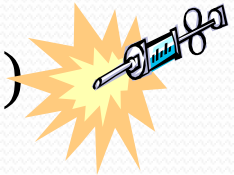
- **Irritants** – cause inflammation of mucous membranes with which they come in contact. Eg. arsenic compounds, HCl, HF.
- **Carcinogens** – cause cancer in animals or humans. Eg. Asbestos, Benzene, Nickel compounds, Wood dust.
- **Asphyxiants** – interfere with supply of oxygen to the vital organs of the body. Eg. Ethane, Nitrogen, Methane, Acetylene.
- **Allergens** – cause adverse reaction to the immune system. Eg. Formaldehyde, Isocyantes.

Possible Routes of Entry

- Absorption
  - Through Skin via dermal contact

- Inhalation
  - Through the Respiratory tract

- Injection
  - Through Skin puncture by Needles and Glasses (Sharps)



- Ingestion
  - Through Digestive tract. Mostly occurs through contaminated hands and work areas.

How to Reduce Risk?

- Identify hazards:
  - How toxic? - Acute or Chronic
  - Is it reactive?
  - Corrosive?
  - Physical hazard?
  - Ignitable/Flammable?
- Can’t change hazard but we can reduce risk
- Increase control measures as hazards increase

How to Reduce Risk?

- **Personal Protective Equipment (PPE)** such as gloves, aprons, and eye protection
- **Engineering Controls** such as chemical fume hoods or enclosures
- **Safe Lab Practices** such as proper chemical storage and labeling, Chemical Handling, Disposal
- **Product Substitution** with less or non hazardous materials
- **Training and Communication** in safe work practices
- **Peer Monitoring** – If you see something, say something

How to Reduce Risk?

Know your surroundings

- Know the location of Emergency Aids -
  - Showers
  - Eye wash
  - Spill kits
  - First aid kits
- Know the locations of PPE – Gloves, Goggles, Face Shield etc.
- Know what chemicals are stored where and prepare accordingly
  - Don’t keep running between labs with contaminated gloves
- Make sure there is sufficient quantity of Chemicals and PPE in the lab where you will be running your experiment.

Personal Protective Equipment (PPE)

- Lab Gloves – Worn at all times

- Chemical Resistant Gloves – When using Hazardous Chemicals

  ** Glove Compatibility chart to be sent **

- Safety Goggles – When using any Chemical

- Safety Glasses – Worn at all times

- Face Shields – When transferring Chemicals from larger container to smaller container

Personal Protective Equipment (PPE)

- Lab Coats – Worn at all times

- Cleanroom Suit – When inside Cleanrooms

- Aprons – When using Hazardous Chemicals

- Closed-toe Shoes (w/disposable booties when working with chemicals) – Worn at all times

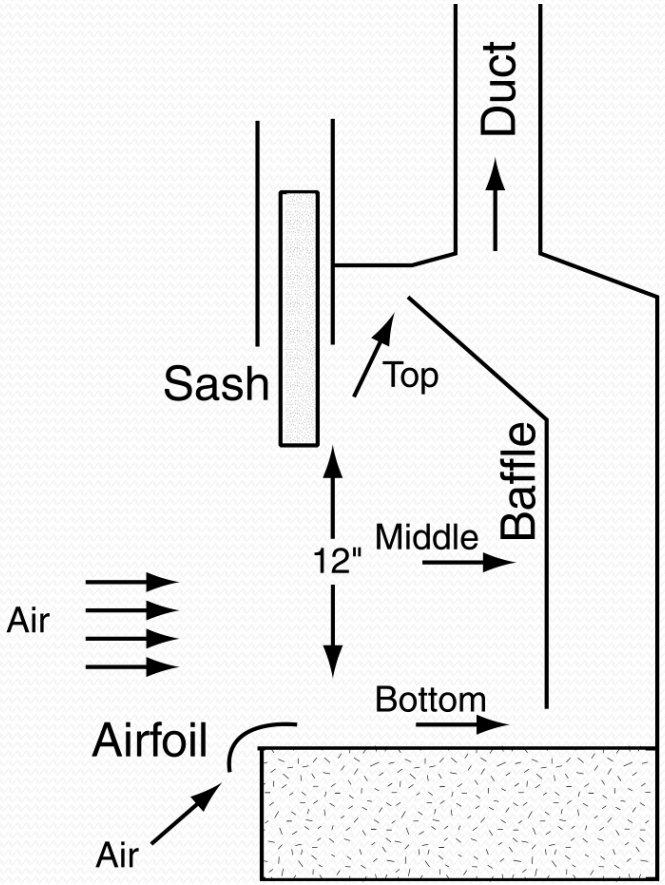
- Respirators – When recommended in MSDS and for Large Chemical Spills

Fume Hood

- Important part of the ventilation system
  - Contributes to laboratory Exhaust ventilation
- Shields workers by containing aerosols, vapors, dusts, gases, and fumes
- Sash helps prevent injury from splashes, fires, or minor explosions
- Certified annually by manufacturer currently. Will gain ability to self-monitor periodically.
- Contact Staff for maintenance.

Proper use of Fume Hood

- Maximize protection
  - Avoid turbulence
  - Work 6” – 8” inside hood face
  - Smallest practical sash opening
  - Keep baffles open, intact & properly adjusted
  - Keep air foil in place and clear
  - Is alarm functional?
  - Avoid using for storage
- Close sash for safety and energy saving



** YouTube video on Fume Hood **

Safe Lab Practices

- Basic Principles
  - Think the process/experiment through ‘carefully’
    - Substrates, Chemicals, Gases, Quantities, Time etc.
  - Review safety resources
    - MSDS, Spill Kits, First Aid, Location of Eye Washes and Safety Showers etc.
    - Choose the appropriate PPE
    - Find a Buddy to be around while you are working
  - Review SOP (Standard Operating Procedure)
    - Each process should have an approved SOP
    - Can be varied slightly to suit your experiment but the basic procedure should be followed.

Safe Lab Practices

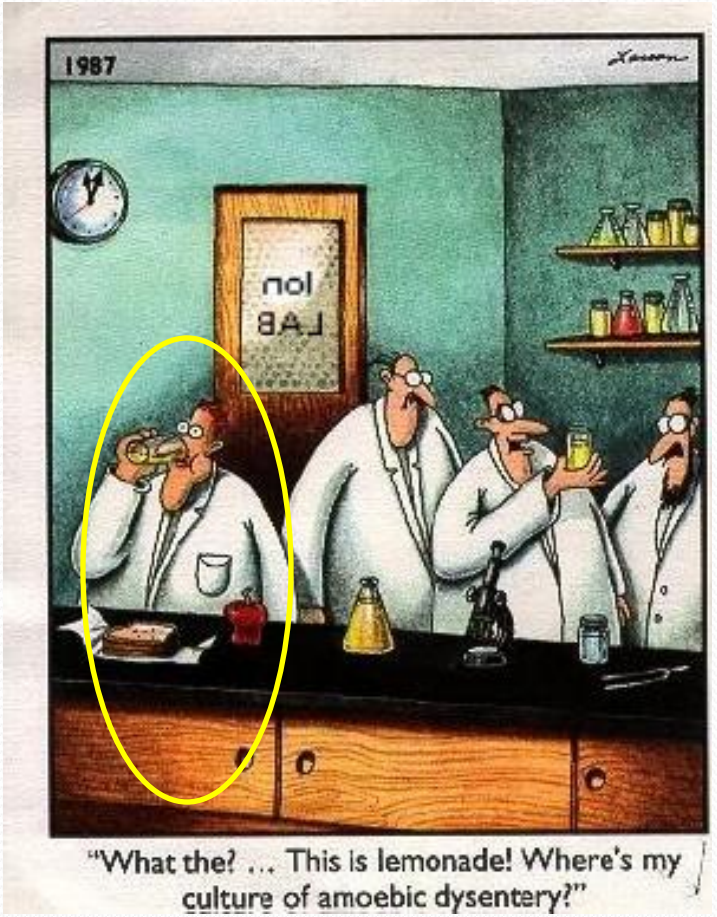
- Minimize Direct Exposure –
  - Transfer only as much chemical as you will need for any experiment.
  - Use a minimum number of Labwares.
  - Stay in the labs **only** as long as you need to, but do not leave the lab unattended while experiments are running – use your judgment.
  - Basic PPE (Labcoats, Lab Gloves, Closed-toe Shoes and Safety Glasses) should always be worn while in the labs.

Safe Lab Practices

- Minimize Indirect Exposure –
  - Safely dispose the chemical once used and clean the labwares immediately after.
  - Clean the workspace you used (Fume hood/Work bench) while still wearing the appropriate PPE.
  - Every time you leave a lab to go to another one, dispose off your current gloves and take new ones once you get to the other lab even if all you did was barely touch the storage cabinet – do not open doors with contaminated gloves! Gloves are cheap, use them freely.

Safe Lab Practices

- **No eating, drinking in labs**
- Wash hands frequently
- Don’t wipe your face/head/arms with gloves on
- Don’t **“sniff”** chemicals
  - If you are not sure what chemical you have in a beaker, safely dispose it and prepare a new solution
- Clean-up spills immediately
- Never work alone!!!
- **Clean-up after yourselves – minimize exposures for your peers.**



Safe Lab Practices

- Never use Fume Hood for storage.
- Try **not** to use the storage area **under** the Fume Hoods as well in case of leaks in the fume hood.

Safe Lab Practices

- Store chemicals in separate designated storage cabinets.
- Always use Secondary containers for storing Chemicals. In case of leaks, it helps minimize the area of impact.
- **Segregate Incompatible materials** and store them separately with the least chance for interaction.

Segregate incompatible materials!

Chemical Compatibility Chart

Safe Lab Practices

- **LABELING**
  - Very Critical
  - Label all containers that are used for storing chemicals with their Full Chemical Name, Abbreviation, % Concentration etc. Include the appropriate **hazards** in the label as well. There are people who don't know the chemical as well as you do.
  - Put a note on the fume hood or by the beaker indicating what chemicals you are working with **even if you are right there.** Eg: "RCA 1 in progress"
  - Label Storage Cabinets indicating what chemicals are stored in there.

Safe Lab Practices

- **LABELING**

  - Label the Secondary containers indicating what chemicals are stored and what general category they are. Eg: “Inorganic Acids”

  - Date any new container when received AND when opened.

  - Check the manufacturer’s data to see how long the chemical is good for after opening.

  - Most chemicals are good for only 1-2 of years after opening – do not overstock them. Old chemicals will affect your research.

Chemical Spills

- Factors to Consider **Before** Spill Clean-up
  - Size of spill area
  - Quantity of chemical
  - Toxicity
  - Volatility
  - Availability of appropriate PPE
  - Clean up materials available
  - Confident enough?

What to do in case of small spills (<1 Liter)

- Evacuate all non-essential persons from the spill area.
- Help anyone who may have been contaminated. Use emergency eyewashes/showers by flushing the skin or eyes for at least 15 minutes. Then contact a Medical Personnel.
- Post someone just outside the spill area to keep people from entering. Avoid walking through contaminated areas.
- Check the chemical's Material Safety Data Sheet (MSDS) in your laboratory or online.
- Wear personal protective equipment, including safety goggles, gloves, and a laboratory coat or other protective garment to clean-up the spill. Use Respirators if the area of spill is not ventilated.

What to do in case of small spills (<1 Liter)

- Turn off sources of flames, electrical heaters, and other electrical apparatus, and close valves on gas cylinders if the chemical is flammable.
- Confine the spill to a small area. Do not let it spread.
- Work with another person to clean-up the spill. Do not clean-up a spill alone .
- **DO NOT ADD WATER TO THE SPILL**
- Use an appropriate kit to neutralize and absorb inorganic acids and bases. For other chemicals, use the appropriate kit or absorb the spill with sorbent pads, paper towels, vermiculite, dry sand, or diatomaceous earth.
- Double bag the contaminated spill kit and set aside for safe disposal

What to do in case of large spills (>1 Liter)

- Any employee with known contact with a particularly hazardous chemical must shower, including washing of the hair as soon as possible unless contraindicated by physical injuries.
- Remove the injured and/or contaminated person(s) and provide first aid
- Call for emergency medical response
- Contact Personnel with Emergency Response Training and update them on situation. **Do not try to clean up by yourself.**
- As you evacuate the laboratory, close the door behind you, and:
  - Post someone safely outside and away from the spill area to keep people from entering
  - Confine the spill area if possible and safe to do so
  - Leave on exhaust ventilation
  - If possible, turn off all sources of flames, electrical heaters, and other electrical equipment if the spilled material is flammable
  - Avoid walking through contaminated areas or breathing vapors of the spilled material

What is Expected of You…

- **Ignorance** is EXPECTED in Students.
  - If you don't know or are unsure of anything, ASK!
  - What is important is that you are willing to LEARN.
- **Mistakes** are EXPECTED.
  - What is important is that you make a CONSCIOUS EFFORT to minimize the number of accidents and the seriousness of accidents, by taking appropriate Safety measures and following Protocols.
- **REPORT** accidents/mistakes.
  - Not looking for an apology. Each mistake is a Valuable Learning Lesson. Let us share it so others don't commit the same mistake.

TO DOs

- Get PPE
- Get Safety Accessories
- Clean All Labs and Dispose Old Chemicals
- Train Personnel on Emergency Response
- Establish and Enforce Safety Protocols
- Establish Standard Operating Procedures for All Processes
- Assign Responsibilities to PhD Students

- QUESTIONS
- CONCERNS
- FEEDBACK

Sources: Various Online Resources

THANK YOU!