



Physical & Chemical Properties

AIM and Objectives

To focus on physical and chemical properties of substances and aims to explain the importance of understanding these properties and their behaviors and their significance in the context of hazardous materials.

Objectives

- Describe relevant chemical and physical properties
- Understand certain relationships between properties
- Understand the available information within SDSs and/or Chemdata
- Identify environmental factors affecting behaviour
 - Such as temperature



Hazards

GHS Symbols



Explosive



Flammable
Pyrophoric



Compressed Gas
Liquefied Gas



Oxidizing



Corrosive
Corrosive to metals



Toxic



Harmful
Irritant
Skin Sensitizer



Environment Hazard



Respiratory Sensitizer
Aspiration Hazard
Reproductive Toxin
Carcinogen
Mutagenic

Transport Symbols



Explosives



Non-Flammable Gas
Non-Toxic Gas



Flammable Gas



Toxic Gas



Flammable Liquid



Dangerous
when wet



Flammable Solid



Spontaneously
Combustible

Transport Symbols



Oxidizer



Organic Peroxide



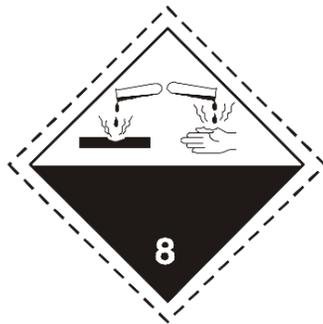
Toxic



Infectious
Substances



Radioactive



Corrosive



Miscellaneous





Physical Properties

States of matter - Solids



- Rigid
- Melting Point (mp)
- Most varied in terms of appearance and form:
 - Flakes, granules, powders etc.
- Initial generic cordon = 25m
- Containment? Mobility? Recovery?



Solubility/Miscibility in Water

Solubility

Will it dissolve
in water?

Mass_(substance) -> Volume_(water)

Sugar = 200g/100ml

Salt = 33g/100ml

Ammonia = 54g/100ml

Chlorine = 0.7g/100ml

States of matter - Liquids

- Melting point (mp)
- Boiling point (bp)
 - Both melting and boiling points can vary substantially, particularly for flammable liquids or heavy oils
- They have viscosity – compare honey & water
 - Relative density (to water)
- Difficult to contain / control
- Most are constantly evaporating (vapour pressure)
- Initial generic Cordon Distance = 50m
 - Consider high evaporation rates



Solubility/Miscibility in Water

Miscibility

Will it mix with water?

Oct/Water (P_{ow})

Water

Ethanol
= -0.32

Hexane
= 3.9

Octanol

-3

+7

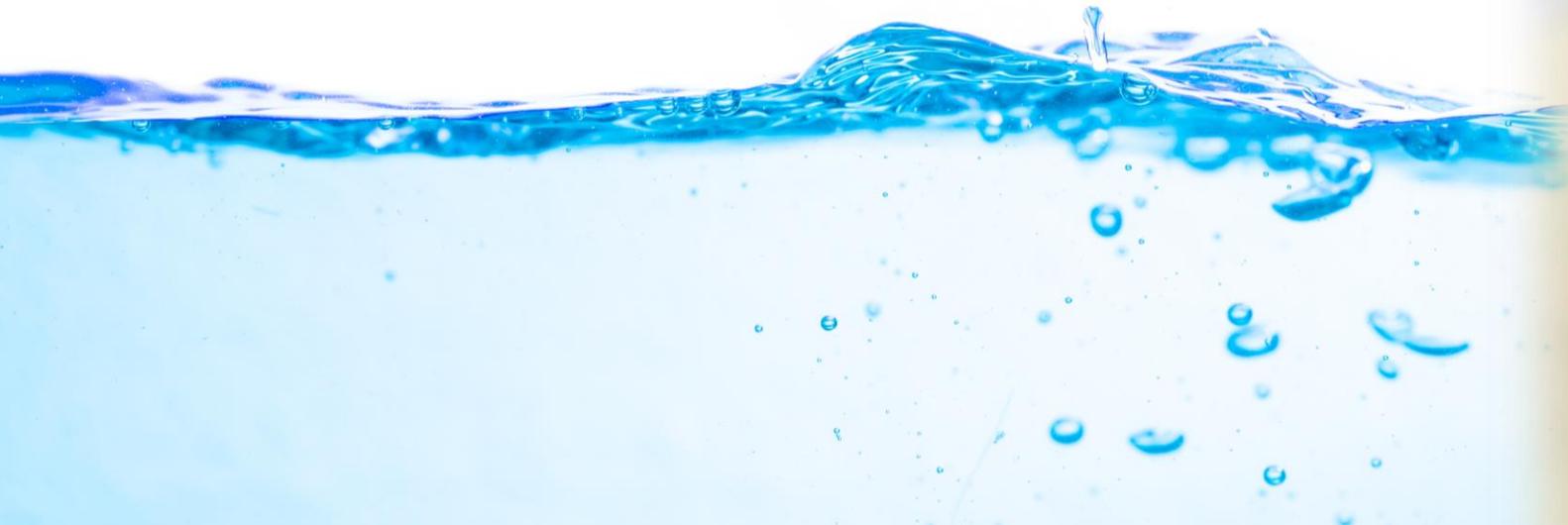
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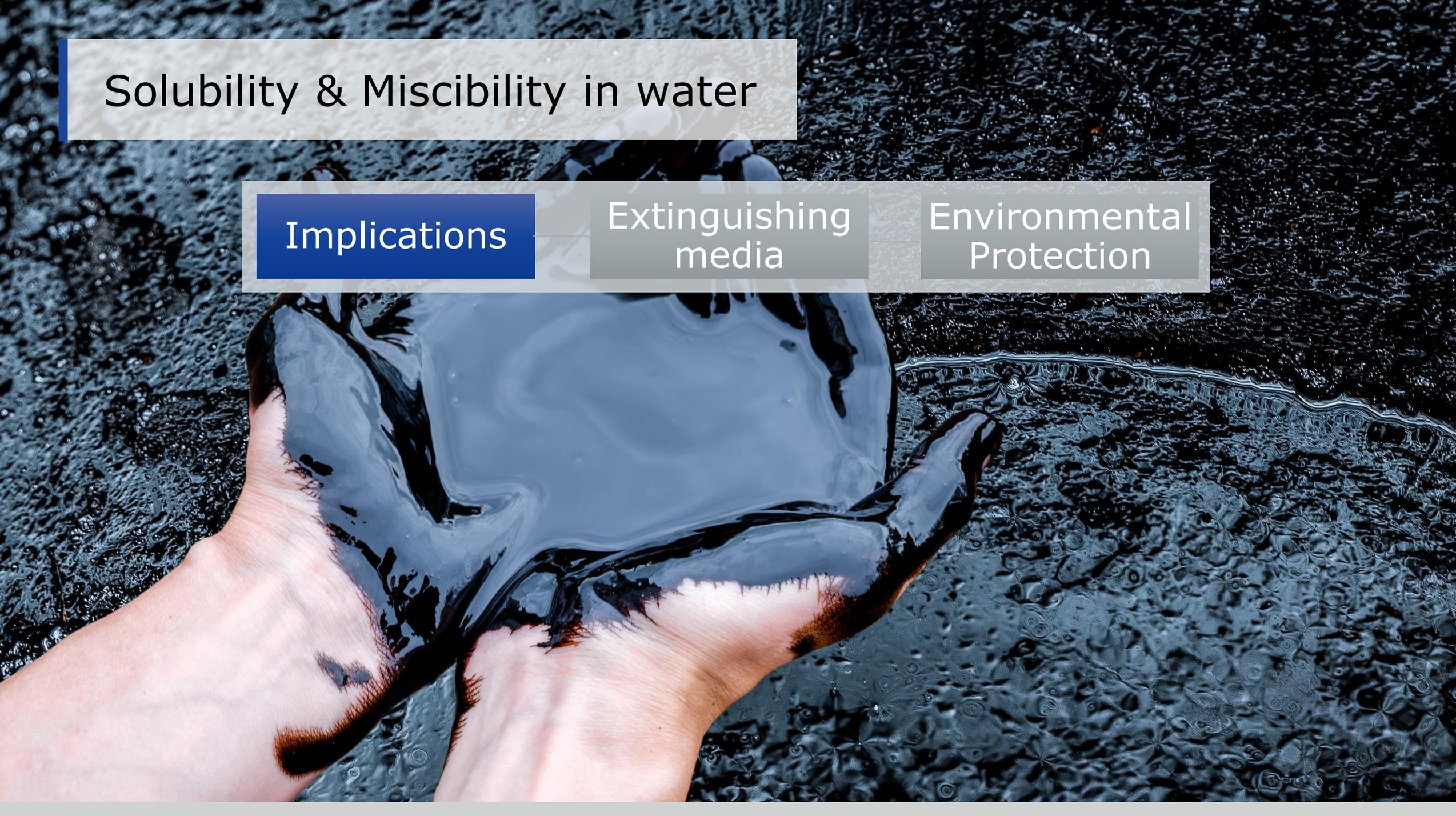
Spill Response

Relative Density

- Compare the density of liquids to water:
 - Less than 1 = lighter than water (it will float)
 - Higher than 1 = heavier than water (it will sink)
- Ethanol:
 - Relative density = 0.8



Solubility & Miscibility in water

A close-up photograph showing a person's hands holding a large, dark, viscous liquid (likely oil) over a surface of water. The liquid is being poured or held in a way that it spreads across the water's surface, creating a thin, dark layer. The water surface is covered in numerous small, concentric ripples, suggesting recent movement or disturbance. The overall scene illustrates the concept of solubility and miscibility in water.

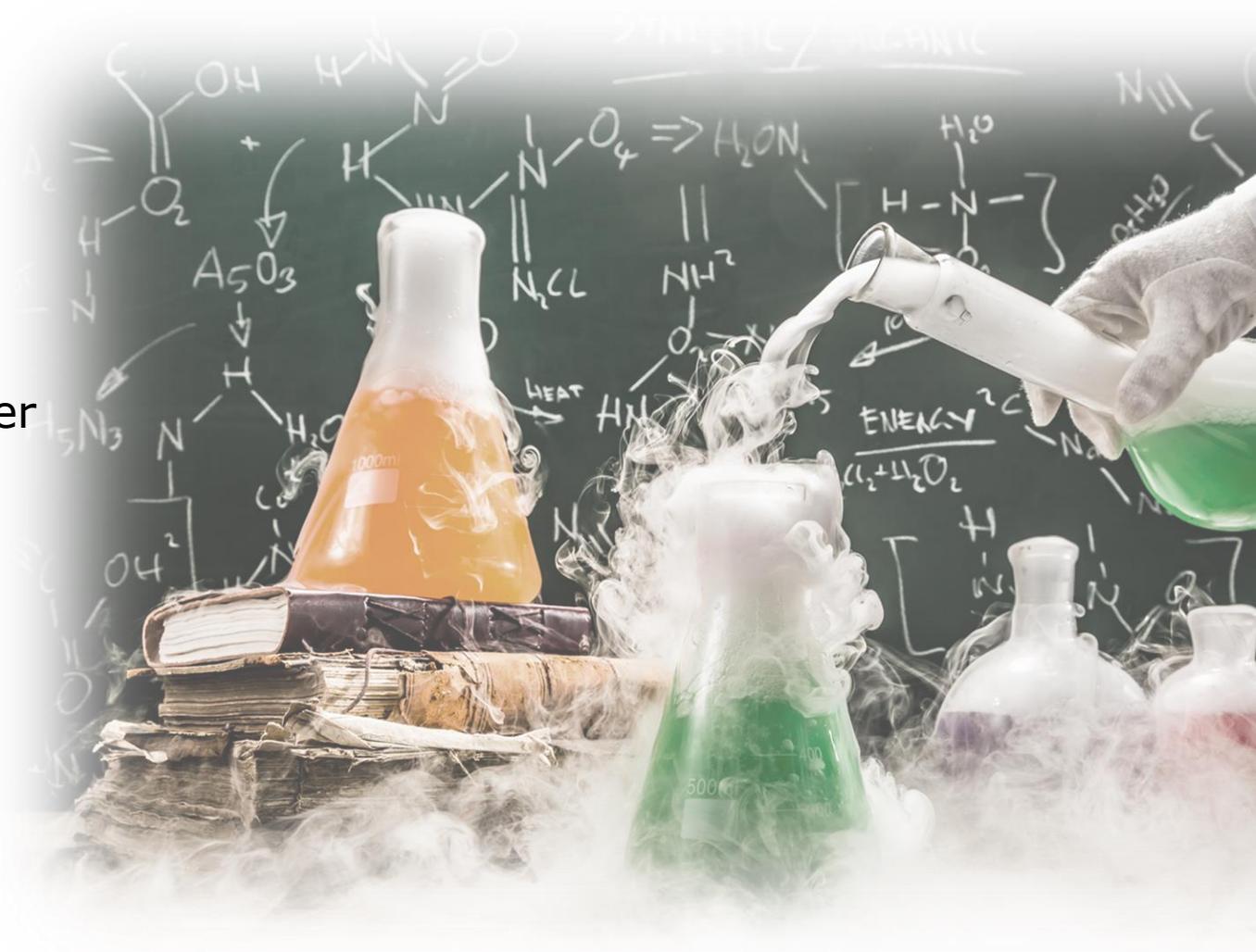
Implications

Extinguishing
media

Environmental
Protection

Vapour Pressure

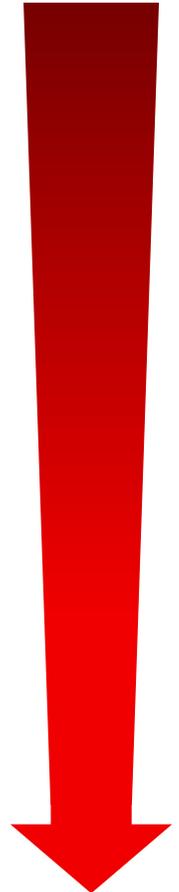
- Measures the tendency for a liquid to evaporate
 - Standard unit - Pascals (Pa)
 - Compare with water = 2.34kPa
 - Substances with higher vapour pressures than water will evaporate faster than water
 - Increases with temperature (turning on a kettle)



Vapour Pressure (measured @ 20°C)

Substance	Vapour Pressure (KPa)	Boiling Point
Diesel	0.95	≈ 300°C
Water	2.34	100°C
Isopropanol (IPA)	4.4	83°C
Ethanol	5.8	79°C
Acetone	24.5	56°C
Diethyl Ether	58.6	35°C

BOILING POINT



States of Matter - Expansion Ratio

Solid

Gas(Vapour)

expansion

expansion

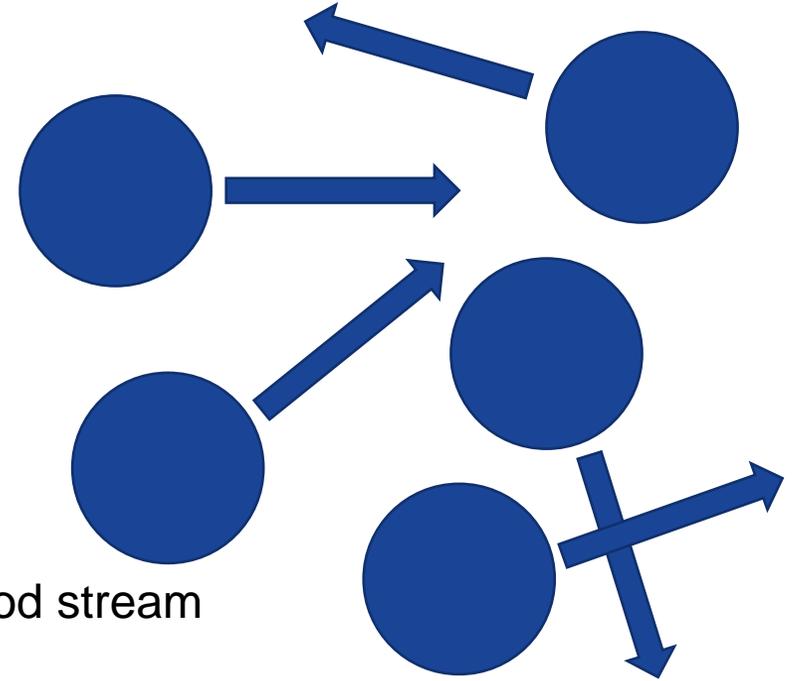
Liquid

Material	Expansion Ratio (liquid to vapour/gas)
Water	1700:1
LPG (Liquefied Petroleum Gas)	270:1
Nitrogen	700:1
Ammonia	850:1

States of matter - Gases

- Dynamic chaos
- Move freely with little interaction
 - Almost impossible to control
- Move at the speed of sound (normal temperature)
- Most affected by temperature
- Boiling Point (bp)
- Relative Vapour Density (to the air)
- Will affect us considerably as inhalation is the quickest path to the blood stream

- Initial generic cordon distance = 100m
 - Consider TIH in the Emergency Response Guidebook



Relative Vapour Density (RVD)

- Compare the density of gases to the air:
 - Less than 1 = lighter than the air (it will rise)
 - Higher than 1 = heavier than the air (it will sink)
- Ethanol:
 - Relative Density = 0.8
 - Relative Vapour Density = 1.6

Interpretation = Ethanol will float on water, but the vapours will be low-lying and collect above the surface of the liquid.

Other properties requiring attention: solubility, vapour pressure, flammability.



States of Matter – Vapours/Gases

Gases

- True gases
- No amount of pressure will cause a liquid to form

Critical Temperature

Vapours

- Not true gases
- Can be compressed back to liquid form

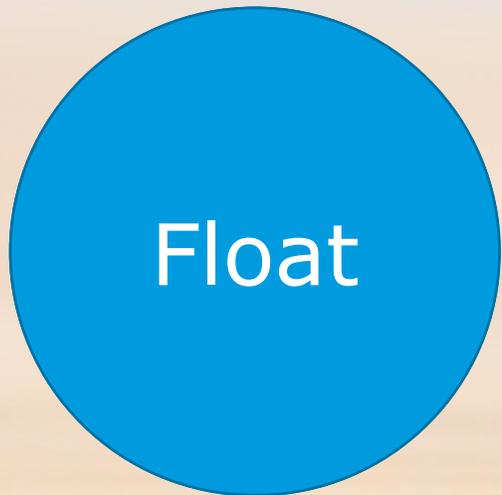
Relative Density/Vapour Density

Heptane:

P_{ow} **4.66**

Relative density (water=1): **0.68**

Relative vapour density (air=1): **3.46**





Chemical Properties

Chemical Properties



Flammability



Reactivity



Corrosivity (pH)



Toxicity

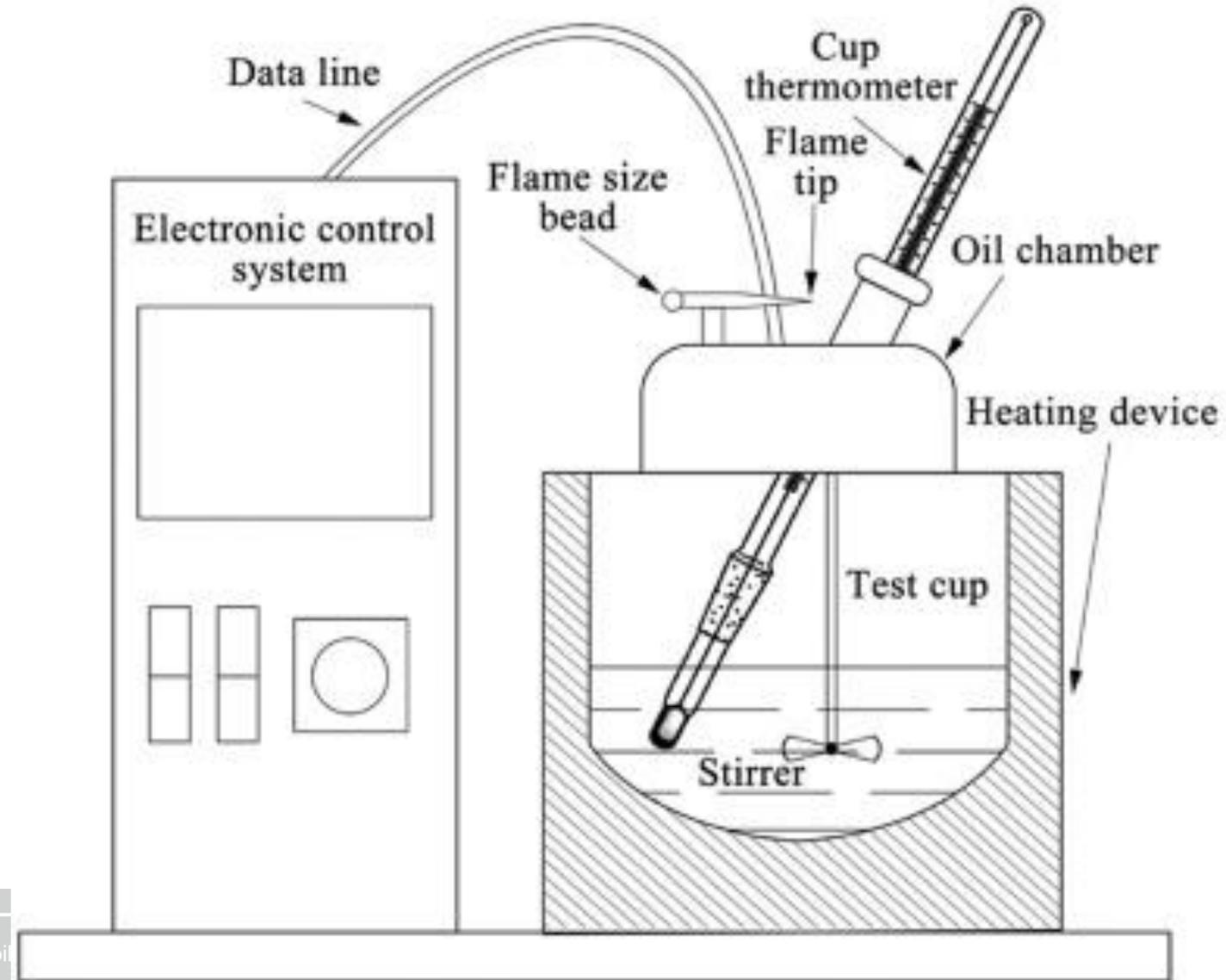
Flash Point

Flash Point

Lowest Temperature

Sufficient Vapour
pressure

Generate vapour in air
concentration (LFL)

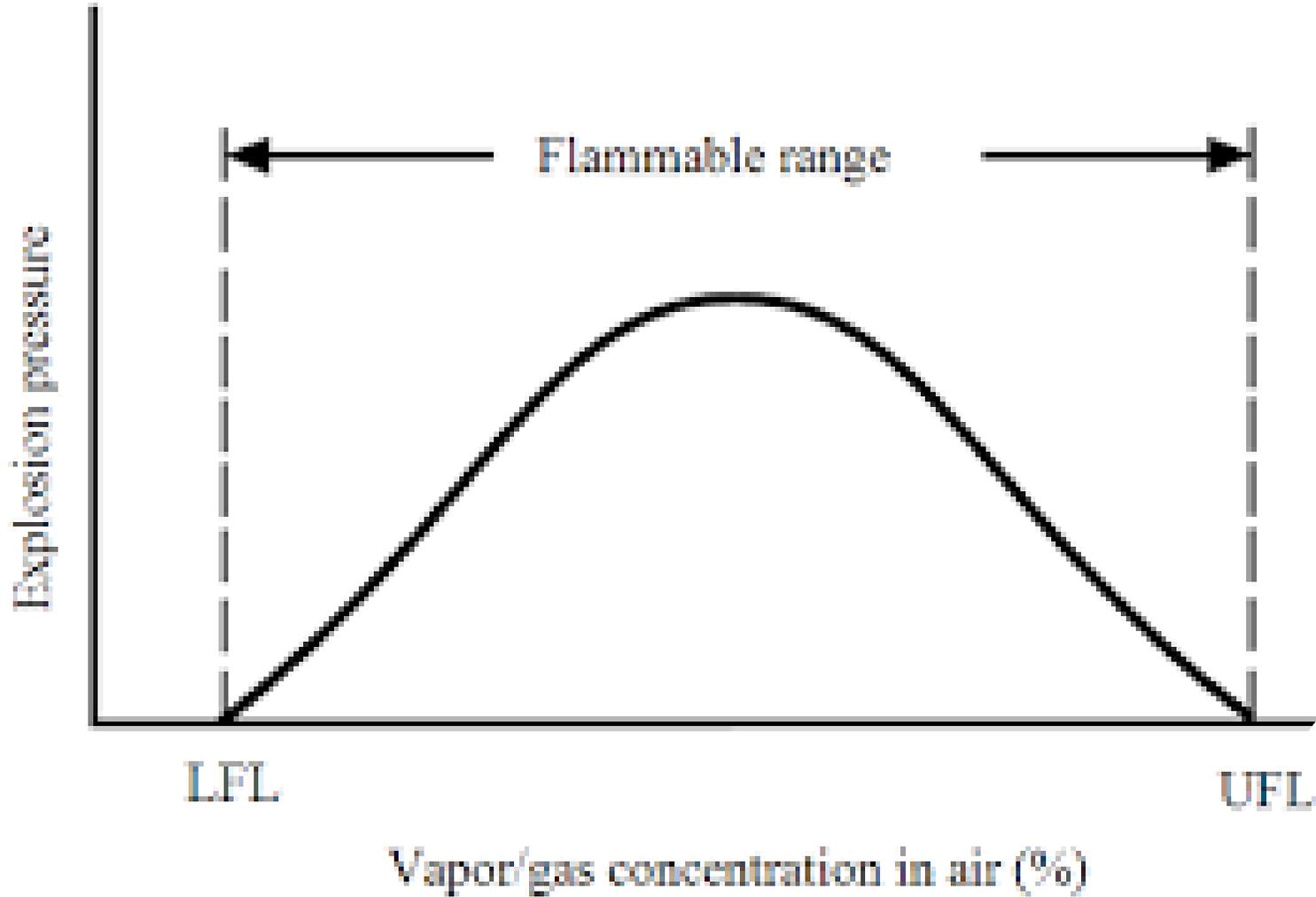


Flash Point examples

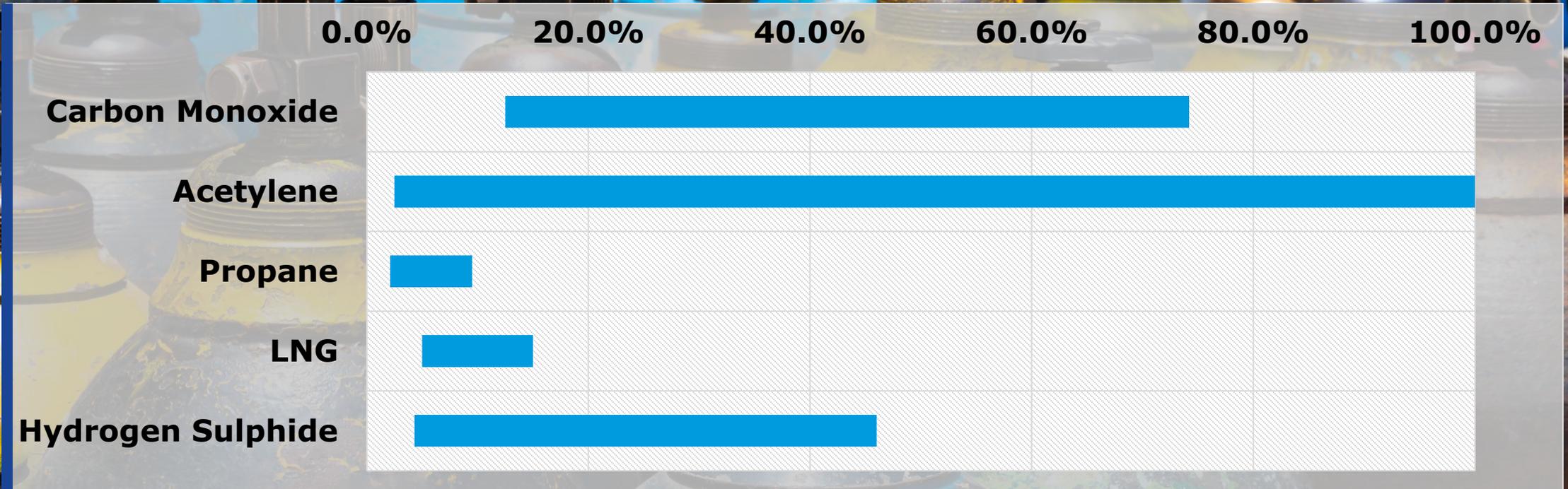


Substance	Flash Point - Closed cup	Flash Point – Open Cup
Heptane	-7°C	-1°C
Octane	13°C	22°C
Acrolein	-26°C	-18°C

Flammable Range



Flammability

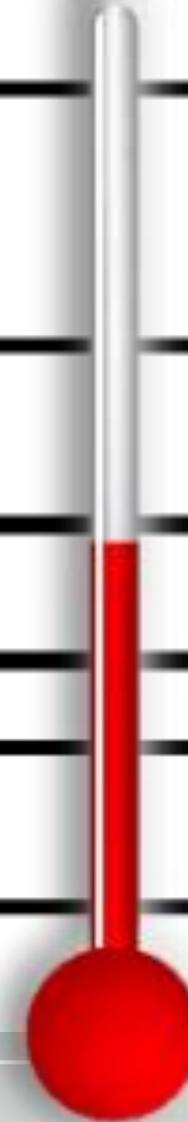


	Carbon Monoxide	Acetylene	Propane	LNG	Hydrogen Sulphide
Upper	74.2%	100%	9.5%	15%	46%
Lower	12.5%	2.5%	2.1%	5%	4.3%

Auto-ignition temperature (AIT)

- The lowest temperature, by heat alone, a vapour in air mixture will ignite spontaneously
 - Usually quite high
- Inversely proportional to flash point
 - A low flash point = high AIT
 - A high flash point = lower AIT

	<u>Gas Groups</u>
Ammonia 630°C	
Hydrogen 560°C	
Methane 537°C	
Propane 470°C	T1 - 450°C
Ethylene 470°C	
Butane 365°C	T2 - 300°C
Cyclohexane 259 °C	
Diethyl Ether 170°C	T3 - 200°C
	T4 - 135°C
	T5 - 100°C
Carbon Disulphide 95°C	
Ethyl Nitrate 90°C	T6 - 85°C



Auto-ignition temperature

PETROL –
Relatively
simple

LOW flash
point

AIT > 450°C

DIESEL – More
complex, slightly
'heavier' mixture

HIGH flash
point

AIT < 250°C



Corrosives

Corrosives

Corrosives are chemicals that have the ability to react and attack other substances without initiation or 'trigger'

Irreversible reaction

Generate heat

Degrade / break other chemicals

Can be slow, can be fast

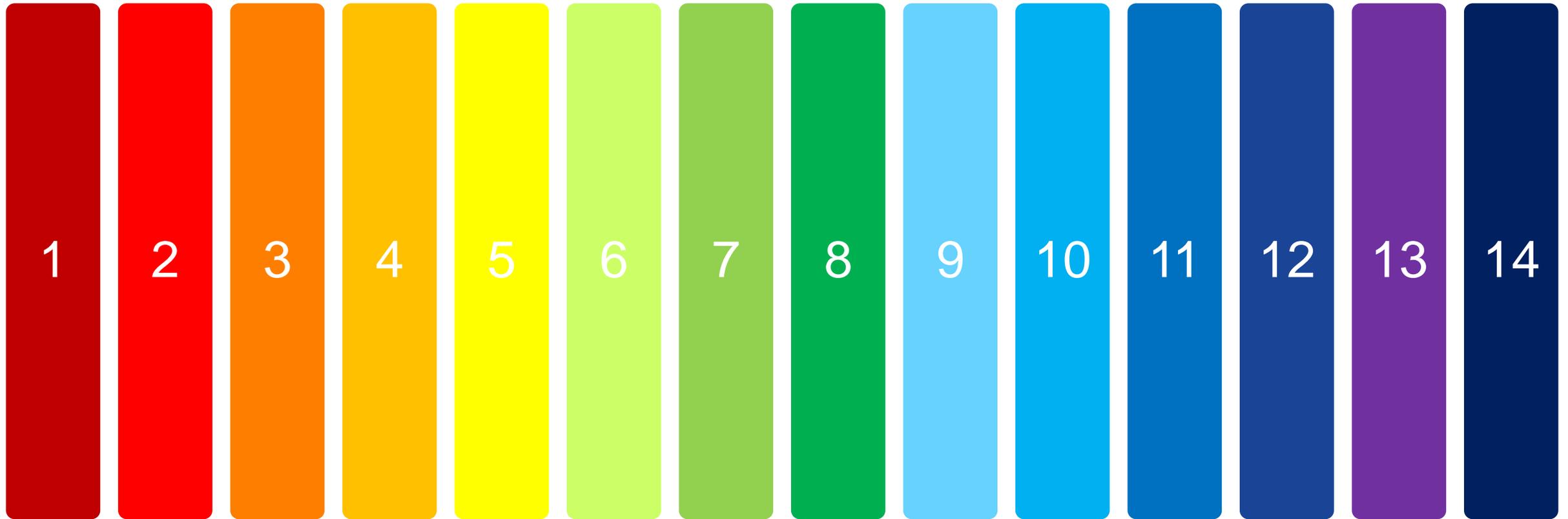
Some can react with a select group of metals to produce hydrogen

React violently with their 'opposite'

pH Scale

ACIDS

ALKALIS



GHS Corrosive ≤ 2

GHS Corrosive ≥ 11.5



Reactivity

Reactivity

Signs & symptoms of reactivity

Energy

Light

Exo/
Endothermic

Observational
change

Change in
colour

Change in
form

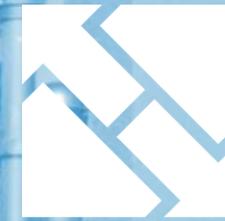
Vapour
production

Bubbles/
Effervescing

Pressure

Generation

Reduction



NCEC
HAZMAT
ACADEMY

Any Questions?