1

Unit 2 Objectives

The responder shall be able to;

- Given the physical and chemical properties of a hazardous material, the student shall identify how the material will behave under incident conditions.
- Given the physical and chemical properties of a hazardous material, the student shall identify the health, fire, and reactivity hazards for that material.
- Given terms associated with materials used as weapons of mass destruction, the student shall define the terms and identify the hazards associated with these materials.

2

Hazardous Materials

- Hazardous materials are capable of causing harm.
- The ability to cause harm is based on the **physical** and **chemical** properties of the material.
- The combination of these physical and chemical properties helps to understand the risk associated with hazardous materials.

3

Physical States of Matter

Gas

Liquid

Solid

4

Gas – any material that has no definite volume or shape.

Gases have a boiling point of less than 68° F. (DOT definition) In a container have an absolute pressure exceeding 40 psi at 70°F or 104psi at 130°F (OSHA)

- Stored in cylinders at pressures from 40 to 5,000 pounds per square inch (psi).

These materials are inherently more dangerous than the other physical states of matter due to their extremely mobile nature. When gases are released, it is hard to control and contain them, making protection of the population difficult.

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Liquefied Compressed Gas –

A gas packaged under pressure is partially liquid at temperatures above 58°F

- Compressed gas in solution – non-liquefied compressed gas which is dissolved in a solvent
- Cryogenic liquid - refrigerated liquefied gas having a boiling point colder than -130°F

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Liquid –any material that has a definitive volume and takes the shape of the container. Boiling point greater than 68º F.

- Liquids, have the ability to move from their point of release.
- Liquids at any temperature above their freezing points will produce vapors.
- Vapors produced by liquids will present the similar properties as gases.

7

Solids –any material that has a definite volume and shape. Solids have a melting point above ambient temperature. Liquids, have the ability to move from their point of release.

- Solids can be broken down into small particles or dusts
- Some solids can be dissolved in water. This can cause an even more dangerous situation.
- Some solids **sublime**, change form solid phase to gas phase. This presents a gas hazard.

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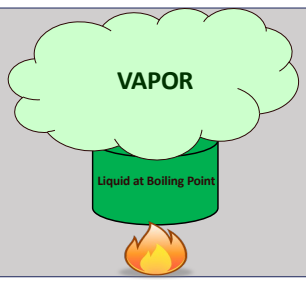
Boiling Point



Temperature at which a liquid changes into a gas or vapor at it's maximum rate

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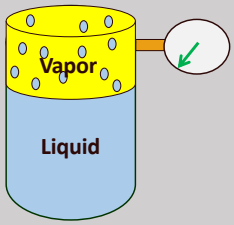
Low Vapor Pressure



Materials with high boiling points have low vapor pressure

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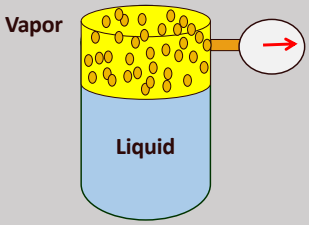
High Vapor Pressure



Materials with low boiling points have high vapor pressure.

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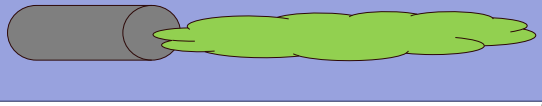
Vapor Density – density of gas compared to air

Materials that have a vapor density **greater than 1** will be **heavier** than air and will **sink.**



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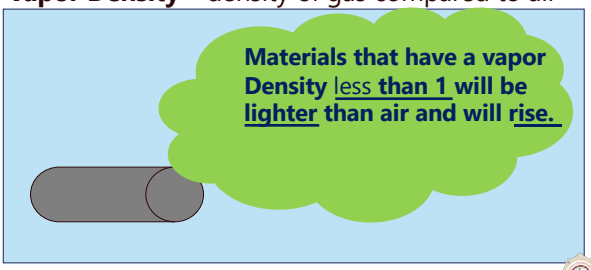
Vapor Density – density of gas compared to air



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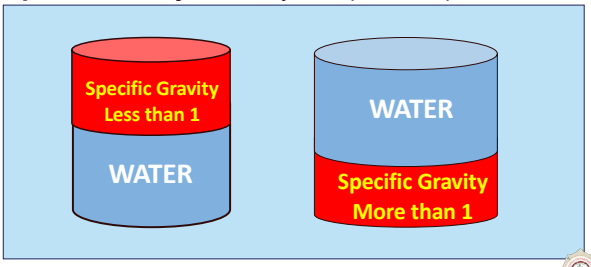
Specific Gravity – density of liquid compared to water



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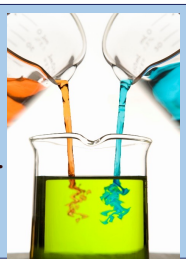
Solubility

The solubility of a material is the ability to dissolve in water or another specific solvent.



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Sublimation

Solid passes directly from a solid to a vapor state.

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Physical Properties to Consider based on Physical State

PROPERTY	GAS	LIQUID	SOLID
Boiling Point		X	
Vapor Pressure	X	X	
Vapor Density	X	X	
Expansion Ratio	X	X	
Specific Gravity		X	X
Solubility		X	X
Melting Point			X
Sublimes			X

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In Class Discussion

Identify And Compare The Physical Behavior Of The Following Materials:

- Propane
- Chlorine
- Methane
- Gasoline
- Sulfuric Acid
- Alcohol
- Naptha
- Aluminum Chloride

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Chemical Hazards Pose unacceptable risk to life, critical systems, property or the environment.

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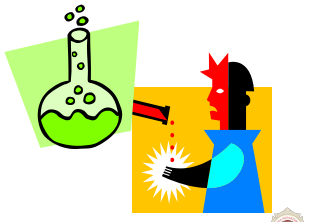
Reactivity Hazards

Materials that undergo chemical reaction that may produce:

- Heat
- Toxic vapors
- Harm to human tissue



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Explosive Materials

- Rapid and violent decomposition of material, releasing large volumes of gas and heat

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Unstable Materials

- Materials that decompose spontaneously or self react.
- Activated by increases in temperature and/or pressure.

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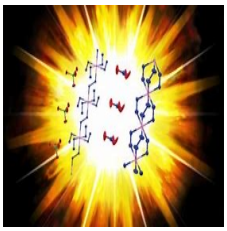
Polymerization

Chemical reaction in which small molecules combine to form larger molecules, releases large amounts of energy.



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Chemical Reactivity

- **Chemical Reactivity** –the ability of a material to undergo a chemical reaction (chemical change) with a release of energy.
  - Mixing of the material with another chemical.
  - The application of some type of stress, such as heat, pressure, or shock.

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Water Reactivity

- Materials that liberate heat and gases when they come in contact with water or the moisture in air.
- May produce flammable, toxic or corrosive gases.
- May react so violently that they produce an explosion.

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Pyrophoric Reactivity

Materials that will ignite spontaneously in dry air.

These materials are often stored in cylinders or under some type of packing liquid to prevent their contact with air.

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Oxidizers

Materials that give up oxygen very easily to support the combustion of flammable or combustible materials.

- Oxygen
- Potassium permanganate

Ammonium Nitrate and Saw Dust

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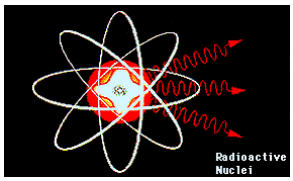
Radioactive Materials

Materials that transmit energy through space in the form of particles and energy rays.

- This energy is produced from the breakdown of the nucleus of atoms.
- These materials are commonly referred to as radioisotopes.



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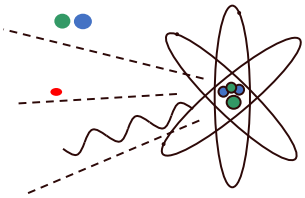
Ionizing Radiation

Alpha particles
2 P + 2N

Beta particles
Electron

Gamma rays
Energy wave



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Corrosive Hazards

Materials that cause visible destruction to living tissue or metals.

- Corrosivity is measured by its pH.
- pH is a scale of 0 – 14
- Neutral pH - 7
- Acid – ph < 7
- Base – pH > 7
- The pH of a material indicates its destructive nature compared to pure water.

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Concentration of Hydrogen ions compared to distilled water				Examples of solutions and their respective pH
	1/10,000,000	14	Liquid drain cleaner, Caustic soda	
	1/1,000,000	13	bleaches, oven cleaner	
	1/100,000	12	Soapy water	
	1/10,000	11	Household Ammonia (11.0)	
	1/1,000	10	Milk of magnesium (10.5)	
	1/100	9	Toothpaste (9.0)	
	1/10	8	Baking soda (8.4), Seawater, Eggs	
	0	7	"Pure" water (7)	
	10	6	Urine (6) Milk (6.6)	
	100	5	Acid rain (5.6) Black coffee (5)	
	1,000	4	Tomato juice (4.1)	
	10,000	3	Grapefruit & Orange juice, Soft drink	
	100,000	2	Lemon juice (2.3) Vinegar (2.8)	
	1,000,000	1	Hydrochloric acid secreted from the stomach lining (1)	
	10,000,000	0	Battery Acid	

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Fire Hazards

Materials that are involved with the initiation, support, or continuation of combustion.

Flammable gases and liquids

Flammable solids

Combustible elements and metals

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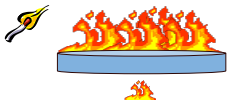
FLASH POINT

- The temperature at which a material will generate enough vapors to ignite in the presence of a outside pilot ignition source (flame or spark).



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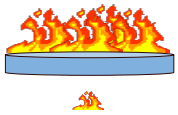
IGNITION TEMPERATURE

- The minimum temperature required to cause ignition without an outside pilot ignition source.



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FLAMMABLE RANGE

- The percent (%) of flammable vapors in air that will burn.
  - **Lower explosive limit (LEL)**
  - **Upper explosive limit (UEL).**

Methane LEL = 5% UEL = 15%

Flammable Range = 5%-15%

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Comparison of Flammable Gases and Liquids

	Propane	Methane Natural Gas	Gasoline	Fuel Oil	Ethanol
Physical State	Gas	Gas	Liquid	Liquid	Liquid
Boiling Point	-43	-285	140-390	560-640	173
Flash Point	-156	-306	-36	125	55
Ignition Temperature	842	1004	853	350-625	689
LEL	2.1%	5%	1.4%	1.3%	3.3%
UE	9.5%	15%	7.4%	6%	19%

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Health Hazards

Hazardous materials can exhibit many different types of properties that can cause harm in humans.

Toxicity - the ability of a substance or hazardous material to cause injury to biological tissues.

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Routes of Entry

Inhalation	Absorption	Ingestion	Injection
			

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Characteristics of Exposure and Hazards

- **Acute exposure** – short term exposure to high concentration of material.
- **Chronic exposure** – long term exposure to low concentrations of material.
- **Internal hazards** are present when materials enter the body and cause harm to internal organs and tissues.
- **External hazards** are caused by materials contacting the human body and causing harm to the skin or underlying tissues.

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Measurement of Toxicity

- Units of measurement for toxicity include:
  - Parts per million (PPM)
  - Parts per billion (PPB)
  - Parts per trillion (PPT)
  - Milligrams per cubic meter (mg/m3)
  - Milligrams per kilogram body weight (mg/Kg)

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Measurement of Toxicity

The most critical concept of evaluating toxicity –

The lower the numerical toxicity value, the greater the toxicity of the material.

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Measurement of Toxicity

Common exposure values and guidelines			
Name	**Symbol**	**Definition**	**Units of Measure**
Threshold Limit Value/Time Weighted Average	TLV/TWA	The maximum concentration that a person may be exposed to for 8 hours per day/40 hours per week without suffering harmful effects.	PPM mg/m^3
Threshold Limit Value/Short-Term Exposure Limit	TLV/STEL	This measurement is used to describe the maximum concentration a person can be exposed to for 15 minutes without suffering harmful effects. The maximum STEL is 4 times per day with a 60-minute rest period between each exposure.	PPM mg/m^3

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Measurement of Toxicity

Common exposure values and guidelines			
Name	**Symbol**	**Definition**	**Units of Measure**
Threshold Limit Value – Ceiling	TLV/C	This measurement represents the maximum concentration that should never be exceeded.	PPM mg/m^3
Permissible Exposure Limit	PEL	Similar to TLV/TWA, this measurement is the maximum concentration that the average worker can be exposed to 8 hours a day/40 hours per week without suffering harmful effects. OSHA uses this measurement in its health standard, and this is a legally enforceable standard.	PPM mg/m^3

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Measurement of Toxicity

Common exposure values and guidelines			
Name	**Symbol**	**Definition**	**Units of Measure**
Immediately Dangerous to Life and Health	IDLH	This measurement represents the concentration of an atmosphere that poses an immediate hazard to life or produces immediate, irreversible, and debilitating effects on health	PPM
Lethal Concentration 50%	LC_{50}	The concentration of a dust, mist, vapor, or gas in air or water that kills 50% of the test population.	PPM mg/m^3
Lethal Dose 50%	LD_{50}	The amount of an injected or ingested material that kills 50% of the test population.	mg/Kg

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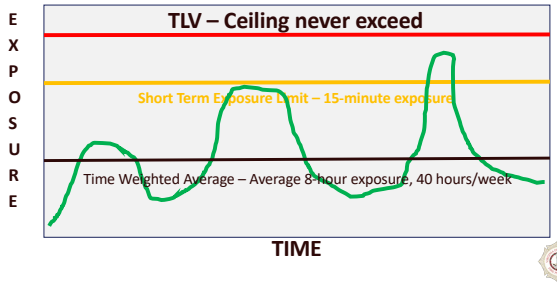
Threshold Limit Value



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Measurement of Toxicity

Examples of exposure values and guidelines					
Compound Name	TLV/TWA	TLV/STEL	IDLH	LC_{50}	LD_{50}
	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/Kg
Chlorine	1.5	3.0	90	850	Not reported
Benzene	3.0	18	9750	233,000	3,306
Parathion	0.1	Not reported	20	336	2.0
Phosgene	0.4	0.8	4.0	Not reported	Not reported

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