دانشگاه صنعتی اصفهان

Safety in the Chemistry Lab

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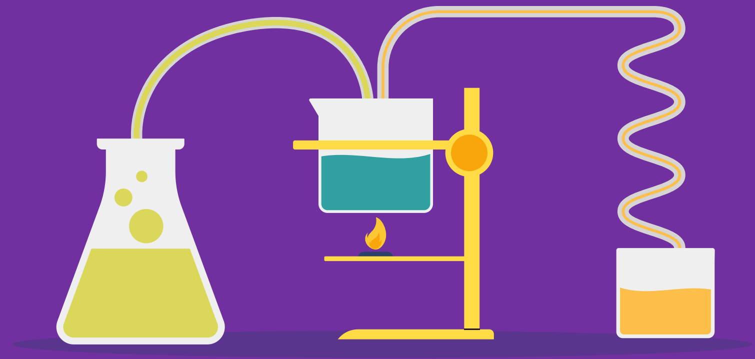
December 2024



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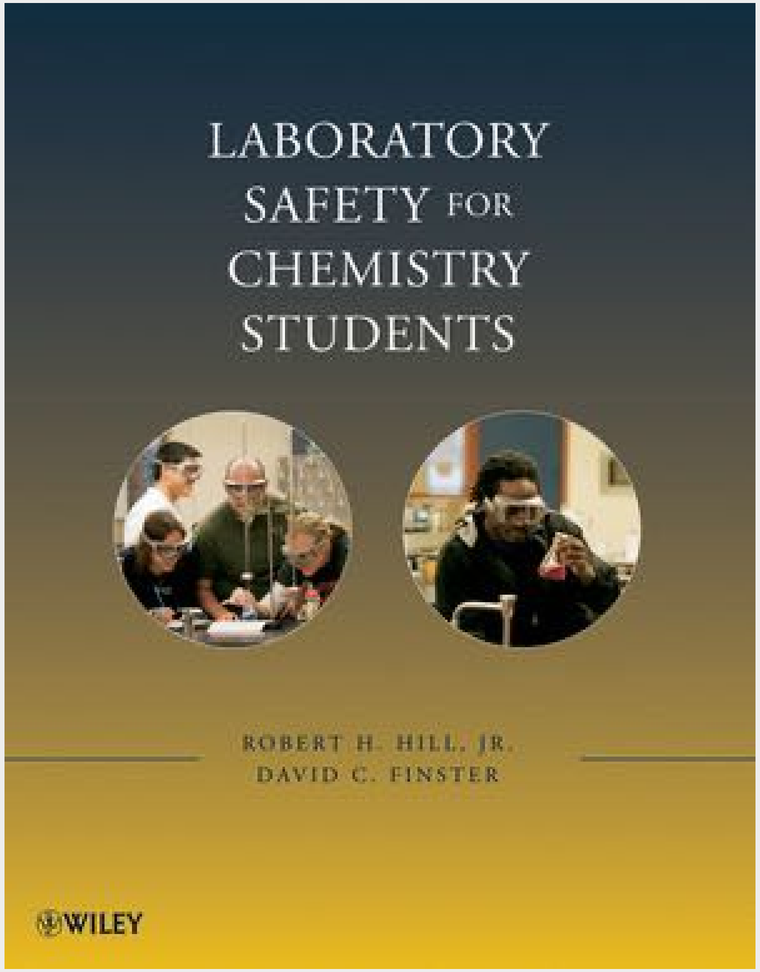

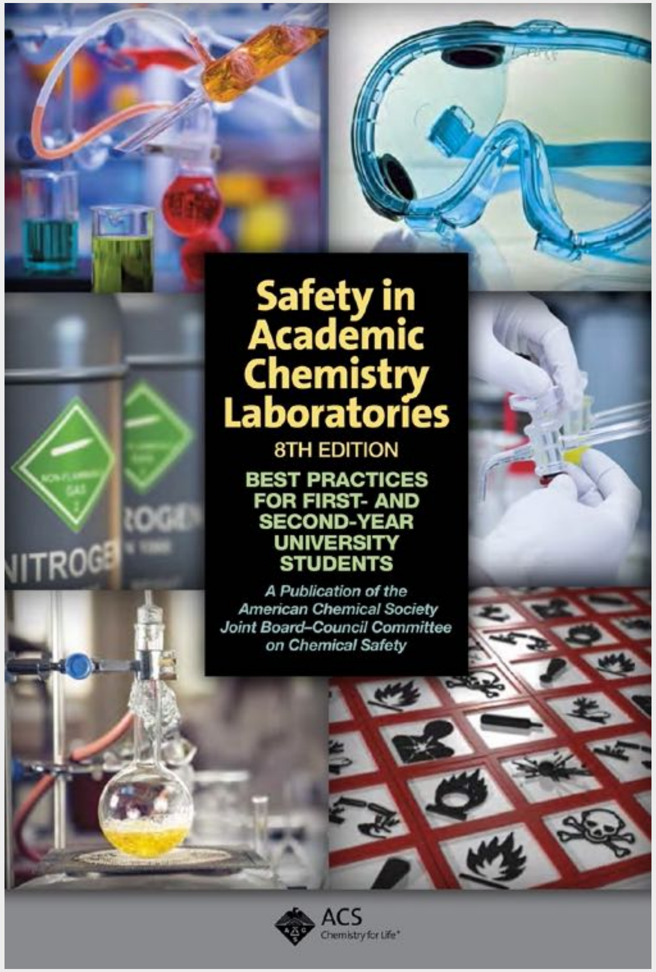

Where did the content come from?

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Article

RAMP: A Safety Tool for Chemists and Chemistry Students

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ABSTRACT: RAMP is an acronym for the process "recognize hazards, assess risk, minimize risk, and prepare for emergencies". This paper describes these four steps in the context of undergraduate instruction about chemical health and safety.

KEYWORDS: *First-year Undergraduate/General, Second-year Undergraduate, Upper-Division Undergraduate, Safety/Hazards, Mnemonics/Rote Learning, Laboratory Management*

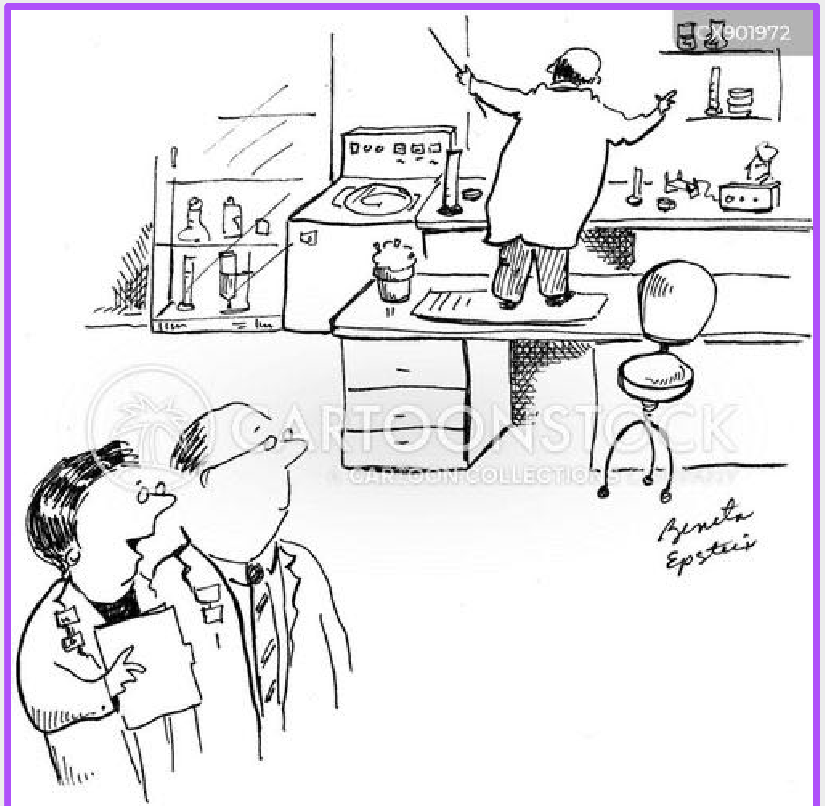
Being Safe in the Laboratory

Safety is freedom from danger, injury, or damage.

Being safe requires actions by you and by others.

When you decide to adopt safety as an integral part of your college laboratory experiences it means that you always seek to do those things that prevent incidents that might cause injury and harm.

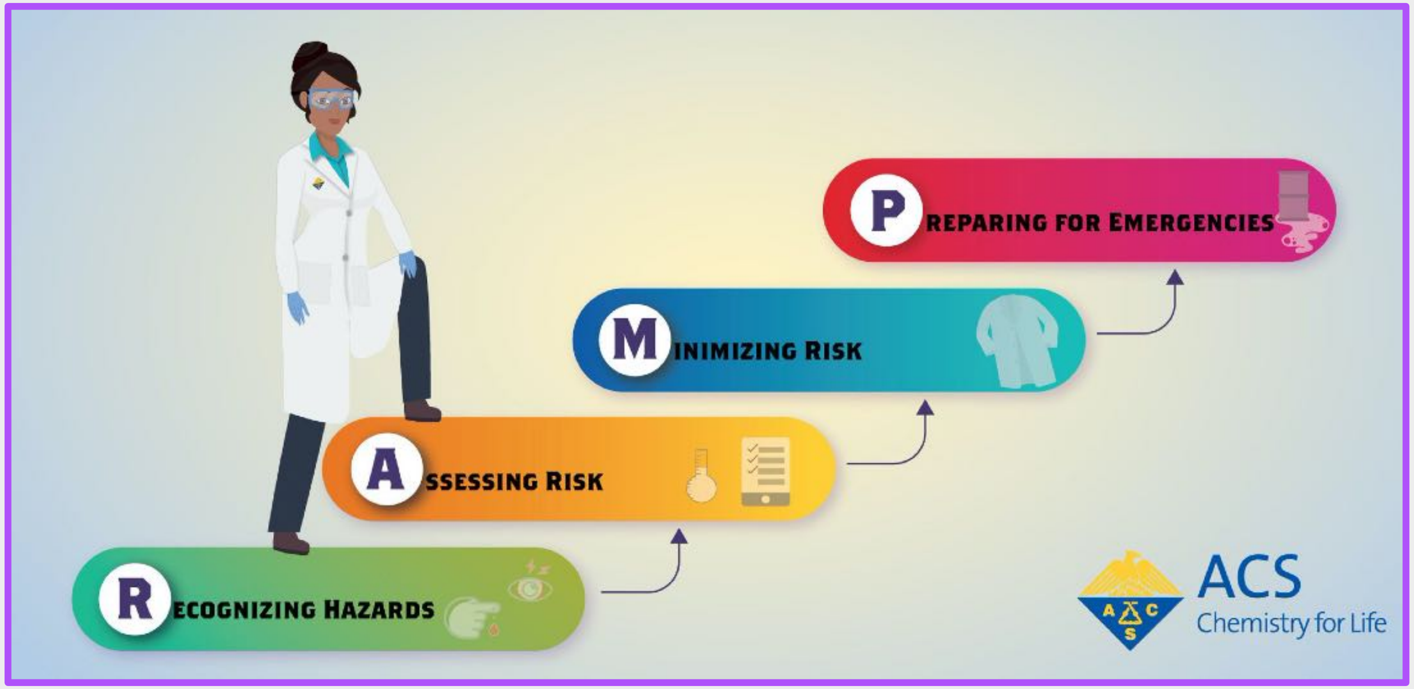
Safety is in fact a discipline of chemistry, just like inorganic, organic, analytical, physical, or biological chemistry.



"That's Dr. Cray conducting research."

Four Principles of Safety, RAMP

To be safe in the laboratory or elsewhere, you need to do only four things



Remember the acronym - RAMP

Four Principles of Safety, RAMP

Four Principles of Safety, RAMP

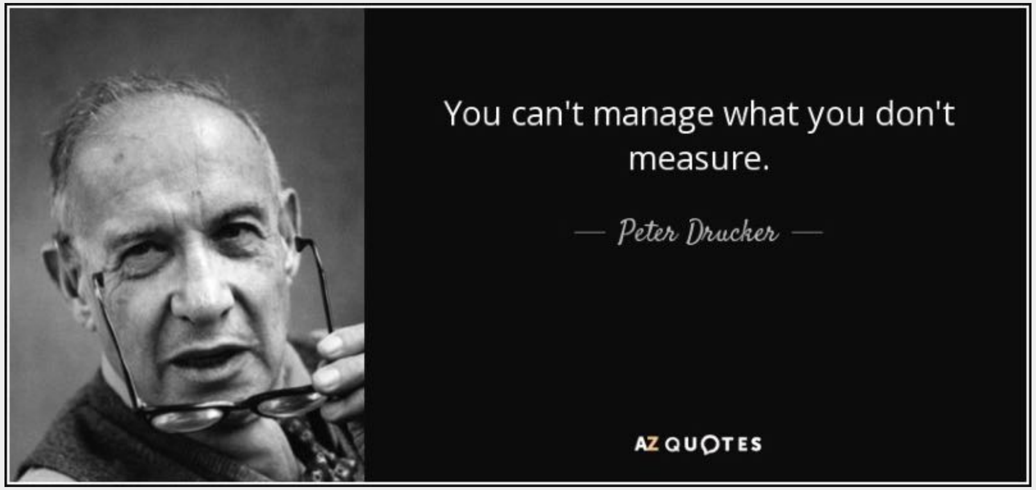
Four Principles of Safety, RAMP

Because I know the **RAMP**, I am allowed to work in the kitchen.






Four Principles of Safety, RAMP



Redesigning an experiment is often necessary to get to an acceptable risk level.

If it is determined that an experimental risk cannot be adequately minimized or some possible emergency could arise that cannot be adequately contained, perhaps the experiment should not be done as planned.

Recognizing Hazards

A *hazard* is **“the potential to do harm”.**

Laboratory bench at Texas Tech University after an explosion. Two students were seriously injured.

Recognizing Hazards

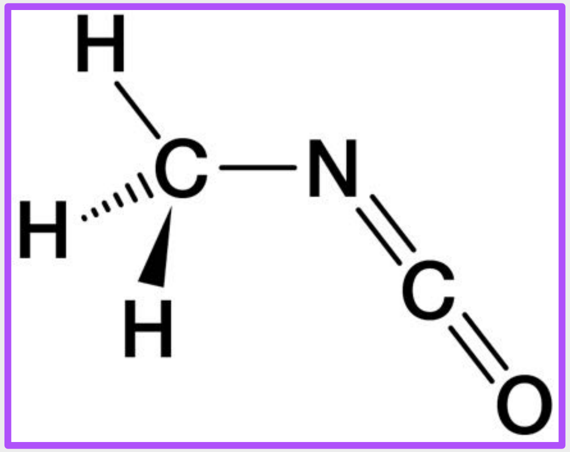
Sources of hazards in chemistry labs

Hazard Types	Examples
Agent	Carcinogenic, teratogenic, corrosive, pyrophoric, toxic, mutagenic, reproductive hazard, explosive, nonionizing radiation, biological hazard/pathogenic, flammable, oxidizing, self-reactive or unstable, potentially explosive, reducing, water reactive, sensitizing, peroxide forming, catalytic, or chemical asphyxiate
Condition	High pressure, low pressure, electrical, uneven surfaces, pinch points, suspended weight, hot surfaces, extreme cold, steam, noise, clutter, magnetic fields, simple asphyxiant, oxygen-deficient spaces, ultraviolent radiation, or laser light
Activity	Creation of secondary products, lifting, chemical mixing, long-term use of dry boxes, repetitive pipetting, scale up, handling waste, transportation of hazardous materials, handling glassware and other sharp objects, heating chemicals, recrystallizations, extractions, or centrifuging

The use of equipment is also a hazards commonly identified for research activities

Recognizing Hazards

Bhopal disaster



Recognizing Hazards

Hazards Are a Part of Our World!

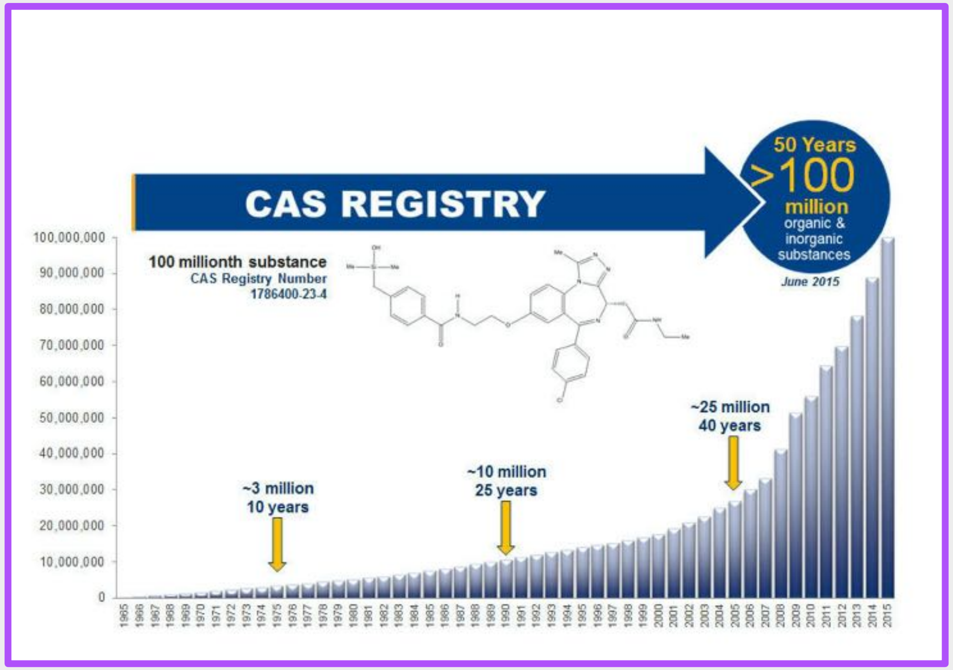
There are many hazardous chemicals in and around our homes.

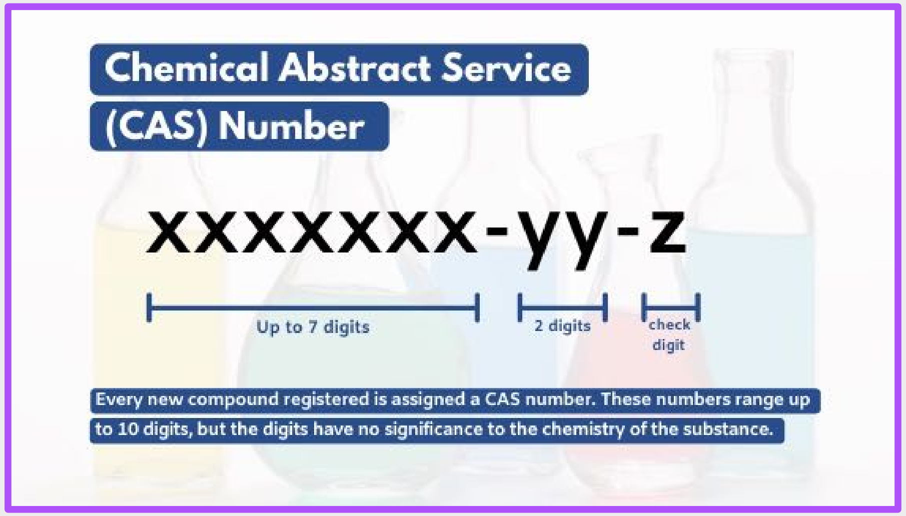
Recognizing Hazards

Chemical Abstract Service (CAS) Number

About 100 years ago the American Chemical Society's Chemical Abstracts Service (CAS) developed a system of identifying chemicals with unique numbers – these are known as CAS numbers.

You will find that it is not unusual for chemicals to have multiple names, but there will always be only one CAS number.





Recognizing Hazards

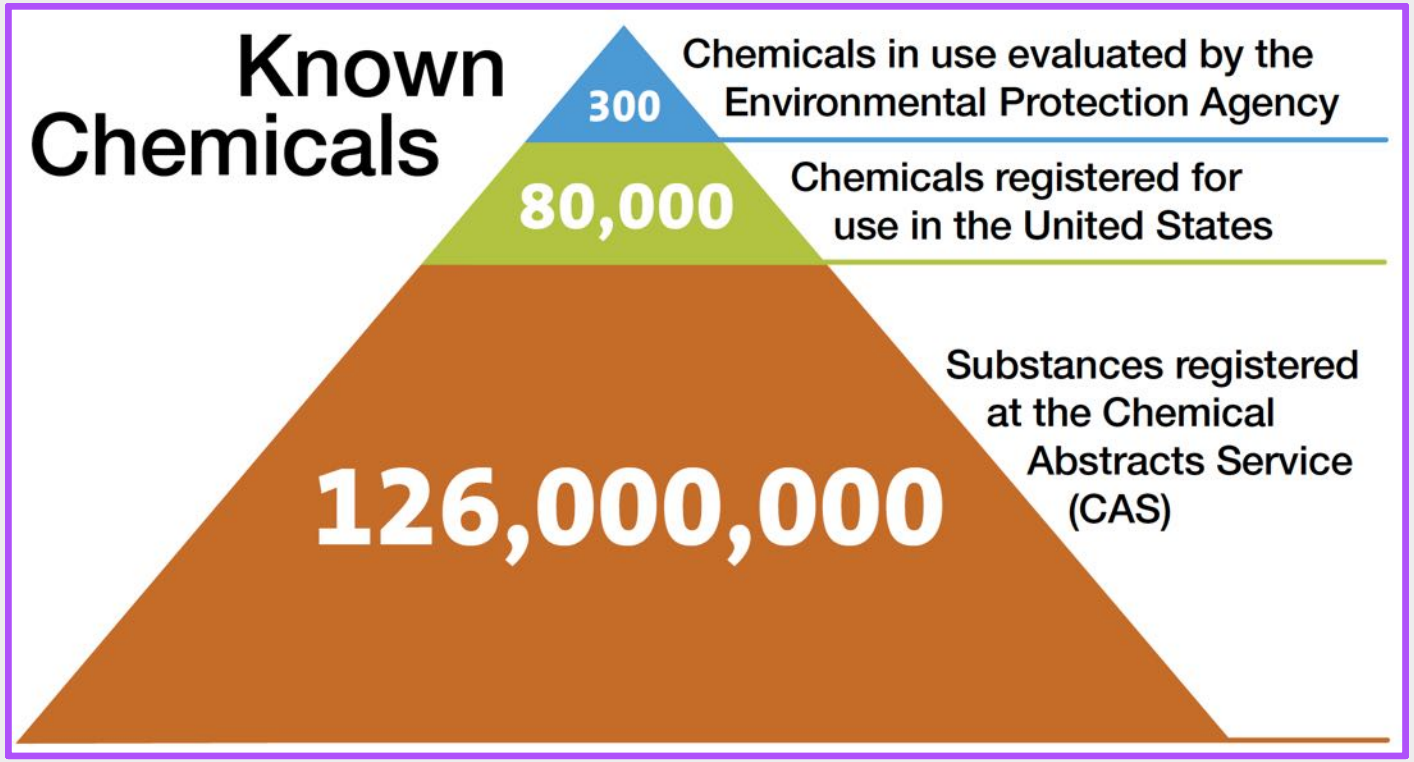
Chemical Abstract Service (CAS) Number

To more generally find a CAS number, it is easy to access reliable web sites. Examples of two such web sites

http://www.chemindustry.com/ apps/chemicals

http://webbook.nist.gov/chemistry/

Recognizing Hazards



So the bad news is that we don’t know about the toxicological properties of >99.9% of the known compounds.

Recognizing Hazards

How can you be expected to know the hazardous characteristics of so many different chemicals?
The answer: classification.

The hazardous characteristics of all chemicals can be sorted into just a few classes.

Four broad subclasses of chemical hazard:
Toxicity
Flammability
Corrosivity
Reactivity

Gasoline and alcohol are flammable liquids, but gasoline is much more hazardous.
Gasoline is easier to ignite and more likely to burn vigorously or explode than alcohol, but we safely use gasoline every day.

You should understand that we can, and do, know how to safely handle even dangerous chemicals.

Recognizing Hazards

Paracelsus
1493-1541

Toxicity

“What is it that is not poison? All things are poison, and nothing is without poison. It is the dose only that makes a thing not a poison.”

Severity of health effects depend on:

- **The route of entry/exposure (ROE)**
- **The dose**
- **The duration**
- **The form**
- **The gender of the exposed person**
- **The stage in the reproductive cycle**
- **Age**
- **Lifestyle**
- **Previous sensitization**
- **Which organ is affected**
- **Allergic factors**
- **The individual’s genetic disposition**

Recognizing Hazards

Toxicity

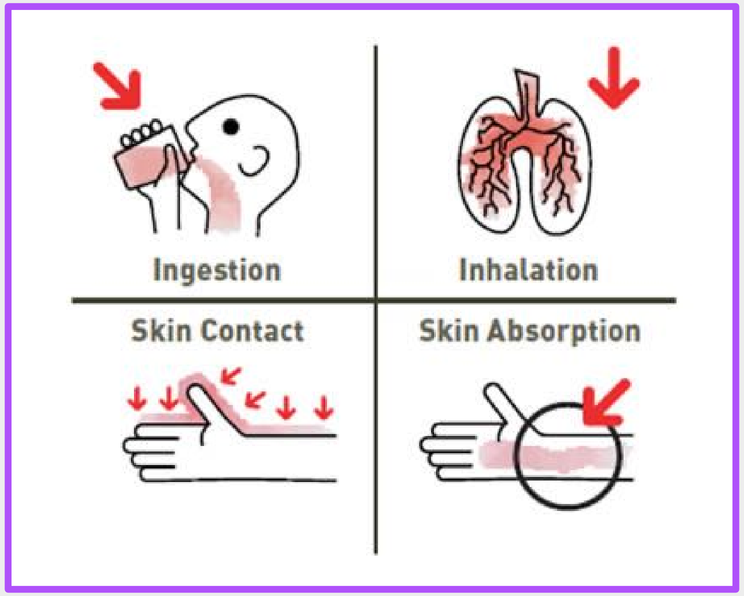
Routes of Entry/Exposure (ROE)

Inhalation

Ingestion

Absorption

Injection



Recognizing Hazards

Toxicity

Dose

For chemicals, dose is defined as the amount of toxicant received at one time.

milligrams per kilogram (mg/kg)

milligrams per square centimeter (mg/cm^2)

micrograms per liter (µg/L), milligrams per cubic meter (mg/m^3), or parts per million (ppm)

Recognizing Hazards

Toxicity

Duration and Frequency of Exposure

The health effects from a toxicant can be described by the duration of exposure and the onset of the effect:

Acute exposure is characterized by rapid assimilation of the toxic substance in one or more doses within 24 hours or less.

Chronic exposure is characterized by repeated exposures, typically of low doses, with a duration measured in months or years.

Systemic effect

Delayed effect or a chronic (long-term) effect

Recognizing Hazards

Toxicity

Characterizing Acute Toxicity

LD50 "lethal dose fifty": single dose (milligrams of substance per kilogram of body mass) expected to result in the mortality of 50% of the test population when administered by any ROE other than inhalation.

LC50 "lethal concentration fifty": the concentration of a chemical in breathing air calculated to result in the mortality of 50% of the test population exposed over a specific time period. often expressed as parts per million (ppm), mg/m^3, or µg/L

LD50 stands for lethal dose, whereas LC50 stands for lethal concentration.

Recognizing Hazards

Flammability

Flammable Solvents

Flammable Solids

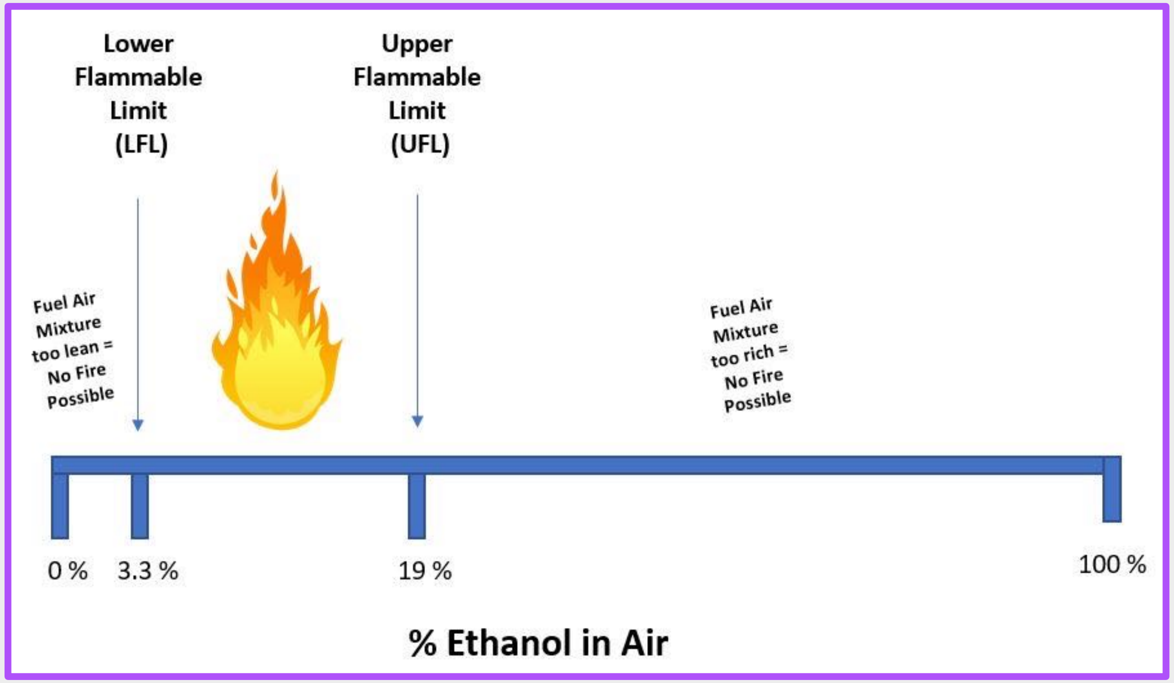
The flash point of a chemical

The autoignition temperature

Recognizing Hazards

Flammability

The lower flammability limit (LFL)
The upper flammability limit (UFL)



Recognizing Hazards

Flammability

Chemical name – formula	Boiling point (°C)	Vapor pressure (mm Hg at 20 °C)	Lower and upper flammability	Autoignition (°C)	Flash point (°C)	GHS rating	NFPA rating
Acetic acid – CH_3CO_2H	118	11	4–16	463	39	3	2
Acetone – CH_3COCH_3	56	180	3–13	465	−18	2	3
Acetonitrile – CH_3CN	82	73	4–16	524	6	2	3
1-Butanol – C_4H_9OH	118	6	1.4–11	365	29	3	3
2-Butanone (methyl ethyl ketone) – $CH_3COC_2H_5$	80	71	2–10	515	−6.1	2	3
Carbon disulfide – CS_2	46.1	300	1–44	90	−30.0	2	4
Chloroform – $CHCl_3$	61	160	None	None	None	No rating	0
Dichloromethane – CH_2Cl_2	40	440		556	None	No rating	1
Diethyl ether – $(C_2H_5)_2O$	35	442	1.85–48	160	−45.0	1	4
Dimethylformamide – $(CH_3)_2NCHO$	153	2.6	2.2–15	445	58	3	2
Ethanol – C_2H_5OH	78.3	43	3.3–19	365	12.8	2	3
Ethyl acetate – $CH_3CO_2C_2H_5$	77	76	2.18–9	427	−4	2	3
Hexane – C_6H_{14}	68.9	124	1.1–7.5	225	−21.7	2	3
Methanol – CH_3OH	64.9	96	6.7–36	385	11.1	2	3
1-Propanol (*n*-propanol) – C_3H_7OH	97	15	2.1–13.5	433	25	3	3
2-Propanol (isopropanol) – C_3H_7OH	82.8	33	2.3–12.7	398	11.7	2	3
Tetrahydrofuran – C_4H_8O	66	132	2–11.8	321	−14	2	3
Toluene – $C_6H_5CH_3$	110.6	22	1.4–6.7	480	4.4	2	3

Recognizing Hazards

Corrosivity

Acids

Bases

Recognizing Hazards

Reactivity

Uncontrolled reactivity

Chemical hood after the explosion due to the rupture of a container from high pressure

Recognizing Hazards

Reactivity

Incompatibles must not come in contact with each other and should not be stored together.

Class	Types of incompatibles	Examples of incompatibles
Acid *incompatibles: substances listed to the right react violently with acids*	Hydroxides	NaOH, KOH
	Inorganic azides	Sodium azide (produces toxic HN_3)
	Chlorates	Potassium chlorate
	Cyanides	Potassium cyanide (produces HCN gas)
	Carbides	Calcium carbide (produces flammable C_2H_2)
	Hydrides	Sodium hydride (produces flammable H_2)
	Oxides	Calcium oxide
	Perchlorates	Potassium perchlorate
	Sulfides	Sodium sulfide (produces H_2S)
	Organic peroxides	Benzoylperoxide, $C_5H_5COO{-}OOCC_6H_5$
Base *(strong) incompatibles: substances listed to the right react violently with bases*	Acids	HCl, H_2SO_4,CH_3COOH
	Inorganic cyanides	Sodium cyanide
	Organic acyl halides	Acetyl chloride
	Organic anhydrides	Acetic anhydride
	Organic nitro compounds	Nitrobenzene
Water-reactives*: substances listed to the right react with water*	Alkali/alkaline earth metals	Sodium, potassium
	Metal carbides	Calcium carbide
	Metal hydrides	Sodium hydride, lithium aluminum hydride
	Nonmetal hydrides	Boranes, silanes
	Alkali/alkaline earth metals oxides	Calcium oxide
Pyrophorics*: substances listed to the right react in air*	Some finely divided metals	Magnesium, zinc
	Alloys of reactive metals	Potassium–sodium alloy
	Alkylmetals	*t*-Butyllithium, trimethylaluminum
	Selected main group elements	White phosphorus
	Metal hydrides	Potassium hydride
	Nonmetal hydrides	Diborane, phosphine
	Iron sulfides	FeS (moist), FeS_2 (powdered)
	Alkylphosphines	Diethylphosphine
	Some organometallics	Bis(cylclopentadienyl)manganese
Oxidizing agents*: substances listed to the right are easily oxidized*	Organic compounds	Acetic acid, aniline
	Metals	Sodium, magnesium
	Metal hydrides	Sodium hydride
	Main group elements	Phosphorus, sulfur, carbon
	Main group compounds with hydrogen	Ammonia
Reducing agents*: substances listed to the right are easily reduced*	Chlorates, perchlorates	ClO_3^-, ClO_4^-
	Chromates	CrO_4^{2-}, CrO_3
	Halogens	F_2,Cl_2
	Nitrates	NO_3^-
	Peroxides	Na_2O_2, H_2O_2
	Persulfates	$S_2O_8^{2-}$
	Permanganates	MnO_4^-

Recognizing Hazards

Reactivity

- **"Contains Nitric Acid – DO NOT ADD ORGANIC SOLVENTS"**

$$CH_3OH + HNO_3 \rightarrow [CH_3ONO_2] + H_2O$$
[unstable]

$$CH_3ONO_2 \rightarrow CO_2\uparrow + N_2\uparrow + NO_2\uparrow + H_2O \text{ (exothermic)}$$

Recognizing Hazards

Reactivity

Two Incidents: Exploding Hazardous Waste

A large glass capped bottle being used in a laboratory to collect nitric acid waste was located in a chemical hood when it spontaneously exploded, spraying nitric acid and glass pieces throughout the lab. A student was working at a computer in the lab when the explosion occurred, but he was not injured. Other waste containers in the hood were either destroyed or cracked. An investigation revealed that the nitric acid waste bottle had originally contained methanol. It was estimated that the explosion occurred about 12–16 hours after the nitric acid had been added to the bottle.

An explosion occurred during an organic chemistry teaching laboratory session (see Figure 5.2.3.1). Two students received first- and second-degree burns as well as lacerations from the exploding glass. While the cause could not definitely be determined, it was speculated that a nitric acid/sulfuric acid solution was added to a bottle containing organic reagent or waste. At least 11 students were present at the time of the explosion. The fire was partially extinguished by two facility management personnel who inhaled smoke and vapors from the chemical fire.

Recognizing Hazards

Reactivity

Oxidizers

Reduction half-reaction	E^o(V)	Strong oxidizing agent on left	Strong reducing agent on right
$\mathbf{F_2}(g) + 2e^- \rightarrow 2F^-(aq)$	2.87	X	
$\mathbf{H_2O_2}(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l)$	1.78	X	
$\mathbf{MnO_4}^-(aq) + 8\ H^+(aq) + 5\ e^- \rightarrow Mn^{2+}(aq) + 2\ H_2O(l)$	1.507	X	
$\mathbf{ClO_4}^-(aq) + 8H^+(aq) + 8e^- \rightarrow Cl^-(aq) + 2H_2O(l)$	1.389	X	
$\mathbf{Cl_2}(g) + 2e^- \rightarrow 2Cl^-(aq)$	1.36	X	
$\mathbf{Cr_2O_7}^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$	1.232	X	
$\mathbf{O_2}(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	1.229	X	
$\mathbf{Br_2}(l) + 2e^- \rightarrow 2Br^-(aq)$	1.09	X	
$\mathbf{NO_3}^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(l)$	0.957	X	
$\mathbf{I_2}(s) + 2e^- \rightarrow 2I^-(aq)$	0.54	X	
$H_2(aq) + 2e^- \rightarrow \mathbf{2H^-}(s)$	–2.23		X
$Al(OH)_4^-(aq) + 3e^- \rightarrow \mathbf{Al}(s) + 4OH^-(aq)$	–2.328		X
$K^+(aq) + e^- \rightarrow \mathbf{K}(s)$	–2.379		X
$Na^+(aq) + e^- \rightarrow \mathbf{Na}(s)$	–2.71		X
$Ca^2+(aq) + 2e^- \rightarrow \mathbf{Ca}(s)$	–2.868		X
$Li^+(aq) + e^- \rightarrow \mathbf{Li}(s)$	–3.04		X
$Cs^+(aq) + e^- \rightarrow \mathbf{Cs}(s)$	–3.06		X

Recognizing Hazards

Reactivity

Peroxide-Forming Solvents

- Certain classes of compounds will form potentially explosive peroxide crystals upon extended storage.

- Common examples of peroxide-forming compounds include 2-propanol, isopropyl ether, diethyl ether, tetrahydrofuran, dioxane, potassium metal.

- These compounds must be used in a timely manner or tested on a regular basis to ensure peroxide formation is not occurring.

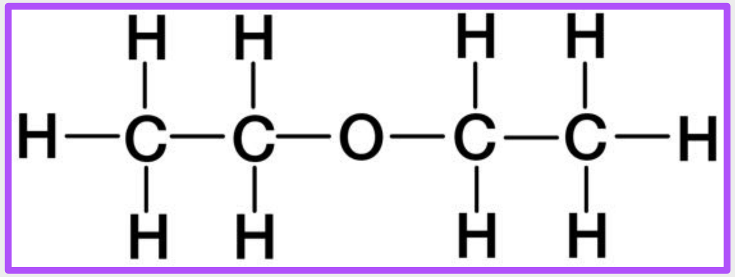
- The peroxide formers should be dated upon receipt, again dated upon opening, and stored away from heat and light with tight fitting, nonmetal lids.

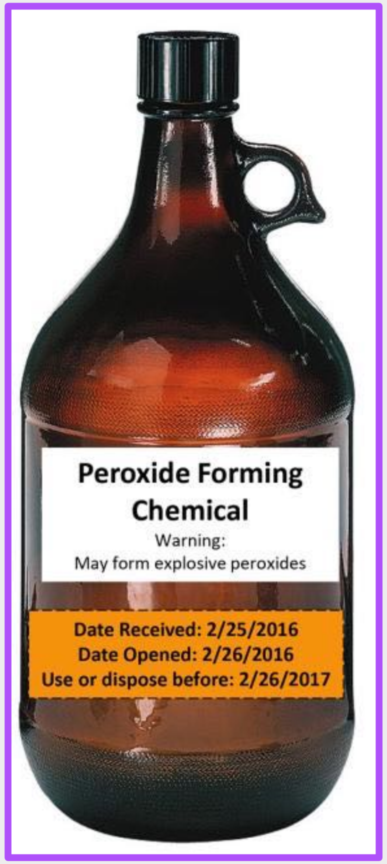
Potassium Iodide Test - to check for the presence of peroxides, shake 10ml of the ether with 1ml of fresh 10% (w/v) potassium iodide solution and a few drops of hydrochloric acid. Peroxides liberate iodine and the aqueous phase becomes yellow. If the result is uncertain, add a little starch solution

Recognizing Hazards

Reactivity

Peroxide-Forming Solvents



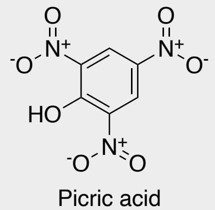


Recognizing Hazards

Reactivity

Perchloric acid ($HClO_4$)

Picric acid



Pyrophoric materials (organolithium)

Shock- and friction-sensitive materials (Metal azides, perchlorate salts, …)

Recognizing Hazards

Allergen	A chemical that causes an allergic reaction – that is, can evoke an adverse immune response in a person. See also sensitizer below. Example: toluene diisocyanate, CAS 584-84-9
Aspiration hazard	Aspiration toxicity includes severe acute effects, such as chemical pneumonia, varying degrees of pulmonary injury or death following aspiration. Aspiration is the entry of a liquid or solid directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system. Example: turpentine (major component is pinene, $C_{10}H_{16}$, CAS 80-56-8)
Carcinogen	A chemical that causes cancer in humans or animals – indicating that it has potential to cause cancer in humans. Example: benzidine, CAS 92-87-5
Combustible	A chemical that burns under most conditions once ignited, but it does not ignite and burn as easily as a flammable chemical (see below). Example: aniline, CAS 62-53-3
Compressed gas	A gas stored under pressure – under this pressure it might be in a gaseous or liquid state but under normal pressure it is a gas. Example: propane, CAS 74-98-6
Corrosive	A chemical that causes destruction of living tissue at the site of contact. Example: sodium hydroxide, CAS 1310-73-2
Cryogen	A chemical that is stored at extremely low temperatures. Example: carbon dioxide (normally as gas, but it is used in solid form, known as dry ice, formed when the gas is compressed and kept cold), CAS 124-38-9
Embryotoxin	A chemical that is harmful to a developing embryo – a developmental toxin. A teratogen (see below) is an embryotoxin that causes physical defects in a developing fetus. Example: carbon disulfide, CAS 75-15-0
Explosive	A chemical that can produce a sudden release of energy or gas when subjected to ignition, sudden shock, or high temperature. Example: 1,3,5-trinitrotoluene, aka TNT, CAS 118-96-7
Flammable	A chemical that is easily ignited and burns very rapidly. Sometimes this term is preceded by descriptors, such as Extremely Flammable (GHS Hazard Class 1) and Highly Flammable (GHS Hazard Class 2) to denote particularly flammable chemicals. A synonym is inflammable – means the same thing. Example: diethyl ether, CAS 60-29-7
Inflammable	A chemical that is easily ignited and burns very rapidly. A synonym is flammable – means the same thing. Example: acetone, CAS 67-64-1

Recognizing Hazards

Irritant	A chemical that causes irritation, either reversible or irreversible, to skin or living tissue at the site of contact – resulting in redness, swelling, itching, or a rash at the site of contact. Example: aluminum powder, CAS 7429-90-5
Lacrimator or lachrymator	A chemical that causes tears upon exposure. Example: α-chloroacetophenone, CAS 532-27-4
Mutagen	A chemical that causes mutagenic or genetic changes to DNA in persons or animals, with the potential to cause adverse effects in future generations of the exposed person or animal. Example: ethidium bromide, CAS 1239-45-8
Nonflammable	A chemical that does not ignite, does not burn, or is extremely difficult to burn. Example: carbon tetrachloride, CAS 56-23-5
Oxidizer or oxidizing agent	A chemical that can rapidly bring about an oxidation reaction by supplying oxygen or receiving electrons during oxidation. Oxidizing agents themselves may not be combustible, but their oxygen-supplying reactions can cause or contribute to the combustion of a material. Example: nitric acid, CAS 7697-37-2
Peroxide former	A chemical that can form peroxides (–O–O–) under storage conditions – peroxides are highly reactive and unstable, and can explode upon concentration or sudden shock. Example: diisopropyl ether, CAS 108-20-3
Poison	A chemical that is known to be extremely toxic to humans or animals. Example: hydrogen cyanide, CAS 74-90-8
Pyrophoric	A chemical that readily ignites and burns in air spontaneously – without a source of ignition. Example: phosphorus (white or yellow), CAS 7723-14-0
Reactive	A chemical that readily reacts or decomposes rapidly (violently) due to shock, pressure, temperature, or contact with air, water, or an incompatible chemical. Example: acetyl chloride, CAS 75-36-5
Reproductive toxicant	Reproductive toxicity includes adverse effects on sexual function and fertility in adult males and females, as well as developmental toxicity in offspring. Example: acrolein, CAS 107-02-8
Self-heating substance	A self-heating substance is a solid or liquid, other than a pyrophoric substance, which, by reaction with air and without energy supply, is liable to self-heat. Example: sodium dithionite, CAS 7775-14-16
Sensitizer	A chemical that upon repeated exposure causes severe adverse immune reaction – see also allergen. Example: formaldehyde, CAS 50-00-0

Recognizing Hazards

Stench	A chemical that has an extremely offensive odor. Example: ethane dithiol, CAS 540-63-6
Teratogen	A chemical that causes physical defects in a developing fetus or embryo. Example: thalidomide, CAS 50-35-1
Toxic	A chemical that causes adverse health effects in humans or animals upon exposure. Example: lead, CAS 7439-92-1
Water reactive	A chemical that upon contact with water or moisture reacts violently to catch fire. Example: sodium, CAS 7440-23-5

Recognizing Hazards

Look at the Label!

The Occupational and Safety and Health Administration (OSHA) requires that the label must contain information about the principal hazards of the chemical **– that's the law!**

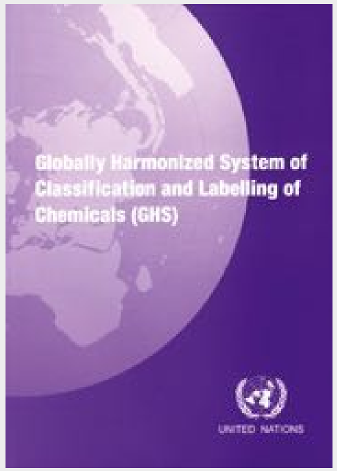
1980

Hazard Communication Standard ("HazCom")

Materials Safety Data Sheets (MSDS)

1992

The Globally Harmonized System of Classification and Labeling of Chemicals (GHS)



The first edition of the GHS appeared in 2003. The document describing the GHS is known as "The Purple Book" and it underwent revisions in 2005, 2007, 2009, and 2013.

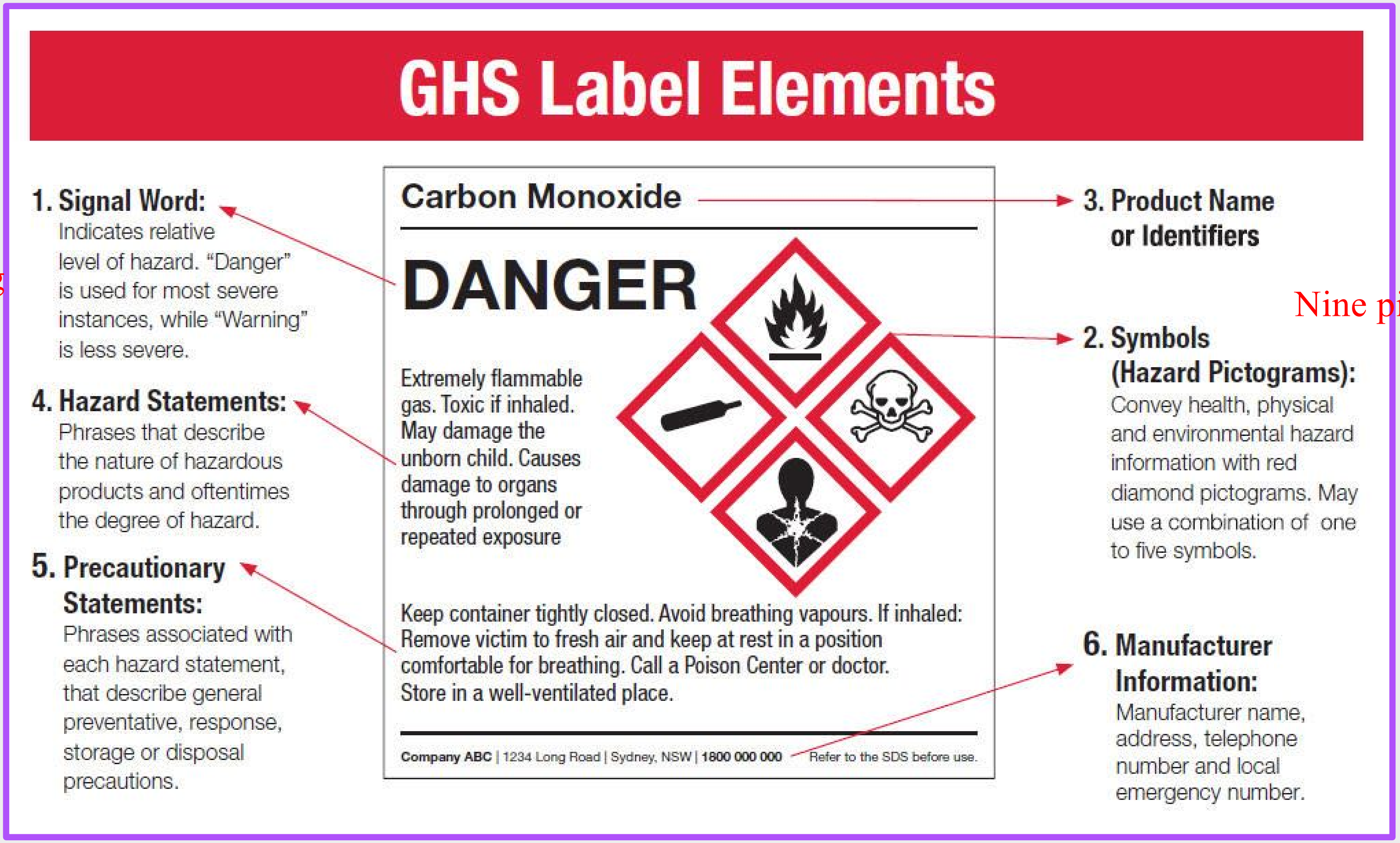
Recognizing Hazards

Safety data sheets (SDSs)
A standardized labeling system for chemicals
The protocols for the determination of the hazard ratings

Recognizing Hazards

Standardized labeling system for chemicals

Danger
Warning



Nine pictograms

Recognizing Hazards

Signal Words

- The signal word indicates the relative degree of severity a hazard.
- The signal words used in the GHS are
  - "Danger"
    - for the more severe hazards
  - "Warning"
    - for the less severe hazards.
- Some lower level hazard categories do not use signal words.
- Only one signal word corresponding to the class of the most severe hazard should be used on a label.

Recognizing Hazards

Statements

- **Located on label and SDS**
- **Hazard Statements**
  - **Hazard statements are standardized and assigned phrases that describe the hazard(s).**
- **Precautionary Statements**
  - **Precautionary information supplements the hazard information by briefly providing measures to be taken to minimize or prevent adverse effects**

Recognizing Hazards

Hazard Statements

Hazard and Precautionary statements are codified using a unique alphanumerical code which consists of one letter and three numbers, as follows:

- **Assigned alphanumeric code**
  - **Not required to use the code – only the statement words**
- **Letter H**
- **Number**
  - **2 for physical hazards**
  - **3 for health hazards**
  - **4 for environmental hazards**
- **Numbers**
  - **Two additional numbers corresponding to specific hazard group**

Recognizing Hazards

Hazard Statements

- H200 Unstable explosive
- H201 Explosive, mass explosive hazard
- H220 Extremely flammable gas
- H221 Flammable gas
- H300 Fatal if swallowed
- H330 Fatal if inhaled
- H400 very toxic to aquatic life

Recognizing Hazards

Precautionary Statements

Hazard and Precautionary statements are codified using a unique alphanumerical code which consists of one letter and three numbers, as follows:

- **Assigned alphanumeric code**
  - **Not required to use the code – only the statement words**
- **Letter P**
- **Number**
  - **1 for general**
  - **2 for prevention**
  - **3 for response**
  - **4 for storage**
  - **5 for disposal**
- **Numbers**
  - **Two additional numbers corresponding to sequential listing**

Recognizing Hazards

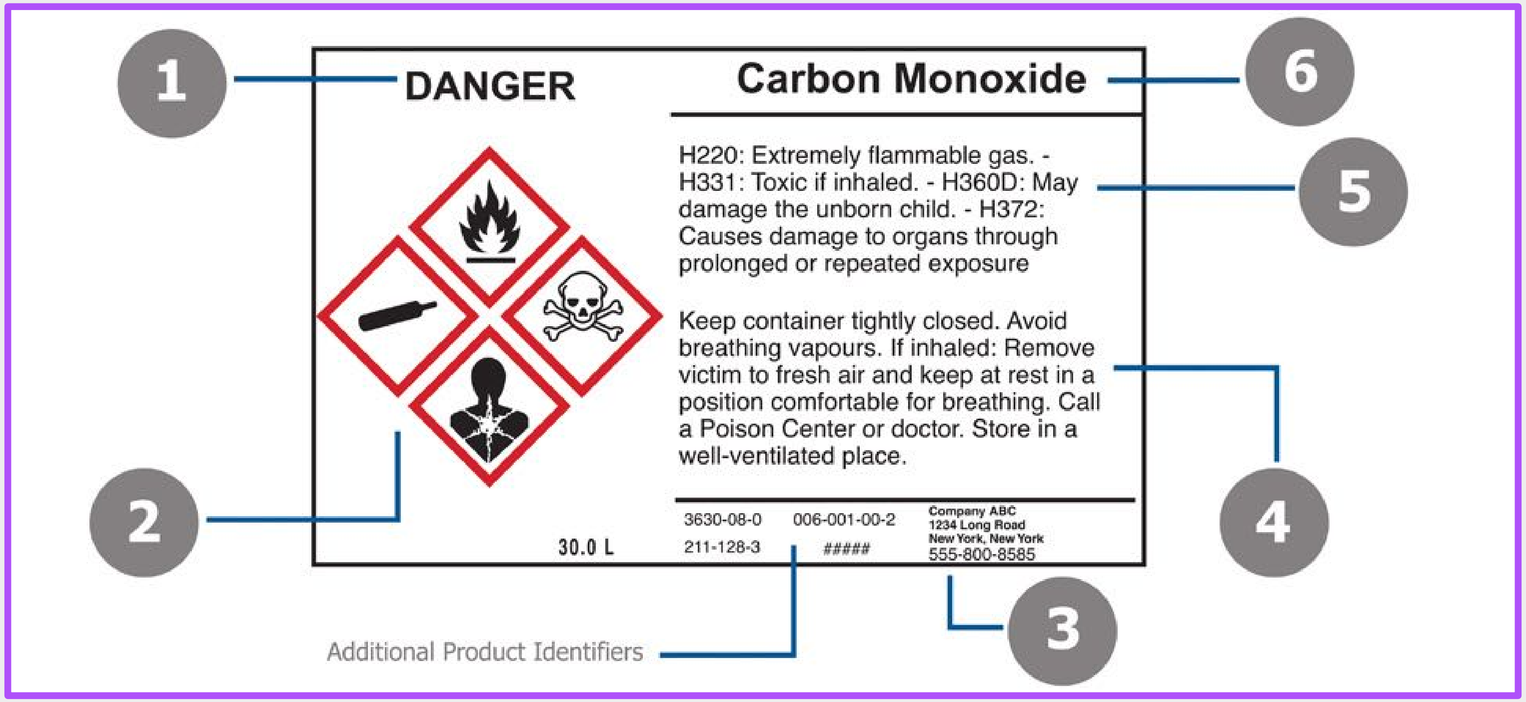
Precautionary Statements

- **P102 Keep out of reach of children**
- **P223 Do not allow contact with water**
- **P301 IF SWALLOWED …….**
- **P362 Take off contaminated clothing**
- **P375 Fight fire remotely due to risk of explosion**
- **P410 Protect from sunlight**
- **P501 Dispose of contents/container to ….**

Recognizing Hazards

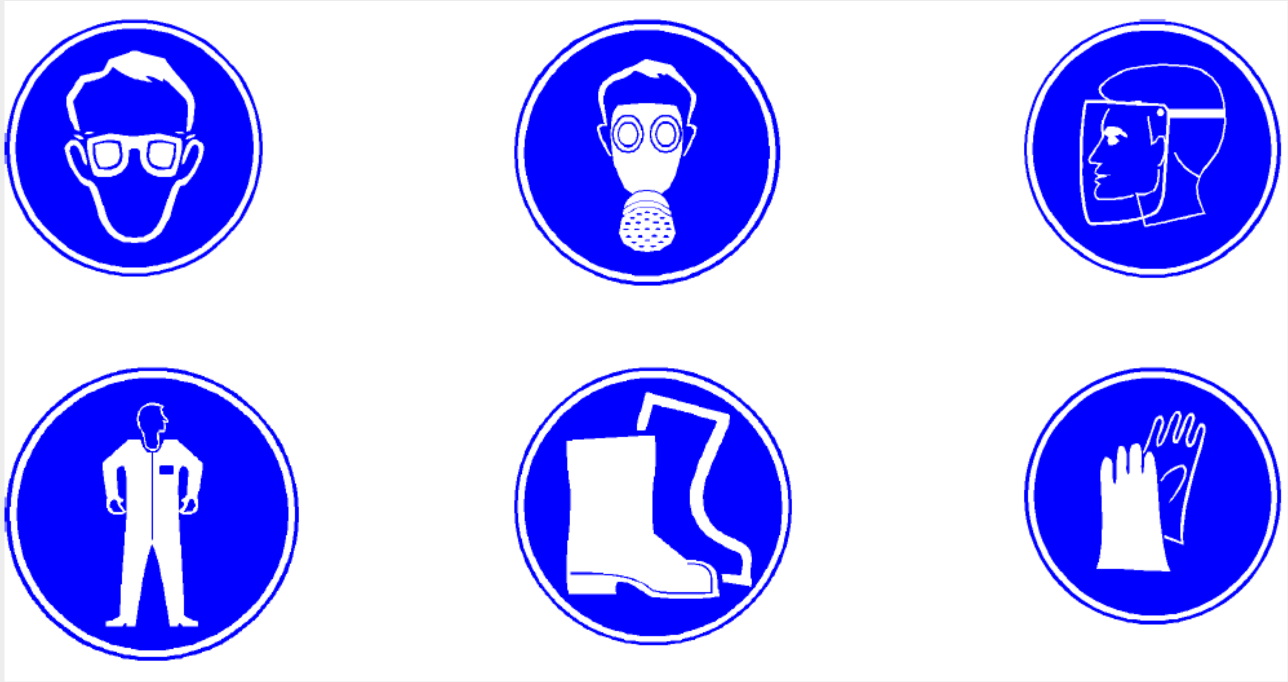
https://ec.europa.eu/taxation_customs/dds2/SAMANCTA/EN/Safety/HP_EN.htm

Recognizing Hazards



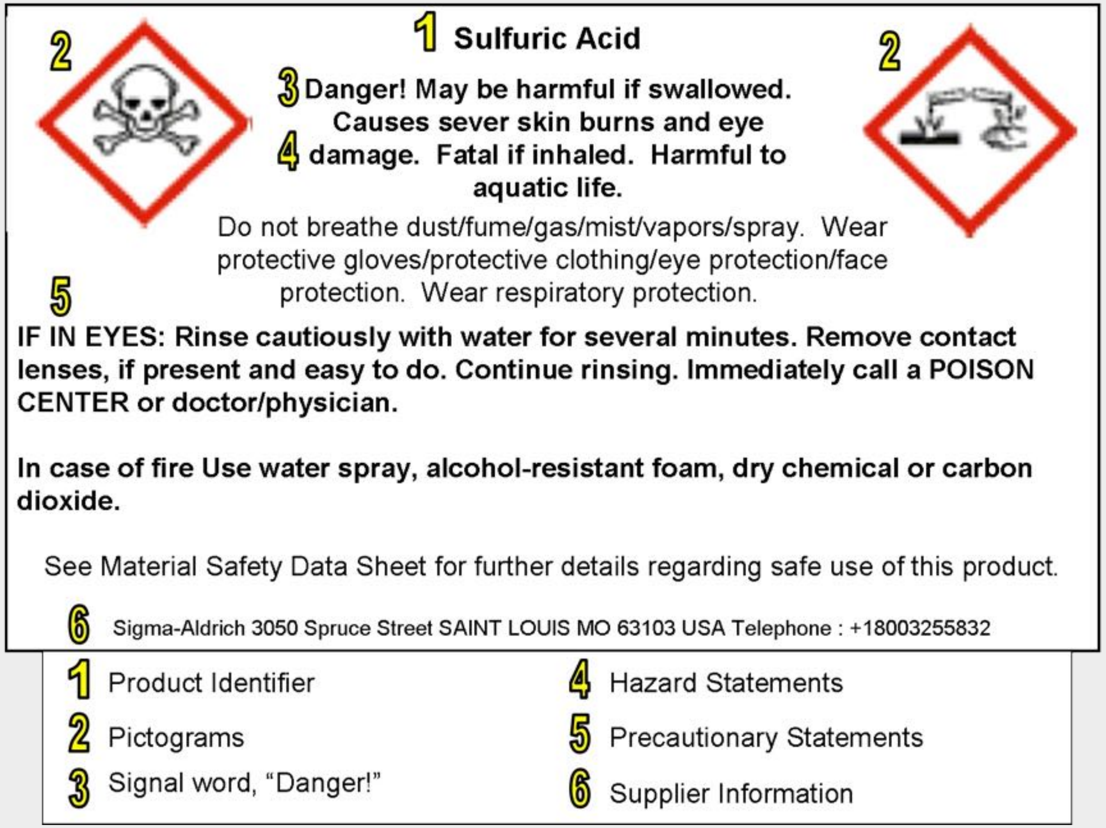
Recognizing Hazards

Precautionary Pictograms



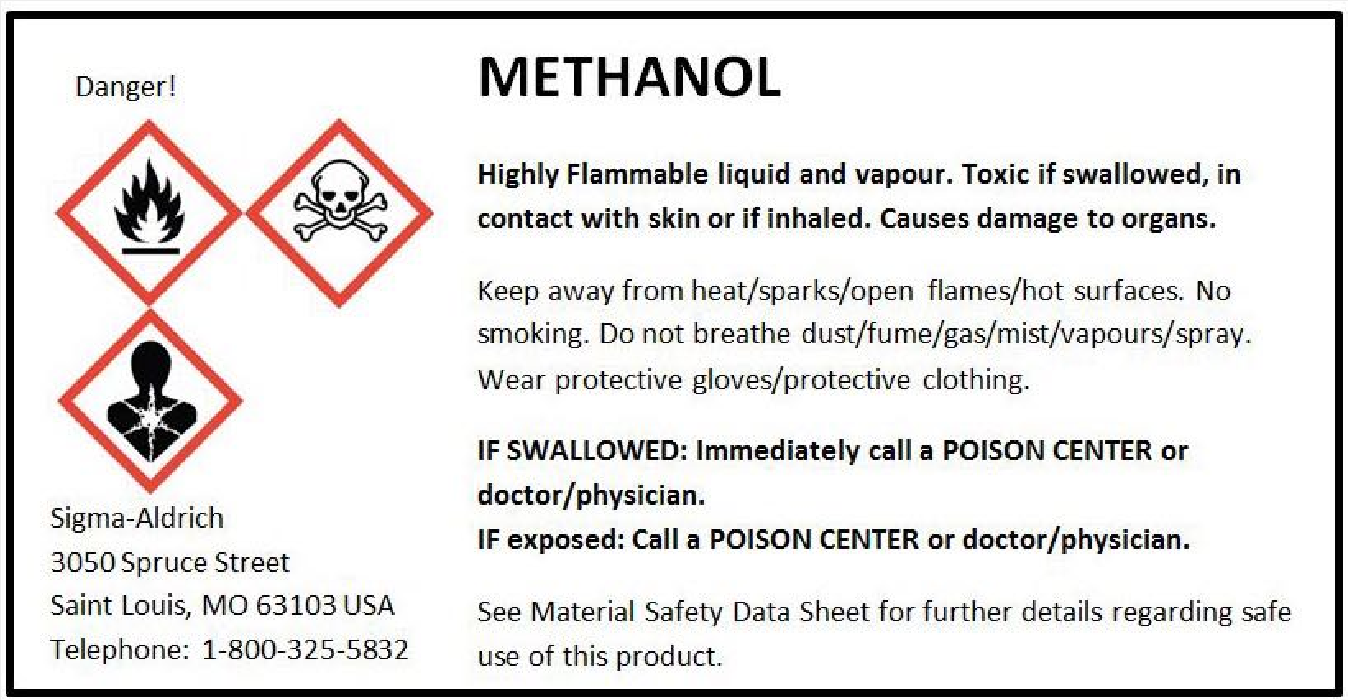
Recognizing Hazards

Sigma Label Example



Recognizing Hazards

Sigma Label Example



Danger!

METHANOL

Highly Flammable liquid and vapour. Toxic if swallowed, in contact with skin or if inhaled. Causes damage to organs.

Keep away from heat/sparks/open flames/hot surfaces. No smoking. Do not breathe dust/fume/gas/mist/vapours/spray. Wear protective gloves/protective clothing.

IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.
IF exposed: Call a POISON CENTER or doctor/physician.

See Material Safety Data Sheet for further details regarding safe use of this product.

Sigma-Aldrich
3050 Spruce Street
Saint Louis, MO 63103 USA
Telephone: 1-800-325-5832

Recognizing Hazards

Sigma Label Example

Recognizing Hazards

Globally Harmonized System (GHS) Hazard Classes and Rating

2 for physical hazards
3 for health hazards
4 for environmental hazards

	Rating for "danger" signal word	Rating for "warning" signal word	No signal word
Physical hazards (sections with information about this hazard)			
Explosives (5.2.2)	Unstable, 1.1, 1.2, 1.3	1.4, 1.5, 1.6	
Flammable Gases (5.1.2)	1	2	
Flammable Aerosols (5.1.2)	1, 2		
Oxidizing Gases (5.2.3, 5.3.2, 5.3.3)	1		
Gases Under Pressure (5.3.1)		Four categories	
Flammable Liquids (5.1.2, 5.2.2)	1, 2	3, 4	
Flammable Solids (5.2.2)	1	2	
Self-reactive Substances (5.2.3)	A, B, C, D	E, F	G
Pyrophoric Liquids (5.2.3)	1		
Pyrophoric Solids (5.2.3)	1		
Self-heating Substances and Mixtures (5.3.3)	1	2	
Substances Which on Contact with Water Emit Flammable Gases (5.2.3)	1, 2	3	
Oxidizing Liquids (5.2.3, 5.3.2, 5.3.3)	1, 2	3	
Oxidizing Solids (5.2.3, 5.3.2, 5.3.3)	1, 2	3	
Organic Peroxides (5.3.2)	A, B, C, D	E, F	G
Corrosive to Metals (5.1.1, 5.2.1)		1	
Health hazards (sections with information about this hazard)			
Acute Toxicity (4.1.2)	1, 2, 3	4, 5	
Skin Corrosion/Irritation (5.1.1, 5.2.1)	1A, 1B, 1C	2, 3	
Serious Eye Damage and Eye Irritation (5.1.1, 5.2.1)	1	2A, 2B	
Respiratory Sensitization (4.1.2)	1		
Skin Sensitization (4.1.2)		1	
Germ Cell Mutagenicity (4.2.1)	1A, 1B	2	
Carcinogenicity (4.3.1)	1A, 1B	2	
Reproductive Toxicity (4.2.1)	1A, 1B	2	
Target Organ Systemic Toxicity (TOST): Single Exposure (4.1.2)	1	2, 3	
Target Organ Systemic Toxicity (TOST): Repeated Exposure (4.2.1)	1	2	
Aspiration Hazard (4.1.2)	1	2	
Environmental Hazards (sections with information about this hazard)			
a. Acute Aquatic Toxicity (4.1.2)		1	2, 3,
b. Chronic Aquatic Toxicity (4.2.1)		1	2, 3, 4
Hazardous to the ozone layer		1	

Recognizing Hazards

Hazard Communication Standard Pictograms

Health Hazard • Respiratory Sensitizer • Carcinogen • Mutagenicity • Reproductive Toxicity • Target Organ Toxicity • Aspiration Toxicity 	**Flame** • Flammables • Pyrophorics • Self-heating • Emits Flammable Gas • Self-reactives • Organic Peroxides 	**Exclamation Mark** • Skin Sensitizer • Irritant (skin, eyes) • Acute Toxicity (harmful) • Narcotic Effects • Respiratory Tract Irritant • Hazardous to Ozone Layer 
Corrosion • Skin Corrosion/Burns • Eye Damage • Corrosive to Metals 	**Exploding Bomb** • Explosives • Self-reactives • Organic Peroxides 	**Flame Over Circle** • Oxidizers 
Gas Cylinder • Gases Under Pressure 	**Skull and Crossbones** • Acute Toxicity (fatal or toxic) 	**Environment** • Aquatic Toxicity 

Recognizing Hazards

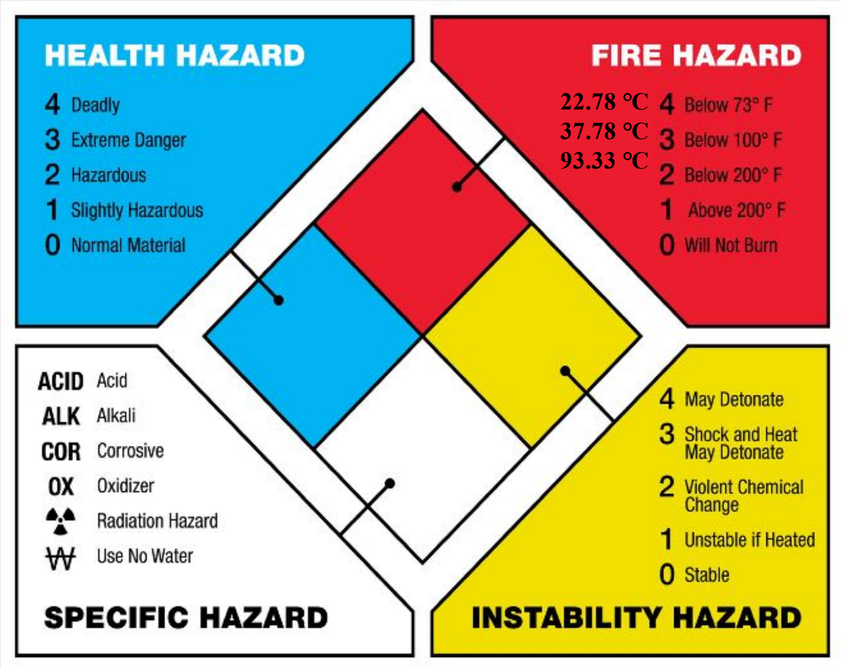
Properties of Flammable and Combustible Liquids as Defined by the GHS

Hazard category	Hazard description	Signal word	Flash point (°C)	Boiling point (°C)
HC 1	Extremely flammable	Danger	<23	≤ 35
HC 2	Highly flammable	Danger	<23	>35
HC 3	Flammable	Warning	≥ 23 to ≤ 60	—
HC 4	Combustible	Warning	>60 to ≤ 93	—

Recognizing Hazards

NFPA Diamond

In addition to the GHS, National Fire Protection Association (NFPA) "fire diamonds" have long been used in academic and nonacademic settings.



Recognizing Hazards

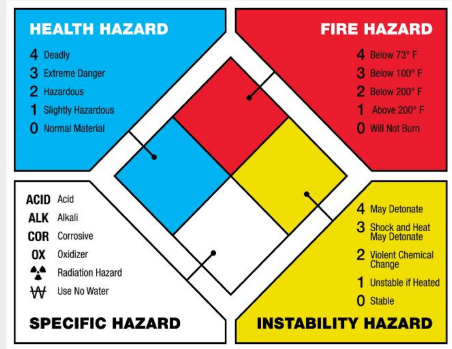
The NFPA Categorization System for Flammable Substances

Hazard rating	Description	Criteria
4	Burns rapidly under ambient conditions; vaporizes easily	Flash point (fp) <22.8 °C and boiling point (bp) <37.8 °C
3	Burns under ambient conditions	fp <22.8 °C and bp >37.8 °C or fp ≥22.8 °C and bp <37.8 °C
2	Burns if moderately heated	fp ≥37.8 °C and <93.4 °C
1	Burns if preheated	fp ≥93.4 °C
0	Will not burn	Will not burn at 816 °C for 5 min

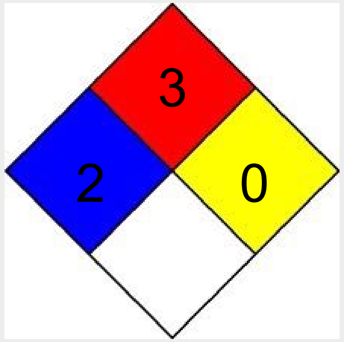
Recognizing Hazards

Laboratory Chemical Bottle with NFPA Diamond. It is important to know the meaning of the ratings (0–4) in the fire diamond to properly assess the various hazard levels of health, flammability, and reactivity.

Recognizing Hazards



Gasoline Example



- **Highly Flammable Liquid - Category 3**
- **Skin Corrosion/Irritation - Category 2**
- **Germ Cell Mutagenicity - Category 1B**
- **Carcinogenicity - Category 1B**
- **Toxic to Reproduction - Category 1A**
- **Specific Target Organ Toxicity (Single Exposure) - Category 3 (respiratory irritation, narcosis)**
- **Specific Target Organ Toxicity (Repeat Exposure) - Category 1 (liver, kidneys, bladder, blood, bone marrow, nervous system)**
- **Aspiration Hazard - Category 1**
- **Hazardous to the Aquatic Environment – Acute Hazard - Category 3**

Recognizing Hazards

SDSs

The SDS for a hazardous chemical is a document that describes the chemical's hazards and the precautions that you must take to avoid harm.

OSHA requires employers to maintain an SDS for each hazardous chemical on the premises, available to any employee who requests it.

As a student, you can also request the SDS for a chemical. The Internet also makes it very easy to search for and find an SDS online, and they can be very educational.

Recognizing Hazards

SDSs

A GHS SDS is divided into 16 sections.

The order of the information presented in an SDS is mandated by regulation, so the information given is relatively uniform from manufacturer to manufacturer.

The SDS must be in English.

Recognizing Hazards

SDSs

- 1. Substance and company identification
- 2. Hazards identification
- 3. Composition/information on ingredients
- 4. First-aid measures
- 5. Fire fighting measures
- 6. Accidental release measures
- 7. Handling and storage
- 8. Exposure control/ personal protection
- 9. Physical and chemical properties
- 10. Stability and reactivity
- 11. Toxicological information
- 12. Ecological information
- 13. Disposal considerations
- 14. Transport information
- 15. Regulatory information
- 16. Other information

Recognizing Hazards

SDSs

Often in an SDS you will see the statement “Data not available” in the Toxicological Information section (section 11). Do not assume that this equates with “safe”; it simply means that the substance has not been evaluated with respect to that value.

Recognizing Hazards

In addition to GHS and NFPA, PubChem is also a rich source of hazard information

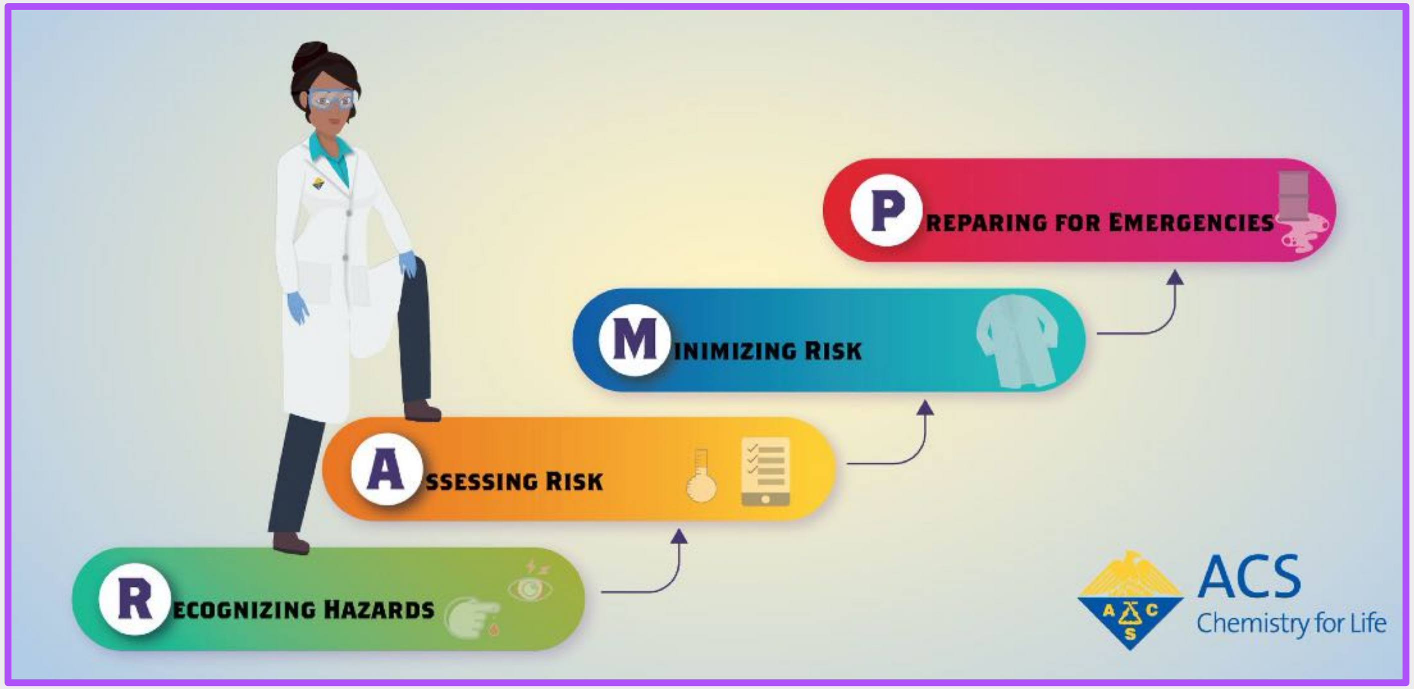
PubChem entries about chemicals list a very wide variety of information about hazards and other information.

Very extensive data containing safety and other information about chemicals. This also includes a subset of chemicals for which there are "Laboratory Chemical Safety Summaries"

https://pubchem.ncbi.nlm.nih.gov/

Assessing Risk

Remember RAMP



Assessing Risk

Hazard And Risk Are Different

A *hazard* is "the potential to do harm".

***Risk* is the probability of harm arising from exposure to a hazard.**

Assessing Risk

Assessing Risk

$$Risk\ Rating\ (RR) = Severity\ of\ Consequences\ Value\ (CV) \times Probability\ of\ Occurrence\ Value\ (OV)$$

Assessing Risk

Severity of Consequences

Consequence Value (CV)		Impact to…				
Rating	**Value**	**Personnel Safety**	**Resources**	**Work Performance**	**Property Damage**	**Reputation**
No Risk	1	No injuries	No Impact	No Delays	Minor	No impact
Minor	2	Minor injuries	Moderate impact	Modest Delays	Moderate	Potential damage
Moderate	3	Moderate to life impacting injuries	Additional resources required	Significant delays	Substantial	Damaged
High	4	Life threatening injuries from single exposure	Institutional resources required	Major operational disruptions	Severe	Loss of Confidence

Assessing Risk

Probability of Occurrence (Exposure)

Occurrence Value (OV)		Probability of Occurrence	
Rating	**Value**	**Percent**	**Description**
Not Present	0	0%	Item/operation is not present in laboratory.
Rare	1	1–10%	Rare
Possible	2	10–50%	Possible
Likely	3	50–90%	Likely
Almost Certain to Certain	4	90–100%	Almost Certain to Certain

Assessing Risk

$$Risk\ Rating\ (RR) = Severity\ of\ Consequences\ Value\ (CV) \times Probability\ of\ Occurrence\ Value\ (OV)$$

		Severity of Consequences (CV) Impact to Personnel Safety, Resources, Work Performance, Property and/or Reputation			
		CV = 1	CV = 2	CV = 3	CV = 4
Probability of Occurrence (OV)	OV = 4	RR = 4 LOW	RR = 8 HIGH	RR = 12 CRITICAL	RR = 16 CRITICAL
	OV = 3	RR = 3 LOW	RR = 6 MEDIUM	RR = 9 HIGH	RR = 12 CRITICAL
	OV = 2	RR = 2 LOW	RR = 4 LOW	RR = 6 MEDIUM	RR = 8 HIGH
	OV = 1	RR = 1 LOW	RR = 2 LOW	RR = 3 LOW	RR = 4 LOW
	OV = 0	RR = 0 Not Applicable—The Material or Process is Not Present in the Laboratory			

Assessing Risk

$$Risk\ Rating\ (RR) = Severity\ of\ Consequences\ Value\ (CV) \times Probability\ of\ Occurrence\ Value\ (OV)$$

Risk Level	Expectation of Response
Low	Acceptable Risk Level Monitor and Manage
Medium	Tolerable Risk Level Implement corrective action and consider additional controls
High	Tolerable Risk Level with Strict Controls and Oversight Implement mitigating and corrective actions with routine monitoring and oversight.
Critical	Intolerable Risk Level Implement mitigating and corrective actions. Engage higher levels of management

Assessing Risk

$$Risk\ Rating\ (RR) = Severity\ of\ Consequences\ Value\ (CV) \times Probability\ of\ Occurrence\ Value\ (OV)$$

A significant hazard, but very low risk.

A significant hazard and risk.

Assessing Risk

Carrying an open beaker containing concentrated sulfuric acid down a hallway presents a very high degree of risk

Having 2 drops of cyclohexane near an open flame presents a quiet risk.
Having 2 L of cyclohexane near an open flame presents a high risk.

Assessing Risk

Risk assessment based on level of hazard and probability of exposure.

Probability \ Degree of Hazard	Low	Medium	High
High	medium	high	high
Medium	medium	medium	high
Low	low	low	medium

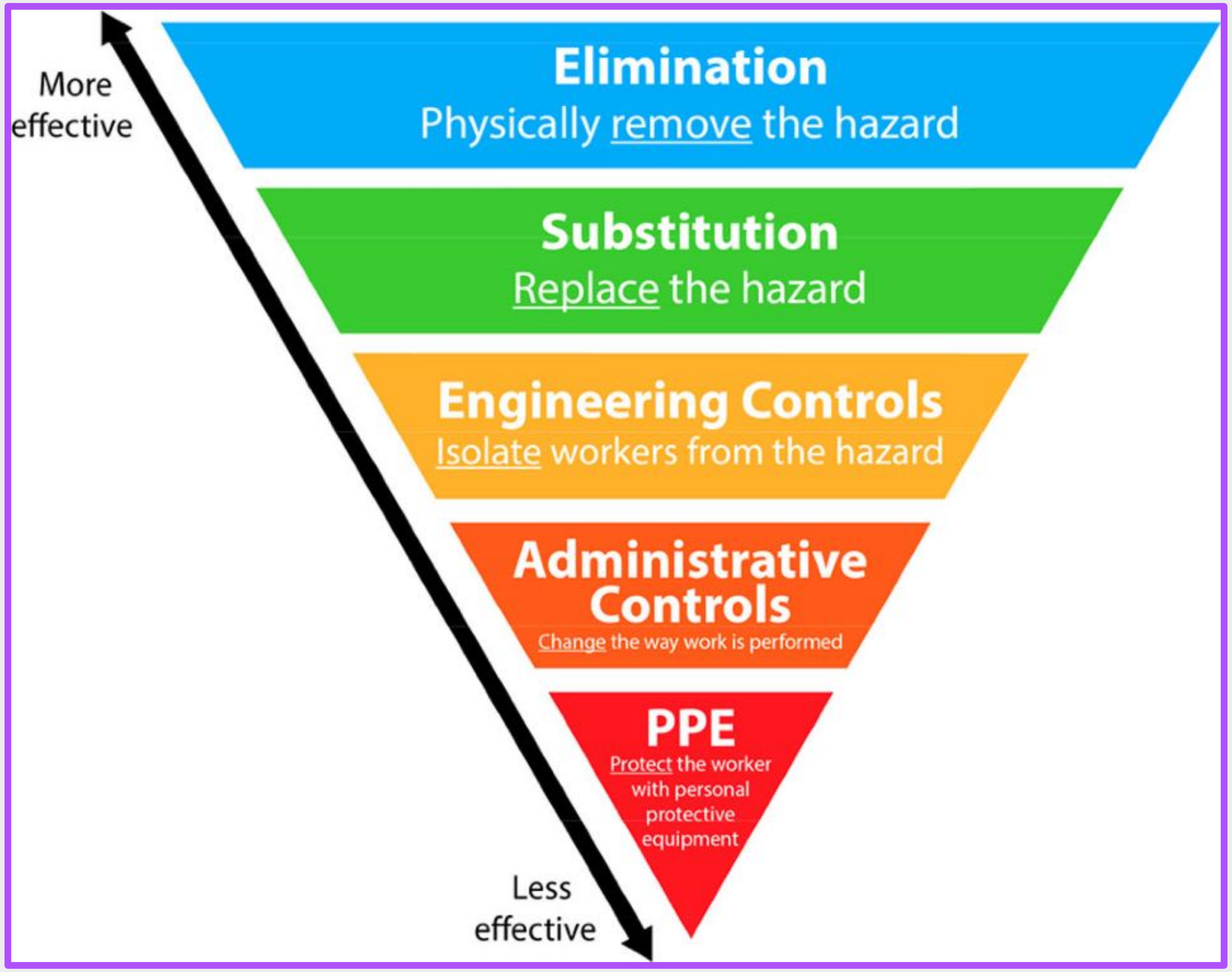
Shall we accept the risk and proceed with the experiment or should we make some changes to reduce the risk level?

Minimizing Risk

Remember RAMP

Minimizing Risk

Hierarchy of controls pyramid



Minimizing Risk

Avoiding Hazards through Elimination or Reduced Scale

Reducing the scale reduces the risk

Reducing the scale to around 25–100 mg is called microscale chemistry.

Learning laboratory operations and safety precautions from others

Minimizing Risk

Avoiding Hazards through Substitution

- If a solvent is flammable, perhaps it can be replaced with another solvent that is less flammable or nonflammable but still has the needed reactant and product solubility characteristics. (Caution is needed here. Replacing a flammable solvent of low toxicity with a nonflammable solvent that is a carcinogen might replace one hazard with a different one.)

- To precipitate a cation, one might use an anion of low toxicity (such as carbonate) instead of an anion of high toxicity (such as cyanide).

- Rather than using high temperature to overcome an activation energy barrier, perhaps UV light or a microwave oven could be used.

Minimizing Risk

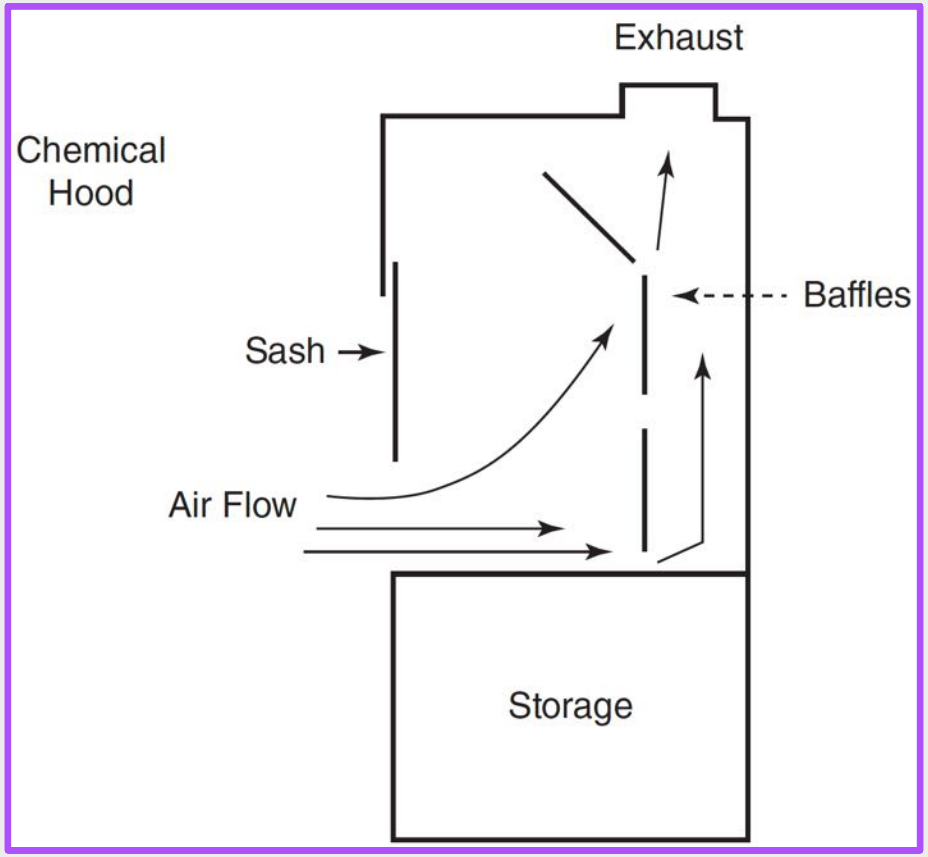
Avoiding Hazards through Engineering Controls

In a laboratory, engineering controls usually refer to having and using chemical hoods.

Laboratory Hood with a Vertical Sash.
Sashes should always be closed except when arms and hands need to be accessing something inside the chemical hood. This both saves energy (for many modern hoods) and provides a shield against explosions and fires.

Minimizing Risk

Avoiding Hazards through Engineering Controls



Minimizing Risk

Hood Performance

Tissue Paper

Ribbon

Minimizing Risk

Unsafe

Lab

Practice

Minimizing Risk

Safe

Lab

Practice

Minimizing Risk

Improper Chemical Storage

Restricted Airflow

Incompatible Chemicals

Chemical Contamination

Minimizing Risk

Improper Equipment Storage

Sash Restricted

Airflow Restricted

Limited Protection

Minimizing Risk

Proper Equipment Storage

Elevate Apparatus

Promote Airflow

Contain Contaminants

Minimizing Risk

Damaged Sash

Limited Protection

Report Damage

Repair Before Using

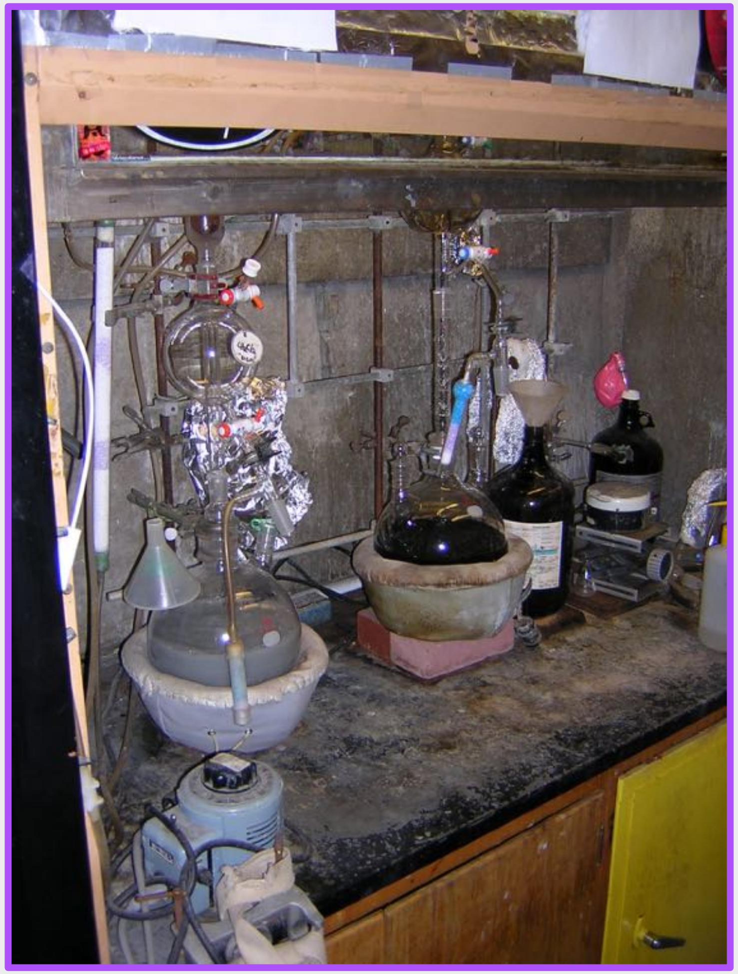
Minimizing Risk

Raised Sash (Unattended)

Reduced Air Velocity

Fire/Explosion

Chemical Exposure



Minimizing Risk

Proper Set Up:

Brightly Illuminated

Clean

Apparatus 6” (15.24 cm) Inside

Slots Unobstructed

Minimizing Risk

Avoiding Hazards through Administrative Controls

- No eating and drinking in the lab.
- No food storage in lab refrigerators designed for and containing lab chemicals.
- Wear appropriate PPE.
- Keep lab benches tidy and keep safety areas clear near eyewashes, showers, and emergency response equipment.
- Dispose of chemicals properly.
- Clean glassware after use.
- Wash your hands if there is some skin exposure to relatively benign chemicals and wash your hands when leaving the lab. If skin exposure presents a serious hazard, know what actions to take immediately.
- Label all containers in the lab.
- Be wary of transferring chemicals to phones, computers, and other lab equipment.

Minimizing Risk

Avoiding Hazards through Administrative Controls

1. Follow instructor and laboratory instruction directions carefully.
2. Wear proper eye protection for use around chemicals at all times in the laboratory.
3. Wear clothing that protects against exposure and provides protection from spills. Wear chemically resistant gloves when prudent to do so.
4. Do not eat, drink, smoke or use smokeless tobacco products, chew gum, or take medications in the laboratory.
5. Use the chemical hood when working with volatile chemicals, flammable liquids or gases, or odorous chemicals, or when there is a possibility of the release of toxic gases, vapors, powders, or dusts.
6. There should be no boisterous conduct, excessive noise (radios, DVD players, iPods), or practical jokes in the laboratory.
7. Never taste any laboratory chemical. Mouth-pipetting is prohibited in laboratories.
8. When smelling a chemical (if you are instructed to do so), gently waft the vapors toward your nose. Do not directly inhale the vapors.
9. If any chemical spills on your skin or in your eyes, immediately flush the affected area with water and notify the instructor.
10. Do not work alone in the laboratory.
11. Notify the instructor immediately of all accidents, incidents, injuries, spills, or hazardous situations.
12. Dispose of waste chemicals in the containers provided.
13. Do not heat flammable liquids with a Bunsen burner or other open flame.
14. Label all containers with the name of the chemical and the concentration if it is a solution.

Minimizing Risk

Avoiding Hazards through Administrative Controls

- If a student has any medical condition that may be affected by chemistry stockroom and laboratory work (allergies, e.g.) or that may affect safe performance of laboratory work (seizure disorders, e.g.), it is strongly recommended that the student inform the Supervisor well in advance of the initiation of any laboratory work.

- If a student thinks or knows they are pregnant, seeking medical consultation for infertility, or is intending to have a child, it is strongly recommended that they contact the Supervisor in advance of the initiation of laboratory work so that an appropriate accommodation can be made.

- Absolutely no unauthorized experiments are to be performed. Never work in the laboratory alone.

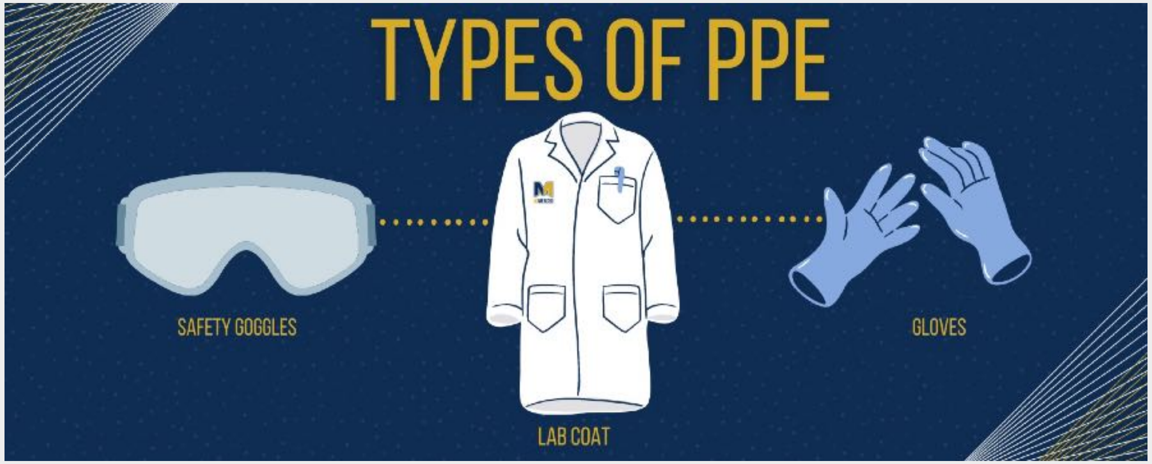
Minimizing Risk

Avoiding Hazards through Administrative Controls

- ❖ All chemicals are labeled properly
- ❖ Chemicals are stored according to compatibility
- ❖ When receiving chemicals inspect the package for any breakage or leakage.
- ❖ Containers and bottles used to store chemicals in the laboratory should show no signs of damage or leakage.
- ❖ Storage areas are labeled. Chemical storage areas within the laboratory must be clearly marked. This includes cupboards, cabinets, drawers and other closed storage areas.
- ❖ Peroxide formers dated.
  (2-propanol, isopropyl ether, diethyl ether, tetrahydrofuran, dioxane, potassium metal, …)

Minimizing Risk

Avoiding Hazards through Use of Personal Protective Equipment (PPE)



Don't depend solely on PPE to protect you, because it is often the final barrier between you and exposure.

Minimizing Risk

PPE

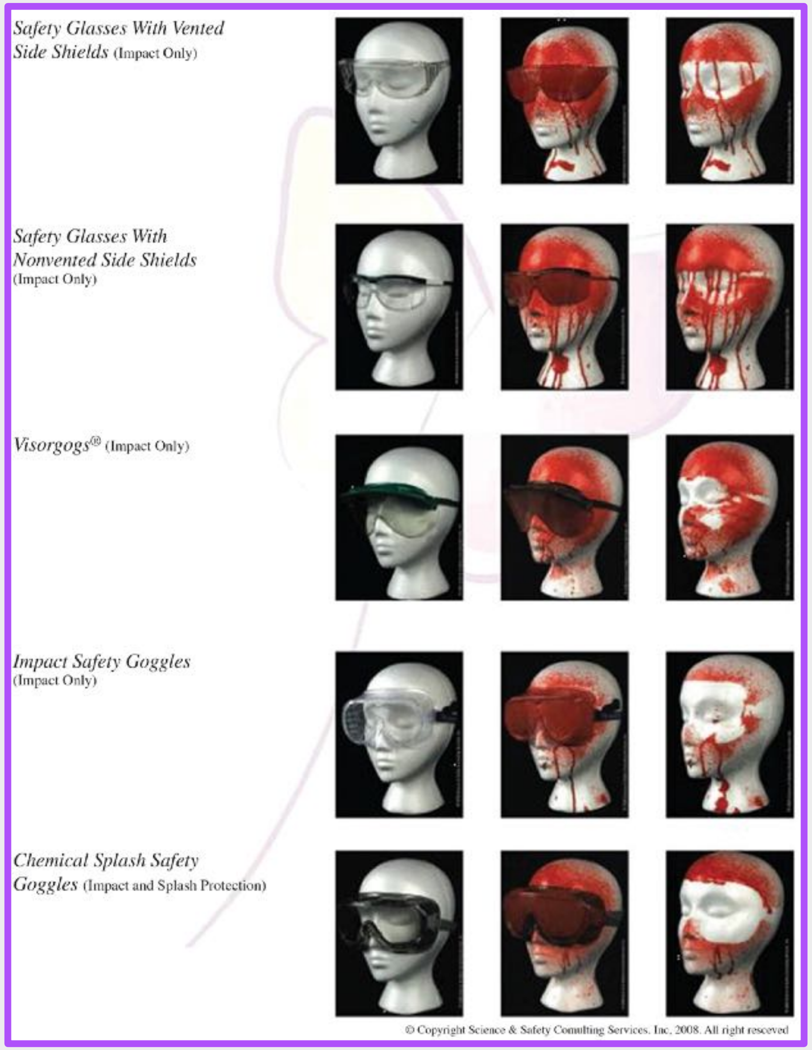
Various Safety Glasses. Safety glasses with side shields can provide some protection against flying shrapnel but are ineffective against chemical splashes.

Chemical Splash Goggles. These goggles provide excellent splash protection and are relatively comfortable to wear, if sized properly.

Minimizing Risk

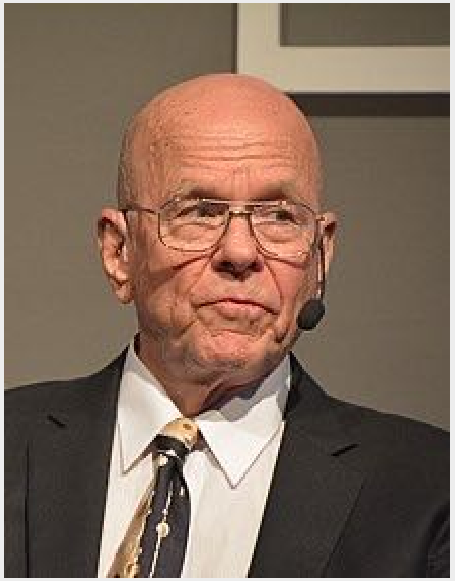
PPE

Degrees of eye protection from Simulated Splashes Using Varied Types of Eye Protection. The mannequin faces on the right show how effective each type of eye protection is against a chemical splash. Only the chemical splash goggles provide adequate protection and are the only acceptable form of eye protection in chemistry laboratories.



Minimizing Risk

He was blinded in one eye during a lab accident in 1970 where an NMR tube exploded, shortly after he arrived at MIT as an assistant professor. After this accident, Sharpless stresses "there's simply never an adequate excuse for not wearing safety glasses in the laboratory at all times."



Karl Barry Sharpless
(1941-)
Nobel Prize in Chemistry(2001, 2022)

Minimizing Risk

PPE

All persons who are working in or visiting the laboratory must wear safety goggles and a lab coat at all times chemicals or glassware are being used or handled.

Safety glasses, carpenter’s goggles, or glasses with side shields are not acceptable for eye protection as per ANSI Z87.1-2003.

Minimizing Risk

PPE

Can I Ever Not Wear My Goggles in the Lab?

Our recommendation is: always wear chemical splash goggles in labs where chemicals are used.

Laboratories without splash hazards are the exception, not the rule.

Any lab involved in the use of liquids or potentially hazardous or infectious substances requires chemical splash goggles.

The chemicals don't know what lab they are in!

Minimizing Risk

PPE

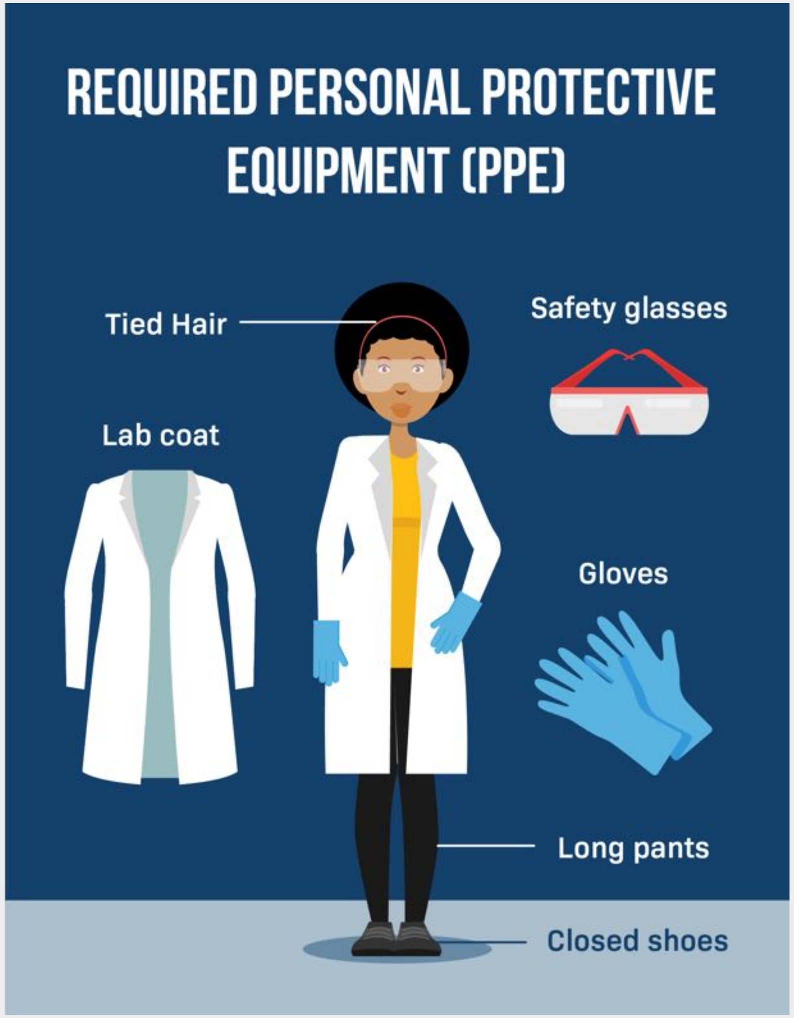
Hair and Apparel (Dressing for the Laboratory)

- ❖ **Bulky and loose-fitting clothing is not appropriate in the laboratory.**

- ❖ **In the laboratory, wear shoes with uppers made of leather or polymeric leather substitute that completely cover your feet and toes (closed-toe shoes**

- ❖ **Constrain long hair and loose clothing.**

- ❖ **The wearing of jewelry, such as rings, bracelets, necklaces, and wristwatches, in the laboratory should be avoided.**



Minimizing Risk

PPE

Hair and Apparel (Dressing for the Laboratory)

Minimizing Risk

PPE

Minimizing Risk

PPE

Gloves

- ❖ **Remove your gloves before leaving the work area and before handling such things as cell phones, calculators, laptops, doorknobs, writing instruments, laboratory notebooks, and textbooks.**

- ❖ **You should wash your hands when leaving the laboratory, even if you have worn gloves.**

- ❖ **Individuals who are latex-sensitive should not wear gloves made of latex.**

- ❖ **The gloves cannot be reused safely because the chemical cannot be totally removed.**

Minimizing Risk

PPE

Glove material must be selected based on the chemicals being used.

Many styles of gloves, made with many different kinds of materials, are available.

It is important to select the right glove to protect against the particular hazard. Degree of protection and dexterity vary considerably.

There is no "universal" glove.

Minimizing Risk

PPE

An Incident: Fatal Exposure Through Inappropriate Gloves

In August 1996 a chemistry professor was using a pipet to transfer some dimethylmercury into an NMR tube. Dimethylmercury was known to be toxic. She was wearing gloves and a lab coat, working in a chemical hood, and had even cooled the liquid to minimize the vapor pressure. She inadvertently spilled a few drops on the latex gloves she was wearing. Tests later showed that dimethylmercury penetrates latex gloves in about 15 seconds. (One SDS recommended latex gloves, one recommended neoprene gloves, and one recommended "chemically impervious gloves".) The professor removed the gloves and washed her hands. Five months later she started to develop symptoms of organomercury poisoning and despite aggressive treatment she went into a coma one month later and died in June 1997.

Dr. Karen Wetterhahn
1948 –1997

Minimizing Risk

Glove material	Intended use	Advantages and disadvantages
Latex (natural rubber)	Incidental contact	• Good for biological and water-based materials. • Poor for organic solvents. • Little chemical protection. • Hard to detect puncture holes. • Can cause or trigger latex allergies
Nitrile	Incidental contact (disposable exam glove) Extended contact (thicker reusable glove)	• Excellent general use glove. Good for solvents, oils, greases, and some acids and bases. • Clear indication of tears and breaks. • Good alternative for those with latex allergies.
Butyl rubber	Extended contact	• Good for ketones and esters. • Poor for gasoline and aliphatic, aromatic, and halogenated hydrocarbons. 
Neoprene	Extended contact	• Good for acids, bases, alcohols, fuels, peroxides, hydrocarbons, and phenols. • Poor for halogenated and aromatic hydrocarbons. • Good for most hazardous chemicals. 
Norfoil	Extended contact	• Good for most hazardous chemicals. • Poor fit (Note: Dexterity can be partially regained by using a heavier weight Nitrile glove over the Norfoil/Silver Shield glove. 
Viton	Extended contact	• Good for chlorinated and aromatic solvents. • Good resistance to cuts and abrasions. • Poor for ketones. • Expensive.
Polyvinyl chloride (PVC)	Specific use	• Good for acids, bases, oils, fats, peroxides, and amines. • Good resistance to abrasions. • Poor for most organic solvents.
Polyvinyl alcohol (PVA)	Specific use	• Good for aromatic and chlorinated solvents. • Poor for water-based solutions.
Stainless Steel Kevlar Leather	Specific use	• Cut-resistant gloves. • Sleeves are also available to provide protection to wrists and forearms. NOTE: If potential for biological or chemical contamination: wear appropriate disposable gloves on top of your cut-resistant gloves and discard after use.
Cryogenic Resistant Material Leather	Specific use	• For use with cryogenic materials. • Designed to prevent frostbite. Note: Never dip gloves directly into liquid nitrogen.

Minimizing Risk

Glove Use Do's and Don'ts

July 2023

Do:

- Choose the appropriate type of gloves for each task
- Inspect gloves for damage or defects before use
- Wash your hands thoroughly before putting on gloves to minimize the risk of contamination
- Change gloves between tasks or when they become contaminated
- Dispose of gloves properly in designated waste containers
- Wear cryogenic gloves when working with any cryogens
- Pinch wrist of glove to remove to avoid touching your skin

Don't:

- Don't wear non-heat resistant gloves when working with hot surfaces or flames
- Don't wear gloves outside of the laboratory
- Don't touch your face, mouth, or eyes while wearing gloves
- Don't reuse disposable gloves
- Don't assume gloves offer complete protection. Gloves can fail, so follow other safety protocols and use additional protective equipment as needed
- Don't dispose of gloves in regular trash

Minimizing Risk

Minimizing Risk

Laboratory Environment

Before working in the laboratory, take note of your surroundings. Locate the exits, eyewash fountains, safety showers, first aid kits, and fire extinguishers; practice walking to them.

This is part of the P of RAMP: Prepare for emergencies.

Minimizing Risk

Visitors in the Laboratory

All laboratory visitors, no matter how brief their visit, should wear eye protection.

Visitors, such as friends and relatives, may not be aware of the hazards and may inadvertently commit unsafe acts.

Obtain your laboratory supervisor's approval before bringing visitors into the laboratory.

Minimizing Risk

Housekeeping

When Is "Messy" the Same as "Not Safe"?

- In the laboratory and elsewhere, keeping things clean and neat generally leads to a safer environment.
- Keep aisles and access to safety equipment free of obstructions such as chairs, boxes, open drawers, backpacks, and waste receptacles.
- Avoid slipping hazards by keeping the floor clear of spilled liquids, ice, stoppers, glass beads or rods, and other such small items.
- Keep workspaces and storage areas clear of broken glassware, leftover chemicals, and dirty glassware.

Minimizing Risk

Housekeeping

When Is “Messy” the Same as “Not Safe”?

- ❖ **Inform your supervisor immediately if chemicals are spilled.**
- ❖ **Follow your laboratory’s required procedure for the disposal of chemical wastes and unused chemicals.**
- ❖ **Wipe your bench area before leaving the laboratory, so that others will not inadvertently touch chemical residue.**
- ❖ **Never leave chemicals on balances, because this may unnecessarily expose the next user to the chemical; in addition, electronic balances are expensive and can easily be damaged by corrosive chemicals.**
- ❖ **Broken glassware should always be disposed of in a broken glass disposal container and NEVER in an ordinary trash can.**

Minimizing Risk

Poor Housekeeping is a Safety Issue

Messy Lab Bench. The bench is so cluttered as to make it unusable in its present state. Bottles might be bumped off the edge. Where would you be able to work?

Minimizing Risk

Poor Housekeeping is a Safety Issue

Cluttered Lab Sink. This sink is so cluttered with glassware that just trying to move something might result in breakage, and broken glass under water is hard to see. There might be odors coming from the sink. Obviously, the sink cannot be easily used without removing what is already in the sink.

Minimizing Risk

Poor Housekeeping is a Safety Issue

Cluttered Lab Hood. Lab hoods are well-known sources of clutter. Unused flasks, bottle beakers, and other lab ware are often left behind from previous experiments so that the user has to move things about to make room for his/her new work. What will you do if you were in a hurry and did not want to take time to clean this up?

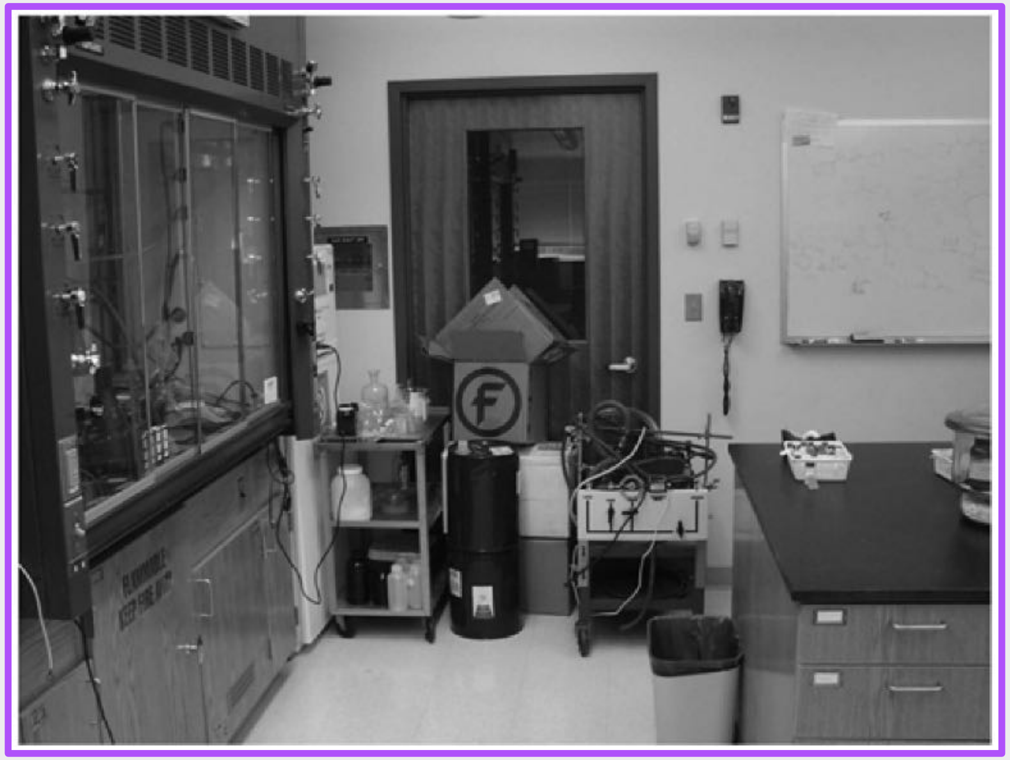
Minimizing Risk

Poor Housekeeping is a Safety Issue

Cluttered Laboratory. Clearly, there are many bottles, vials, and containers at the edge waiting to be easily bumped onto the floor.

Minimizing Risk

Poor Housekeeping is a Safety Issue



Blocked Laboratory Exit. How rapidly could you exit through this door in an emergency? In the daily routine of working in a lab it is easy to move something to a space that is not being used. Make sure that you don't block exits and that you have a clear access for emergencies.

Minimizing Risk

Poor Housekeeping is a Safety Issue

Cluttered Laboratory.
The carts blocking the safety eyewash and safety shower

Minimizing Risk

First, and most importantly, you are responsible for your own safety in any lab.

If the behavior of supervisors (or professors) and coworkers (other students) creates a hazardous lab situation, that is something that needs to be addressed.

Minimizing Risk

Chemical Waste Management

Think of labeling hazardous waste as a normal and necessary part of your responsibility when working in the laboratory. Just do it!

Perhaps the most important aspect of handling hazardous waste is the possibility of incompatibility of wastes that might be thoughtlessly mixed in a container as "waste".

Minimizing Risk

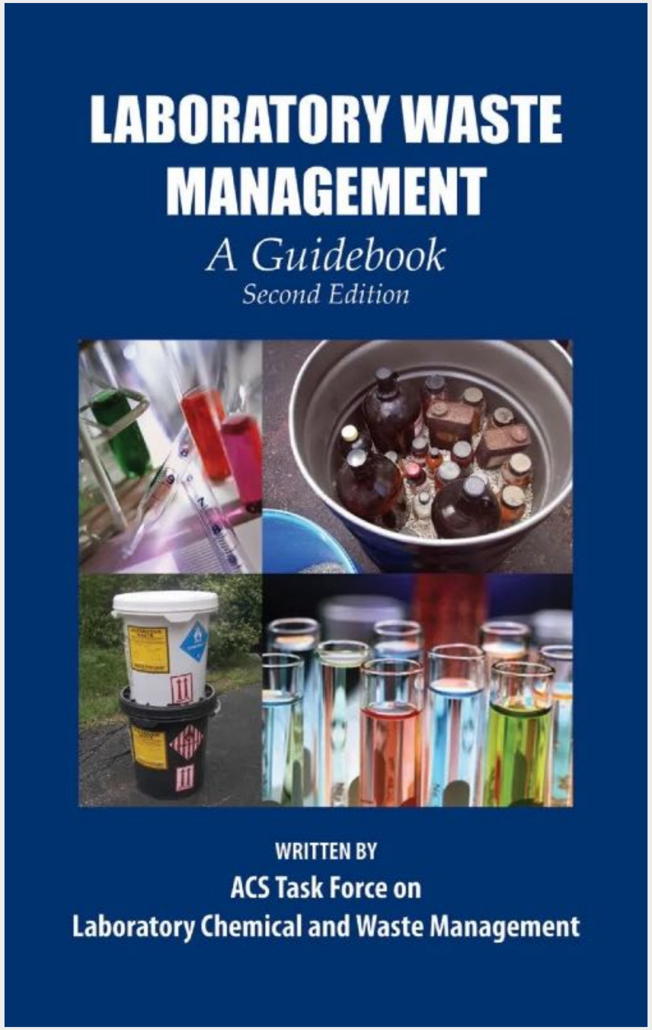
Chemical Waste Management

An Incident: The stinking Building

An analytical chemist working on the third floor of a laboratory building was using ethanedithiol in a reaction and had completed his work. He decided that he would pour the waste down the sink, which was connected to all of the other laboratory sinks. The stinking odor from the ethanedithiol smelled like the mercaptan odorant added to natural gas. The occupants of the building thought there was a gas leak and the evacuation notice was given for the entire building. The fire and police departments arrived, while the many building occupants huddled outside. Soon thereafter the local news media arrived. After investigation the source of the odor was discovered. The news media reported the inappropriate disposal of a hazardous chemical.

Minimizing Risk

Chemical Waste Management



Minimizing Risk

Chemical Waste Management

- Don't order more of a chemical than you need; then you won't have much hazardous waste.
- Substitute less hazardous or nonhazardous chemicals for hazardous ones.
- Use small (mini- or micro-) scale experiments to minimize the chemicals needed.
- Share chemicals with colleagues. Recycle or reuse wherever possible.
- Separate various wastes as much as possible to allow maximum treatment and recovery of chemicals by waste handlers.
- Spread the word about the benefits of waste minimization and other laboratory pollution prevention efforts.
- Consider incorporating, as part of your planned experiments, methods that minimize waste, such as recycling solvents or neutralizing solutions.

Minimizing Risk

Chemical Waste Management

Label for solid waste ***Room number:***

Contact person:

☐ Inorganic salts and other inorganic solids

☐ Inorganic solid base ☐ Organic solids

☐ Organic solid acids ☐ Organic solid bases

☐ contains halogen ☐ contains Cd

☐ contains Hg ☐ contains other heavy metals

Label for liquid waste ***Room number:***

Contact person:

☐ Organic solvent without halogen ☐ Organic solvent with halogen

☐ Organic waste ☐ Organic alkaline waste

☐ Organic acidic waste

☐ Inorganic acid ☐ Inorganic base

☐ Oil (PBC-free) ☐ Oil (containing PBC)

☐ contains halogen ☐ contains isocyanates

☐ heavy metals (not Cd or Hg) ☐ Cd

☐ Hg ☐ aqueous, pH-value:_____

☐ water content > 10%

Minimizing Risk

Chemicals: Gas Cylinders

- **Can have > 100 atm of pressure! If the regulator is snapped off, the cylinder can become a rocket.* A protective cap is required for storage or transport.**
- **Gas cylinders need to be secured in the lab with a strap or chain.**
- **Cylinders must be transported using a cart and must be secured with a strap or chain.**

Preparing for Emergencies

Remember RAMP

Preparing for Emergencies

Life safety considerations should always override the protection of property.

- ❖ **Eyewash station**
- ❖ **Safety showers**
- ❖ **Fire extinguishers**
- ❖ **First aid kit**

Preparing for Emergencies

Fire Prevention

- ❖ Are you working with any source of heat, flame, or spark?
- ❖ Are you working with flammable liquids or vapors?
- ❖ Are there any damaged wires on the electrical equipment?
- ❖ Are bottles or glassware (containing flammable solvents) too close to the edge of the laboratory bench?
- ❖ Is the workspace cluttered?

Prepare to Respond to a Fire

Preparing for Emergencies

Chemical Contamination on Skin, Clothing, and Eyes

Preventing Chemical Contact

Prepare to Respond to Chemical Contact

Preparing for Emergencies

Chemical Spills

Unintentional and uncontrolled release of a chemical/hazardous material into the environment

Preventing Chemical Spills

Prepare to Respond to a Chemical Spill

Preparing for Emergencies

Chemical Transport

- **Transport of <u>any</u> hazardous materials outside of your lab requires secondary containment, which can be either a specialized container or a sturdy plastic pail. Would you want to be on the elevator when someone dropped a bottle of solvent?**

<u>Our rules</u>: Chemical containers must be securely closed and carried within secondary container (unless they are still sealed in shipping container/box)

Preparing for Emergencies

Chemical Transport

Plastic Safety Small Bottle Carriers

Preparing for Emergencies

Preventing Chemical Spills

- ❖ **Awareness**
- ❖ **Good housekeeping**
- ❖ **Transporting or moving chemicals**
- ❖ **Transferring or pouring chemicals**
- ❖ **Preventing equipment failure**
- ❖ **Preventing adverse chemical reactions or explosions**

Preparing for Emergenciesc

Chemical Spills

Two main categories of chemical spills:

- **Major spills**
- **Minor spills**

In academic labs, it is very likely that identifying what was spilled will be fairly easy.

- DO NOT remain in area of spill unless you are ABSOLUTELY SURE you are not in danger.
- If you can safely remain near the spill, use chairs/tables/trash cans to block off area.

Preparing for Emergenciesc

Chemical Spills: "Should I stay or should I go?"

- If a spill is large or dangerous, **get away!**

- You may attempt to deal with chemical spills if:
  - You are not in danger, you are not alone and you have a safe path of retreat.
  - You have appropriate personal protective equipment and a spill kit.

Preparing for Emergenciesc

Chemical spills: what should you do?

- **For any spill, alert others and close off the area;**
  - **Use chairs/stools to close off part of a corridor.**

Preparing for Emergencies

Chemical Spills

- If a spill occurs
  - Do not panic
  - Determine the identity of the spilled substance
  - Refer to the Material Safety Data Sheet (MSDS)
  - Assess the situation
  - Cordon off the area
  - Determine the severity of the spill
    - Major vs. minor

Preparing for Emergencies

Chemical Spills

- **Acids**
  - **Confine, neutralize (bicarbonate), clean up, dispose (call EHS).**
- **Flammable solvent**
  - **Eliminate ignition sources, confine, absorb, clean up, dispose (call EHS).**
- **Mercury**
  - **Consolidate, collect, dispose of, wash yourself.**
  - **Always call supervisor for consult**
- **Solids**
  - **Scoop, place in container for disposal by EHS.**

Preparing for Emergencies

Chemical Spills

- Adsorbent materials
  - Utilized to clean the spill
- Personal Protective Equipment (PPE)
  - Safety glasses
  - Laboratory gloves

R.A.M.P.
-BEFORE- WORKING IN THE LAB!
NOT SURE?? ASK YOUR TEACHER!
1. RECOGNIZE: THE HAZARDS!
CAUTION HOT SURFACES DO NOT TOUCH
HAZARD
CAUTION
Electrical Hazard
2. ASSESS: RISKS FROM THE HAZARDS!
DO
DON'T
3. MINIMIZE: RISKS FROM THE HAZARDS!
CAUTION: HOT SURFACE!
4. PREPARE: FOR EMERGENCIES!
EMERGENCY ← EXIT
EMERGENCY SHOWER
EYE WASH
FIRST AID
BAKING POWDER

Think Safe. Act Safe. Be Safe.