Chemical Safety

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Some definitions

- Hazard:
  - The potential to cause harm
- Risk:
  - The likelihood (probability) of harm actually
  - Occurring and the severity of its consequences
- Safety is basically concerned with controlling the risks

Risk assessment

- Identify the hazard
  - The potential to cause harm
  - Intrinsic properties of the organism/material
  - The way in which organism/material will be used in laboratory
- Adopt effective measures to control risk
  - Reduce likelihood (probability) of harm actually
  - Occurring and the severity of its consequences

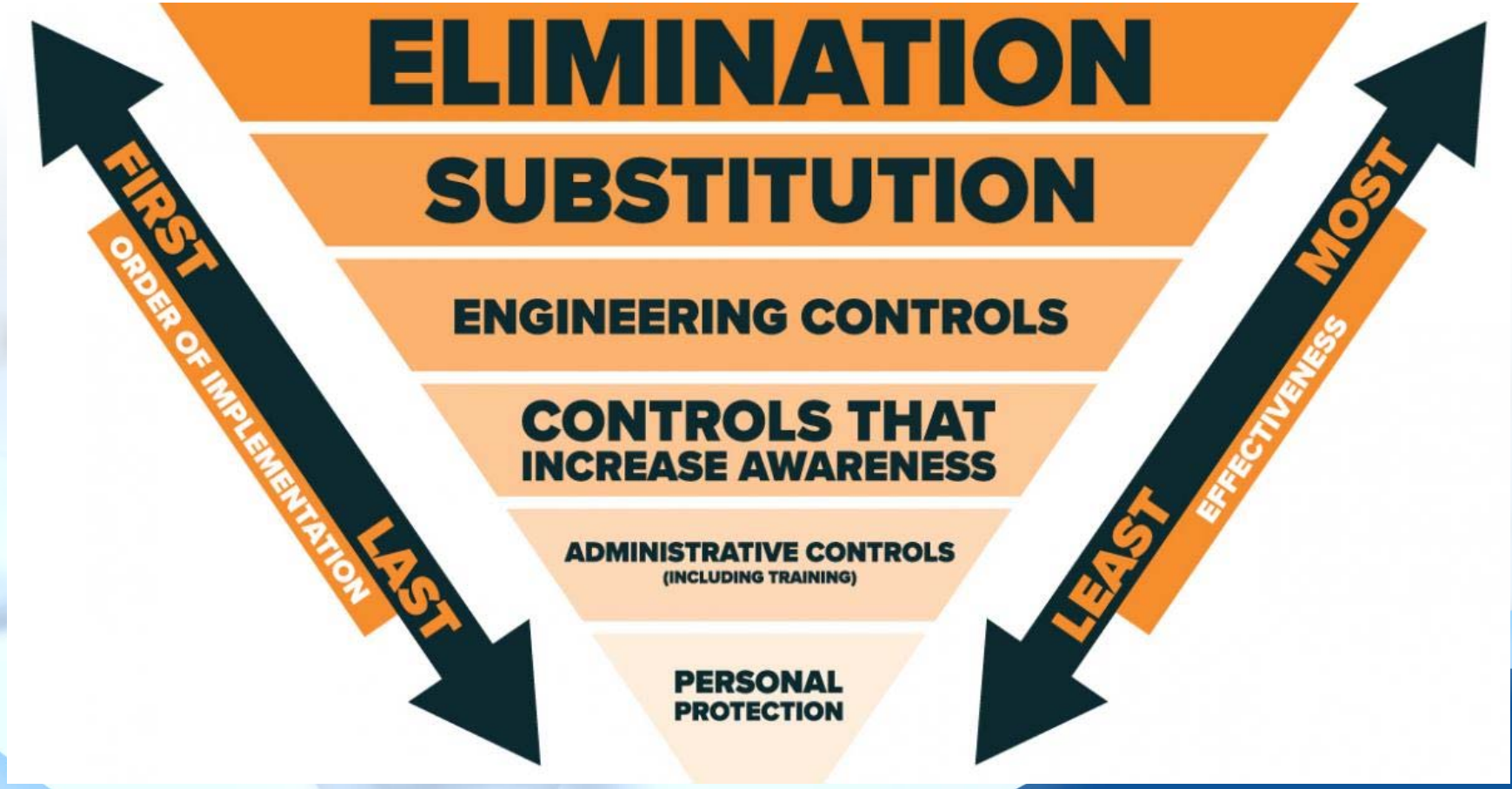
Risk assessment in a laboratory setting

- Identify the hazard
  - Slips, Trips, Falls
  - Electric shock
  - Mechanical – from machines etc
  - Heat/Cold – autoclaves, freezers, cryogens
  - Pressure (positive and negative) – gas cylinders
  - Musculo-skeletal – manual handling, computer use etc
  - Glassware, sharps/knives, needles
  - Chemicals – fire, burns, toxicity, carcinogenicity
  - Biological agents – infection
  - Radiation, LASERs
  - Noise e.g. from machinery

Risk assessment in a laboratory setting

- Assess the risk:
  - Varies between laboratories
- Apply the controls:
  - Basic rules, COPs, SOPs, guarding, PPE etc.
  - Laboratory practices and techniques
  - Safety equipment including PPE (primary barriers)
  - Laboratory facilities (secondary barriers)

Minimize exposure to chemicals – Hierarchy of control



Hierarchy of control – Engineering

Fume cupboard

Local exhaust

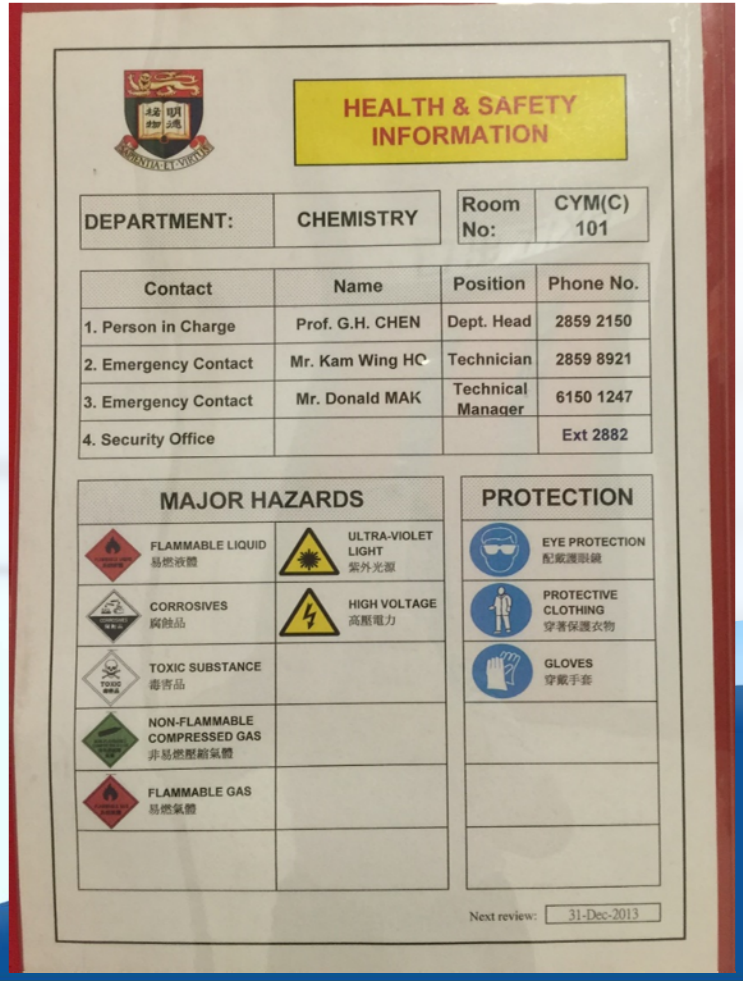
Glove box

Emergency ventilation

Hierarchy of control – Administrative

Warning notice

Health and safety information sheet



HEALTH & SAFETY INFORMATION

DEPARTMENT:	CHEMISTRY	Room No:	CYM(C) 101

Contact	Name	Position	Phone No.
1. Person in Charge	Prof. G.H. CHEN	Dept. Head	2859 2150
2. Emergency Contact	Mr. Kam Wing HC	Technician	2859 8921
3. Emergency Contact	Mr. Donald MAK	Technical Manager	6150 1247
4. Security Office			Ext 2882

MAJOR HAZARDS

- FLAMMABLE LIQUID 易燃液體
- ULTRA-VIOLET LIGHT 紫外光源
- CORROSIVES 腐蝕品
- HIGH VOLTAGE 高壓電力
- TOXIC SUBSTANCE 毒害品
- NON-FLAMMABLE COMPRESSED GAS 非易燃壓縮氣體
- FLAMMABLE GAS 易燃氣體

PROTECTION

- EYE PROTECTION 配戴護眼鏡
- PROTECTIVE CLOTHING 穿著保護衣物
- GLOVES 穿戴手套

Next review: 31-Dec-2013

Hierarchy of control – Personal Protective Equipment

Why is PPE not favored?

- Only protects the person using it, all other controls protect others in lab as well
- To be effective must be fitted and used correctly – training and competence
- False sense of security, particularly if hazardous material can be inhaled eg.
  - Correctly used powered air purifying respirator (PAPR) provides 40 fold reduction in concentration of inhaled hazard
  - Correctly used fume cupboard or biological safety cabinet provides 100000 fold reduction in concentration of inhaled hazard

Basic laboratory safety rules

- Observe the warning signs and symbols
- Learn about the Dos and Don'ts
- Assess risks before starting work
- Know the location of and how to use the emergency equipment
- Know the types of personal protective equipment available and use them e.g. labcoats, gloves, goggles and respirators
- Always be alert to unsafe conditions and actions and call them to the attention of your supervisor. Safety is the responsibility of everyone – don't expect someone else to sort it out
- Use equipment only for its designed purpose

General laboratory safety

- Long hair, loose clothing and jewellery should be confined
- NO food and/or drink should be kept or consumed in laboratories except for experimental purposes
- Do not apply make-up
- No sandals, flip flops or open-toed shoes

General laboratory safety

- Keep work areas clean and tidy
- Keep clear of all exits and passages
- Handle broken glass and chemical spillage immediately
- Hands and forearms should be washed thoroughly with soap or disinfectants before leaving the laboratory
- Apply good housekeeping practice

General laboratory safety

- Poor housekeeping will lead to:
  - Hinder escape route
  - Chemical contamination
  - Cuts
  - Slipping
  - Tripping
  - Falling

What is chemical?

- Chemical substance is a form of matter that has constant chemical composition and characteristic properties
- It cannot be separated into components by physical separation method
- It can be solid, liquid, or gas
- Daily examples: water, table salt, gold, diamond
- Laboratory examples: Ethanol, hydrochloric acid, liquid nitrogen, etc…

Some incidents

- A 23-year-old Pomona College graduate was using a plastic syringe to extract from a sealed container a small quantity of t-butyl lithium -- a chemical compound that ignites instantly when exposed to air.
- As she withdrew the liquid, the syringe came apart in her hands, spewing flaming chemicals, according to a UCLA accident report. A flash fire set her clothing ablaze and spread second and third-degree burns over 43% of her body.
- Eighteen excruciating days later, Sangji died

Researcher Dies After Lab Fire

Email | Print

UCLA research assistant burned in incident with *tert*-butyl lithium

By ***Jyllian Kemsley***

Sangji
Credit: Courtesy of Daniel O'Leary

A research assistant in the **University of California, Los Angeles**, department of chemistry and biochemistry died on Jan. 16 from injuries sustained in a laboratory fire that occurred in December, the university has confirmed.

UCLA officials declined to provide C&EN with specific details of the incident, pending an investigation. But according to a Dec. 30, 2008, e-mail to C&EN from department chair **Albert J. Courey**, university investigators believe that on Dec. 29, Sheharbano Sangji, 23, was drawing *tert*-butyl lithium (t-BuLi) from a bottle into a syringe when the plunger came out of the syringe barrel. The chemical, which ignites spontaneously in air, splashed onto Sangji's clothes and set them on fire. Sangji was burned on her hands, arms, and upper torso, for a total of 40% of her body. After initial treatment at **Ronald Reagan UCLA Medical Center**, she was transferred to the **Grossman Burn Center** in Sherman Oaks, Calif., where she died.

An unconfirmed description of the accident was posted on Jan. 7 to the **ACS Division of Chemical Health & Safety** e-mail list by Debbie M. Decker, a member of the division and a UC

Some incidents

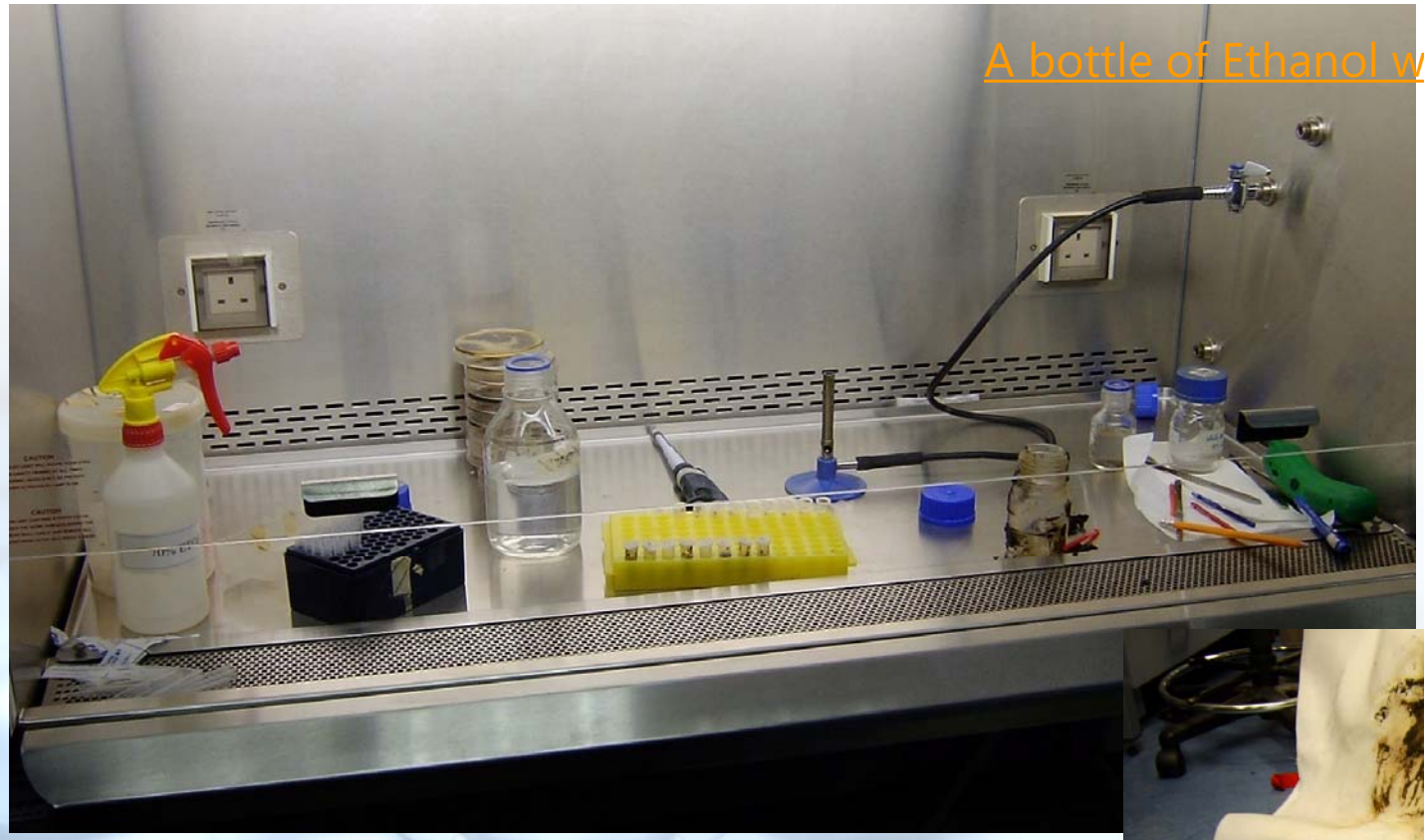
Some incidents

Some incidents

Some incidents

Some incidents

A bottle of Ethanol was knocked over ---



Handling of chemicals

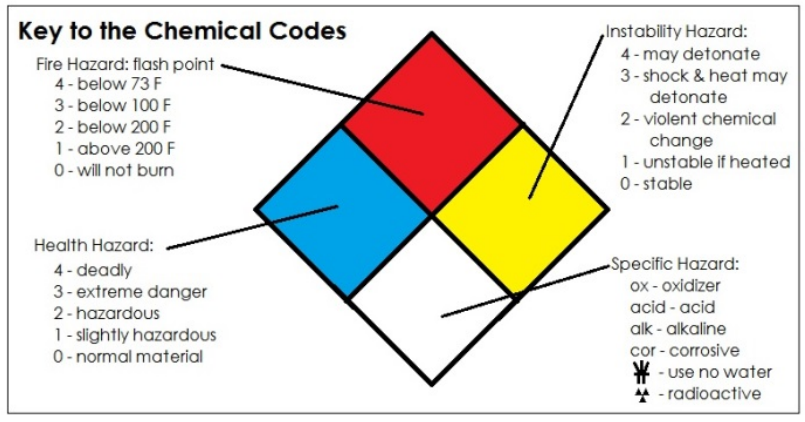
- Chemical Handling – Labelling System

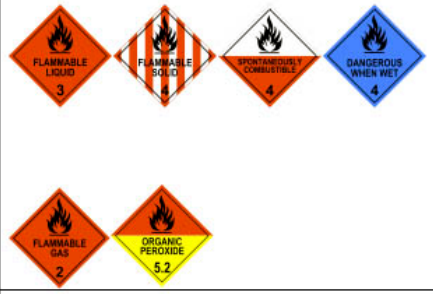
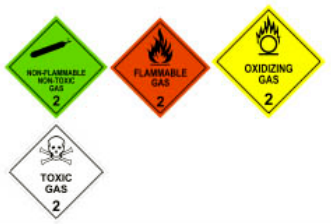
Handling of chemicals

- Chemicals should be properly labelled and stored
- Information of labels should include at least:
  - Name of Chemical
  - Hazard Symbol
  - Date of Opening / Preparation
- Report to your supervisor if chemicals remain after completion of research project

Handling of chemicals

Chemical Handling – Hazard labels



Hazard Pictograms	GHS Hazard	Dangerous Goods class labels (pictograms)	Dangerous goods classes
	Explosives Self-reactives Organic peroxides		Explosive
	Flammables Self-reactives Pyrophorics Self-heating Emits flammable gas in contact with water Organic peroxides		• Flammability (Liquid, Solid or Gas) • Pyrophoric, • Emits Flammable Gas • Organic Peroxide
	Oxidisers		• Oxidiser • Oxidising gas
	Gases under pressure		Non-toxic non-flammable gas, flammable gas, oxidising gas, toxic gas
	Acute toxicity		• Acute toxicity • Acute Toxic gas

Handling of chemicals

- Hazard warning labels – limited information on chemicals
- More detailed document – Materials Safety Data Sheet (MSDS)
- Source of MSDS: Chemical supplier on delivery, website of chemical suppliers

Storage of chemicals

- Disposal is also considered as storage – storage in waste drums
- Chemicals should be stored only at designated cabinets – not bench tops, fume cupboards, etc…
- Check for compatibility before putting/disposing chemicals together

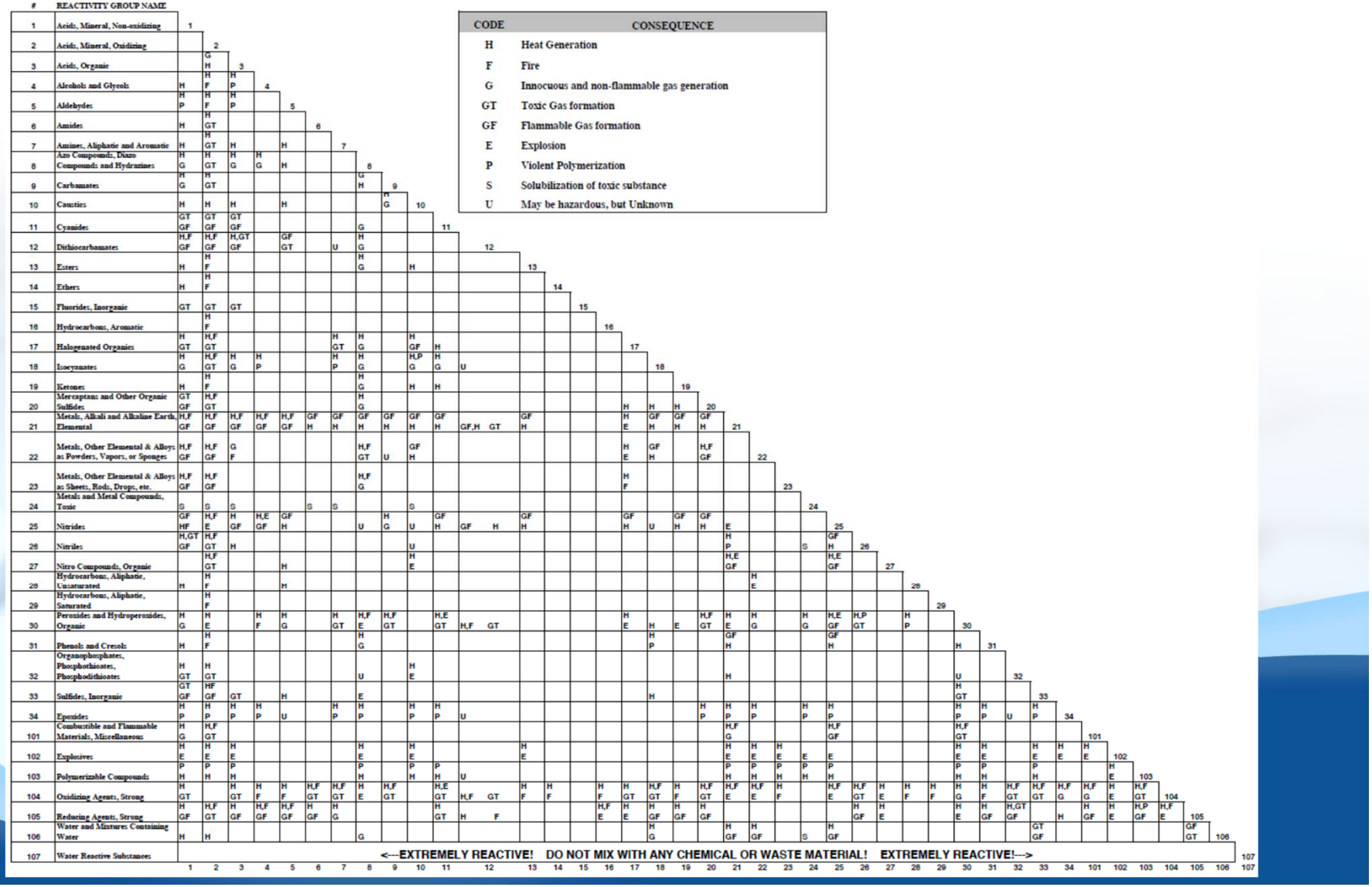
Compatibility chart - Simplified

Incompatibilities by Hazard Class

	Acids, Inorganic	Acids, Oxidizing	Acids, Organic	Alkalis (Bases)	Oxidizers	Poisons, Inorganic	Poisons, Organic	Water-Reactives	Organic Solvents
Acids, inorganic			X	X		X	X	X	X
Acids, oxidizing			X	X		X	X	X	X
Acids, organic	X	X		X	X	X	X	X	
Alkalis (bases)	X	X	X				X	X	X
Oxidizers			X				X	X	X
Poisons, inorganic	X	X	X				X	X	X
Poisons, organic	X	X	X	X	X	X			
Water-reactives	X	X	X	X	X	X			
Organic solvents	X	X		X	X	X			

X indicates incompatibility between two chemical product groups. Incompatible products should not be stored in close proximity.

Compatibility chart – US EPA



CODE	CONSEQUENCE
H	Heat Generation
F	Fire
G	Innocuous and non-flammable gas generation
GT	Toxic Gas formation
GF	Flammable Gas formation
E	Explosion
P	Violent Polymerization
S	Solubilization of toxic substance
U	May be hazardous, but Unknown

#	REACTIVITY GROUP NAME
1	Acids, Mineral, Non-oxidizing
2	Acids, Mineral, Oxidizing
3	Acids, Organic
4	Alcohols and Glycols
5	Aldehydes
6	Amides
7	Amines, Aliphatic and Aromatic
8	Azo Compounds, Diazo Compounds and Hydrazines
9	Carbamates
10	Caustics
11	Cyanides
12	Dithiocarbamates
13	Esters
14	Ethers
15	Fluorides, Inorganic
16	Hydrocarbons, Aromatic
17	Halogenated Organics
18	Isocyanates
19	Ketones
20	Mercaptans and Other Organic Sulfides
21	Metals, Alkali and Alkaline Earth, Elemental
22	Metals, Other Elemental & Alloys as Powders, Vapors, or Sponges
23	Metals, Other Elemental & Alloys as Sheets, Rods, Drops, etc.
24	Metals and Metal Compounds, Toxic
25	Nitrides
26	Nitriles
27	Nitro Compounds, Organic
28	Hydrocarbons, Aliphatic, Unsaturated
29	Hydrocarbons, Aliphatic, Saturated
30	Peroxides and Hydroperoxides, Organic
31	Phenols and Cresols
32	Organophosphates, Phosphothioates, Phosphodithioates
33	Sulfides, Inorganic
34	Epoxides
101	Combustible and Flammable Materials, Miscellaneous
102	Explosives
103	Polymerizable Compounds
104	Oxidizing Agents, Strong
105	Reducing Agents, Strong
106	Water and Mixtures Containing Water
107	Water Reactive Substances

Compatibility check

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#	REACTIVITY GROUP NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	101	102	103	104	105	106	107
1	Acids, Mineral, Non-oxidizing																																									
2	Acids, Mineral, Oxidizing			G H																																						
3	Acids, Organic				H F	H P																																				
4	Alcohols and Glycols	H																																								
5	Aldehydes	H P			H F	H P																																				
6	Amides	H			H GT																																					
7	Amines, Aliphatic and Aromatic	H			H GT	H		H																																		
8	Azo Compounds, Diazo Compounds and Hydrazines	H G			H GT	H G	H G	H																																		
9	Carbamates	H G			H GT					G H																																
10	Caustics	H			H	H		H			H G																															
11	Cyanides	GT GF			GT GF	GT GF				G		H																														
12	Dithiocarbamates	H,F GF			H,F GF	H,GT GF		GF GT		H G																																
13	Esters	H			H F					H G		H																														
14	Ethers	H			H F																																				
15	Fluorides, Inorganic	GT			GT	GT																																			
16	Hydrocarbons, Aromatic				H F																																				
17	Halogenated Organics	H GT			H,F GT				H GT	H G		H GF	H																													
18	Isocyanates	H G			H,F GT	H G	H P		H P	H G		H,P G	H G	U																											
19	Ketones	H			H F					H G		H	H																													
20	Mercaptans and Other Organic Sulfides	GT GF			H,F GT					H G										H	H	H	20																		
21	Metals, Alkali and Alkaline Earth, Elemental	H,F GF			H,F GF	H,F GF	H,F GF	H,F GF	GF H	GF H	GF H	GF H	GF H	GF,H	GT	GF H				H E	GF H	GF H	GF H	21																	
22	Metals, Other Elemental & Alloys as Powders, Vapors, or Sponges	H,F GF			H,F GF	G F				H,F GT	U	GF H								H E	GF H		H,F GF		22															
23	Metals, Other Elemental & Alloys as Sheets, Rods, Drops, etc.	H,F GF			H,F GF					H,F G										H F						23														
24	Metals and Metal Compounds, Toxic	S			S	S		S	S			S															24													
25	Nitrides	GF HF			H,F E	H GF	H,E GF	GF H			U	H G	GF U	GF H	GF	H				GF H	U	GF H	GF H	E				25												
26	Nitriles	H,GT GF			H,F GT	H							U											H P			S	GF H	26											
27	Nitro Compounds, Organic				H,F GT			H				H E												H,E GF				H,E GF		27									
28	Hydrocarbons, Aliphatic, Unsaturated	H			H F			H															H E						28									
29	Hydrocarbons, Aliphatic, Saturated				H F																									29									
30	Peroxides and Hydroperoxides, Organic	H G			H E		H F	H G	H GT	H,F E	H,F GT		H,E GT	H,F	GT					H E	H	E	H,F GT	H E	H G	H G		H G	H,E GF	H,P GT		H P		30					
31	Phenols and Cresols	H			H F					H G											H P			GF H				GF H			31							
32	Organophosphates, Phosphothioates, Phosphodithioates	H GT			H GT					U		H E												H								U		32					
33	Sulfides, Inorganic	GT GF			HF GF	GT		H		E										H												H GT			33				
34	Epoxides	H P			H P	H P	H P	U	H P	H P		H P	H P	U								H P	H P	H P	H P		H P	H P				H P	H P	U	H P	34			
101	Combustible and Flammable Materials, Miscellaneous	H G			H,F GT																			H,F G				H,F GF				H,F GT				101			
102	Explosives	H E			H E	H E				H E		H E			H E									H E	H E	E	E					H E	H E	H E	H E	102		
103	Polymerizable Compounds	P H			P H	P H				P H		P H	P H	U										P H	P H	P H	P H	P H				P H	P H	P H			103		
104	Oxidizing Agents, Strong	H GT			GT	H F	H F	H,F GT	H,F GT	H E	H,F GT		H,E GT	H,F	GT	H F	H F		H F	H GT	H,F GT	H F	H,F GT	H,F E	H,F E	H F		H,F E	H,F GT	H,F GT	H,F G	H,F GT	H,F G	H,F G	H E	H,F GT	104		
105	Reducing Agents, Strong	H GF	H,F GT	H GF	H,F GF	H,F GF	H GF	H G				H GT	H	F			H,F E	H E	H GF	H GF	H GF							H GF	H E			H GF	H E	H,P GF	H,F E	105		
106	Water and Mixtures Containing Water	H	H						G										H G			H GF	H GF		S	H GF							GT GF				GF GT	106	
107	Water Reactive Substances	<---EXTREMELY REACTIVE! DO NOT MIX WITH ANY CHEMICAL OR WASTE MATERIAL! EXTREMELY REACTIVE!--->																																						107
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	101	102	103	104	105	106	107

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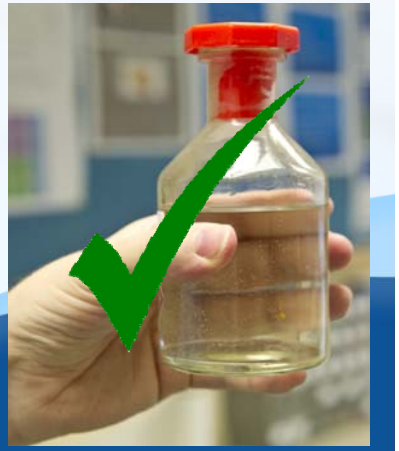
Use of chemicals

- Understand Materials Safety Data Sheet (MSDS)
- Information on MSDS:
  - Chemical identification
  - Hazards identification
  - First-aid measures
  - Fire fighting measures
  - Accidental release measures
  - Handling and storage
  - Physical and chemical properties
  - Exposure control
  - Personal protection
  - Stability and reactivity
  - Toxicological information
  - Disposal information
  - Others

Transfer of chemicals

- Use goods lift as far as possible
- Suitable carrier

- Within laboratory – use both hands, one on the neck and the other at the bottom

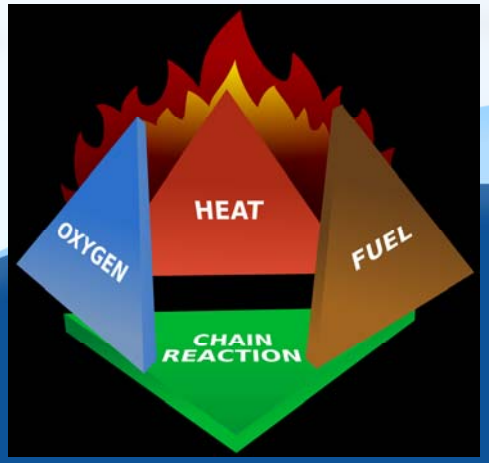


Disposal of chemicals

- Follow the practice of chemical storage
- Proper storage at designated waste containers
- Proper labelling
- Compatibility check
- Record on amount of waste generated

Handling specific chemicals – Flammables

- Solid, liquid, gas
- Flash point (fp)
  - The lowest temperature at which a liquid has sufficient vapour pressure to form ignitable mixture with air.
  - The lower the fp, the higher the flammable risk
  - Examples: Diethyl ether (-45 °C), Ethanol (13 °C)
- Fire triangle/tetrahedron
  - Source of ignition include matches, burner, hotplate, oven, running motor, spark
  - Source of fuel such as solvent
  - Source of oxygen, ie, atmosphere



Handling specific chemicals – Flammables

Solvent	Flash Points (°C)	Boiling Points (°C)
Acetone	-18	56
Acetonitrile	5.6	82
Diethyl ether	-45	34.6
Ethanol	13	78
Ethyl acetate	-4.4	77.1
Hexane	-26	68
Methanol	11	64.7
Tetrahydrofuran	-14	66
Toluene	4.4	110
Xylene	30	138.5

Handling specific chemicals – Flammables

- Work safely with flammables:
  - Ventilation
  - Ignition
  - Containment/Control
  - Exchange
  - Separation

Think **V I C E S**

Handling specific chemicals – Toxics

- Acute vs Chronic
- LD_{50} (Lethal $Dose_{50}$)
  - The individual dose required to kill 50% of a population of test animals
  - The lower the LD_{50} dose, the more toxic is the chemical
- LC_{50} (Lethal $Concentration_{50}$)
  - Through inhalation
- Occupational Exposure Limit (OEL)
  - Concentration of chemical in air can be exposed without adverse effect
- Time-Weighted Average (TWA)
  - Concentration safe for exposure during entire 8-h workday for 5-day working week

Handling specific chemicals – Toxics

Chemicals	LD_{50} (mice, mg/kg)
Sugar	29700
Ethanol	14000
Vinegar	3310
Sodium chloride	3000
Malathion	1200
Aspirin	1000
Caffeine	130
DDT	100
Arsenic	48
Strychine	2
Nicotine	1
Aflatoxin-B	0.009
Dioxin(TCDD)	0.001
Botulinum toxin	0.00001

Handling specific chemicals – Oxidizers

- React vigorously with organic solvents
- Avoid storing with incompatibles such as organic solvents, reducing agents, etc…
- Examples: Nitric acid, perchloric acid, hydrogen peroxide, chlorates, nitrates, dichromates, permanganates

Handling specific chemicals – Cryogens

- Cryogenic liquids are liquefied gases that are kept in their liquid state at very low temperatures, usually below -150°C
- Examples: liquid nitrogen, liquid argon, etc…
- Understand the properties of cryogens
- Hazards: Burns, adhesion, boils and splashes, oxygen deficiency and asphyxiation, etc…
- Use in a good ventilated area
- Wear proper personal protective equipment such as goggle, face shield, cryogloves, laboratory gown, etc…

Handling specific chemicals – Hydrofluoric acid

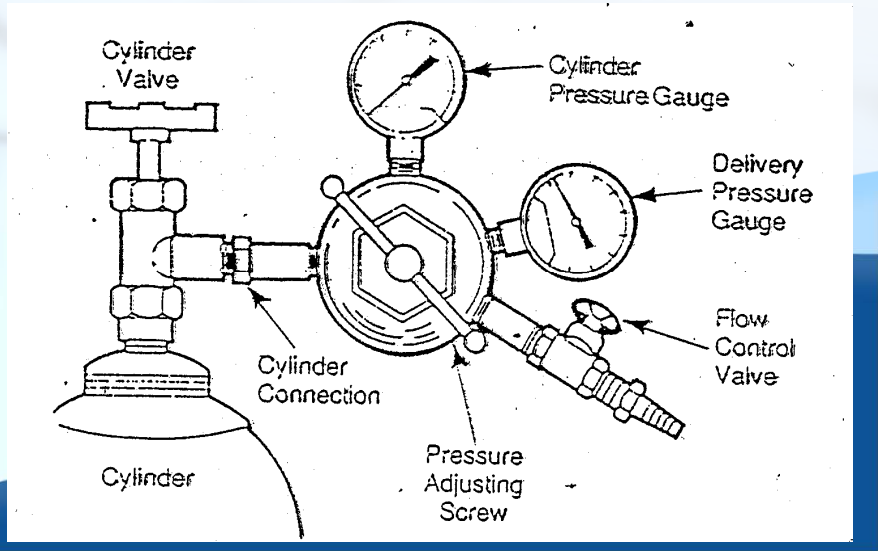
- Choose alternative
- Understand MSDS
- Avoid storing/working/disposing with incompatibles
- Specific training for the operation of hydrofluoric acid should be developed, completed and documented
- Develop standard operating procedures (SOP) for each specific work
- Wear proper personal protective equipment with protection against hydrofluoric acid

Handling specific chemicals – Pyrophorics

- Pyrophoric materials are substances that ignite instantly upon exposure to air, moisture in the air, oxygen or water
- Choose alternative
- Understand MSDS
- Examples: tert-butyllithium, diethylzinc, organoaluminum compounds, palladium catalysts
- Specific training should be developed, completed and documented for the operation of pyrophorics
- Develop SOP for each pyrophoric material
- Wear proper personal protective equipment

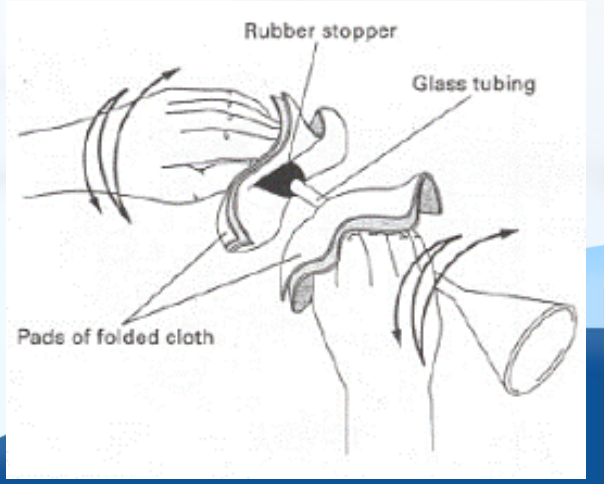
Handling specific chemicals – Compressed gas cylinders

- Know the properties
- Kept fastened on rigid fixture
- Use trolley for transfer
- Use regulator & flow control valve
- Use flashback arrestor for flammable gas
- Periodic leak test & pressure test



Routes of contamination

- Inhalation
- Ingestion
- Absorption/Adsorption
- Injection



Routes of contamination – Protections

- Inhalation – use fume cupboard, local exhaust
- Ingestion – no mouth pipetting, no eating/drinking in laboratory, wash hand after leaving laboratory
- Absorption/Adsorption – use protective clothing such as gloves and laboratory gown
- Injection – take care of sharps and glass

Oops! Spill! What? How?

1. Don't panic
2. Ventilate and evacuate
3. Large/Small spill?
   - Large spill → call for emergency help
   - Small spill → unsafe or not trained → call for help
   - Small spill → safe and trained → control the spill
4. Know the chemicals
5. Wear PPE (suppose you are wearing in the lab)
6. Act quickly
7. Cover/absorb
8. Clean

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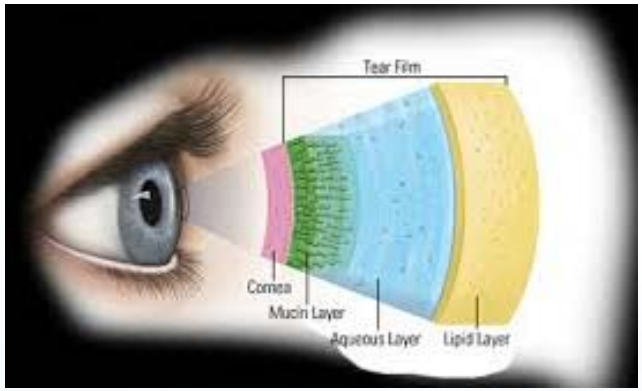
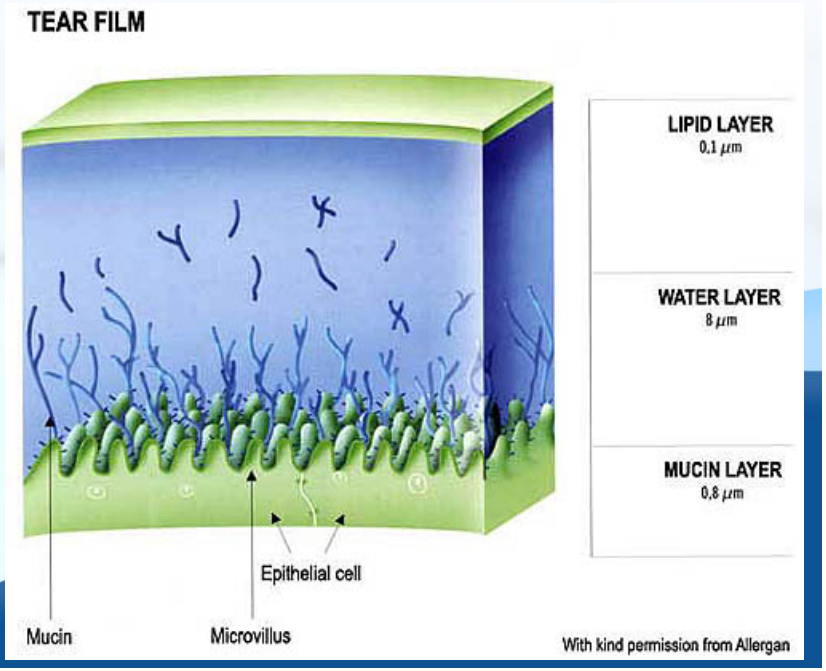
Emergency response – Chemical in eyes

- Wash with copious amount of water for 15 mins
- Keep your eyelid open with fingers
- Consult doctor (bring MSDS)

Emergency response – Chemical in eyes

- Structure of tear film not simple
- Outer lipid layer partial barrier to materials eg. eye wash getting in to tear layer
- Inner mucin layer can act as a "sponge" for chemical or biological contaminants
- Need to irrigate eye Immediately for 15 minutes to be effective
- Better to avoid by wearing suitable eye protection in the first place





Legal requirements

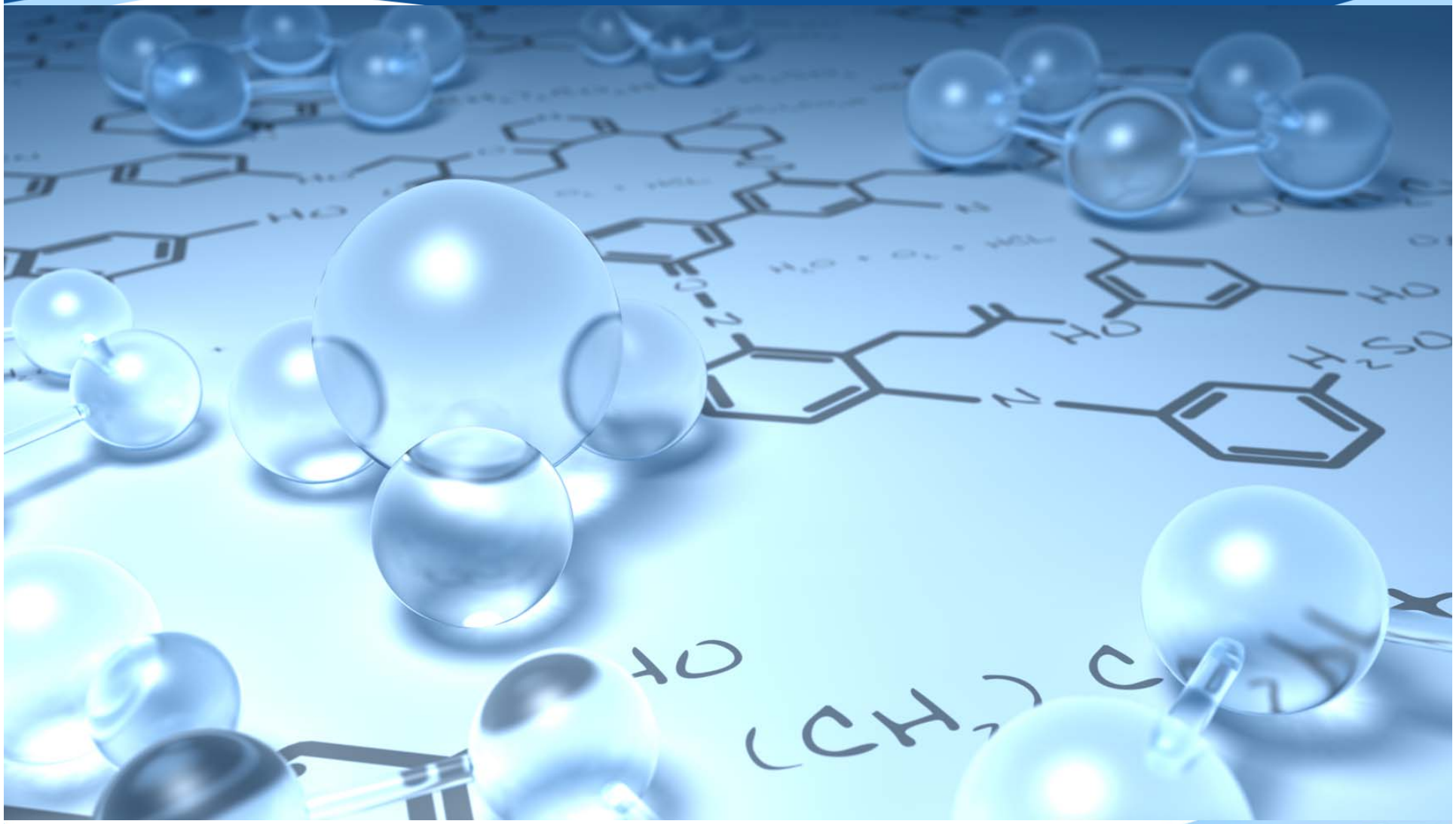
- Dangerous goods ordinance and regulations
- Waste disposal ordinance and regulations
- Control of chemical ordinance and regulations
- Chemical weapons (conventions) ordinance
- Hazardous chemicals control ordinance and regulations

Summary

- Identify hazard of the chemicals
- Minimize the exposure of chemicals using the hierarchy of control
- Employ good house keeping practice
- Utilize safe practice of chemical usage including but not limited to storage, transfer, disposal, etc...
- Understand the response to emergency situations
- Understand the legal requirement on the use of chemicals

Take home message:

Safety will work ONLY when precautions are utilized.



Thank You!

Controlled chemicals under the Control of Chemicals Ordinance

- Schedule 1:
  - Acetic anhydride, Acetyl chloride, Acetyl bromide
- Schedule 2:
  - Ephedrine, Piperidine, Ergotamine, Safrole, Ergometrine, Isosafrole, Pseudoephedrine, Piperonal, Lysergic acid, Anthranilic acid, 1-phenyl-2-propanone, Phenylacetic acid, N-acetylanthranilic acid, 3,4-methylenedioxy-phenyl-2-propanone, Potassium permanganate, Norephedrine
- Schedule 3: Export control to some countries

Chemicals in the Chemical Weapons Convention Ordinance

- Schedule 1:
  - These chemicals pose a high risk to the objective and purpose of the Convention and are considered to be highly dangerous.
  - Examples of such chemicals include Sarin, VX, Mustards, Saxitoxin, Ricin etc.
- Schedule 2:
  - These chemicals pose a significant risk to the objective and purpose of the Convention.
  - Examples of such chemicals include Amiton, PFIB, BZ etc
- Schedule 3:
  - These chemicals pose a risk to the objective and purpose of the Convention.
  - Examples of such chemicals include Triethanolamine, Phosphorus Oxychloride, Thionyl Chloride etc.