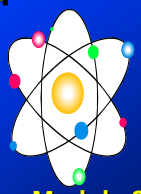
Chemistry & Toxicology for the Operational Responder

A quick overview



Module 2

Chemistry & Toxicology

Objectives

Basic Sources of Hazards:

- Physical
- Chemical
- Biological
- Radiological

What are the problems associated with chemicals?

- Fire
- Explosion
- Reactions
- Corrosion
- Toxicity
- Radiation

Physical properties:

- How will the chemical behave in the environment?
- What happens when it is released into air or water?

- **it will ignite the propane and burn down your house in a most convincing demonstration of the importance of relative densities.**

Rule of Thumb:

Most of the gases and vapors you will encounter have a V_{den} greater than 1

What about liquids?

- Specific Gravity (SG) compares the density of one liquid to another ($SG = D_1/D_2$).
- $SG_{benzene}$ = 0.88 (immiscible in and floats on water)
- $SG_{carbon\ disulfide}$ = 1.27 (immiscible in and sinks in water)

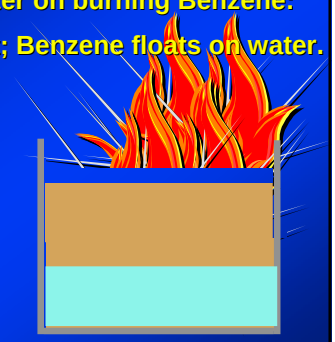
If you pour Water on burning Benzene:

It has no effect; Benzene floats on water.

FIRE

BENZENE (SG = 0.88)

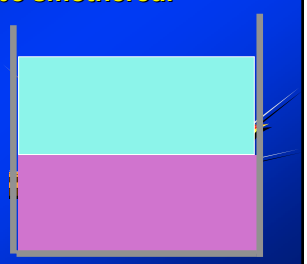
WATER



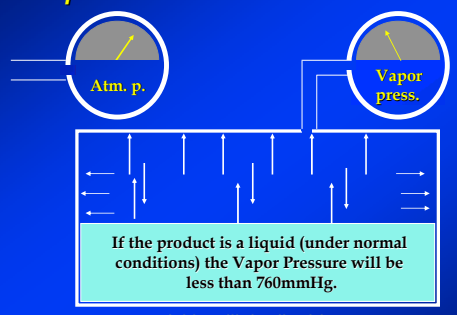
If you pour water on burning Carbon disulfide: The fire may be smothered.

WATER

CARBON DISULFIDE SG = 1.27



Vapor Pressure



How quickly will the liquid become an airborne hazard?

Vapor Pressure

- Rule of Thumb:
- Vapor Pressure <10 indicates Low Volatility.
- Vapor Pressure = 10 to 100 indicates Moderate Volatility (VP_{water} is 25mmHg at room temp.)
- Vapor Pressure > 100 indicates High Volatility.

Boiling Point

- Vapor pressure varies with temperature.
- The BOILING POINT of any material is the temperature where:

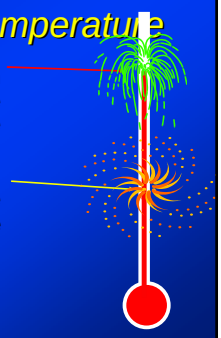
  vapor pressure = atmospheric pressure

- Average atmospheric pressure at sea level is 760mmHg.
- This varies with altitude and local conditions.

Flash Point and Auto-ignition Temperature

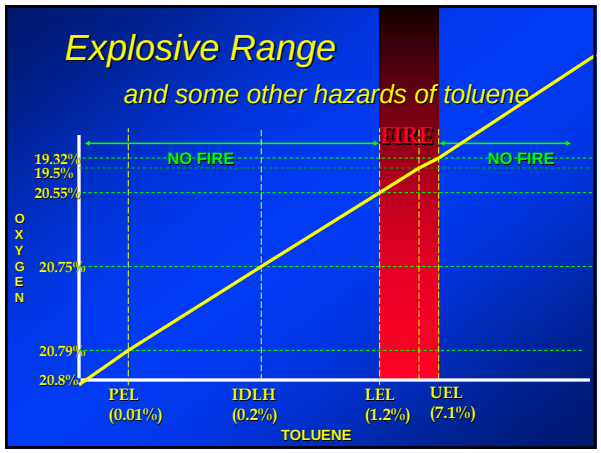
Auto-ignition Temp. - combustion is initiated by the temp. of the product; no external ignition source is required.

Flash Point - lowest T° where the vapor given off by a substance forms an ignitable mixture with air.



Explosive Range

and some other hazards of toluene



pH

- pH is a measure of corrosivity.
- pH of 7 is neutral
- pH greater than 7 is basic (Lye).
- pH less than 7 is acidic (Hydrochloric acid)

pH

- **pH is a logarithmic scale**
- **as the pH number "goes down" from 7,**
- **the strength of the acid changes by a factor of 10:**
- **pH 7 neutral**
- **pH 6 is 10x more acidic than 7**
- **pH 5 is 100x more acidic than 7**
- **pH 4 is 1,000x more acidic than 7**
- **pH 3 is 10,000x more acidic than 7 etc.**

pH

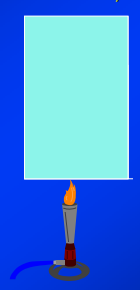
- **as the pH number "goes up" from 7,**
- **the strength of the base changes by a factor of 10:**
- **pH 7 neutral**
- **pH 8 is 10x more basic than 7**
- **pH 9 is 100x more basic than 7**
- **pH 10 is 1,000x more basic than 7**
- **pH 11 is 10,000x more basic than 7 etc.**

Expansion Ratios:

- Release a compressed or cryogenic material from its confinement and it expands :
- LNG 1:635
- Oxygen 1:850
- Propane 1:270

Expansion of heated liquids:

- Like other forms of matter; heat a liquid and it will expand.



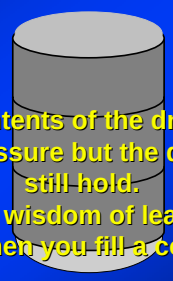
What happens to liquid in a sealed container?

Heat a topped-off drum of gasoline:

- 55 gallons of gasoline will expand to occupy 57.47gal. when heated from 65º to 140ºF
- Since liquids are incompressible, what happens to 57gallons in a 55 gallon drum?

Try it with 50 gallons:

- If you heat 50 gallons of gasoline in a 55 gallon drum from 65- 140 degrees (F), it will expand to 52.25gal
- 52+ gallons still fit in the drum and since gases **<u>are</u>** compressible (5 gal headspace), the drum should hold.



The contents of the drum are under pressure but the drum may still hold.
Hence, the wisdom of leaving head space when you fill a container.

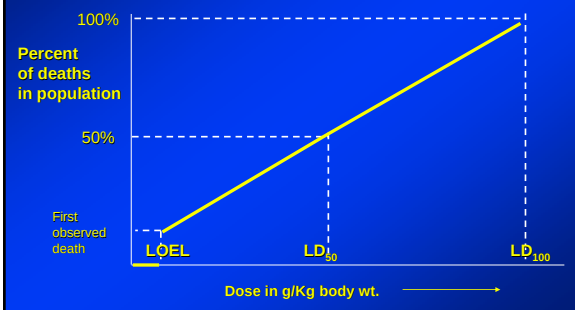
TOXICOLOGY

- **Every chemical is dangerous in certain amounts...**
- **Every chemical is safe in certain amounts...**
- ***WHAT IS THE AMOUNT???***

Median Lethal Dose and Dose Response Curve

- **Median Lethal dose is the amount of a substance that you expect to kill half of the group.**
- **LD_{50} is the oral or skin absorption dose.**
- **LC_{50} is the airborne concentration.**

Median Lethal Dose and Dose Response Curve

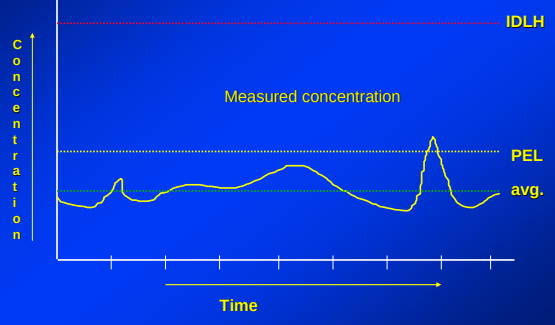


Extremes of toxicity:

☺ $LD_{50\ Saccharin}$ = 2,000g/Kg (Relatively harmless)

☹ $LD_{50\ Sarin}$ = 0.00001g/Kg (Extremely Toxic)

TWA - Time Weighted Average



TWA

- **TLV** - published by the American Council of Governmental Industrial Hygienists (ACGIH) based on (human) work place studies.
- **REL** - published by the National Institute of Occupational Safety and Health (NIOSH) based on (animal) laboratory studies.
- **PEL** - published by the Occupational Safety and Health Administration (OSHA) based on (all) published data and factoring in costs of compliance.

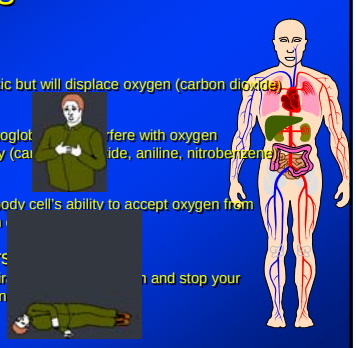
Asphyxiants

Simple Asphyxiants
Materials that may not be toxic but will displace oxygen (carbon dioxide)

Blood Asphyxiants
Materials that bond with hemoglob rfere with oxygen transport in the body (car ide, aniline, nitrobenzene)

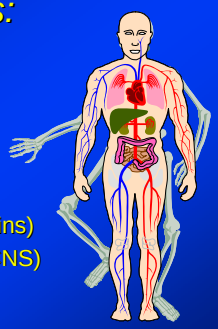
Tissue Asphyxiants
Materials that interfere with body cell's ability to accept oxygen from the blood (hydrogen

Respiratory Paralyzers
Materials that affect the respir n and stop your breathing (hydrogen



Systemic poisons:

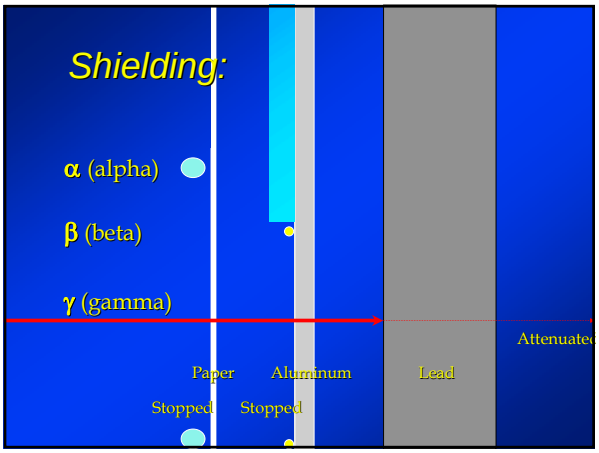
- Liver (hepatotoxins)
- Kidneys (nephrotoxins)
- Bone marrow
- Muscle poisons
- Nerve poisons (neurotoxins)
- Central Nerve System (CNS)



RADIATION

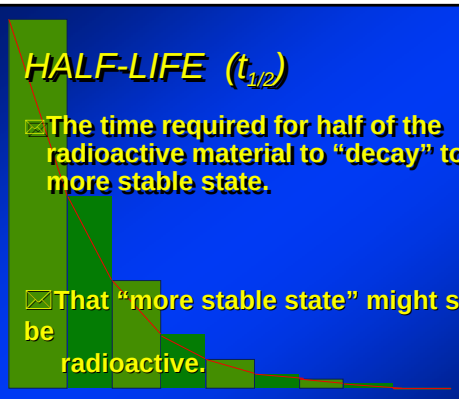
- TIME / DISTANCE / SHIELDING
- The less time, the less the dose
- The greater the distance, the less the dose
- The better the shielding, the less the dose

Shielding:



HALF-LIFE ($t_{1/2}$)

- The time required for half of the radioactive material to "decay" to a more stable state.
- That "more stable state" might still be radioactive.



Where do you find this information?

- **Printed materials:**
  - NJ DHSS (Dept. of Health and Senior Services) Fact Sheets
    MSDS (Material Safety Data Sheets)
  - Merck Index
    Hawley's Condensed Chemical Dictionary (Sax & Lewis)
    Hazardous Chemicals Desk Reference (Sax & Lewis)
    Emergency Handling of Hazardous Materials (AAR)
    Handbook of Toxic and Hazardous Chemicals and Carcinogens (Sittig)
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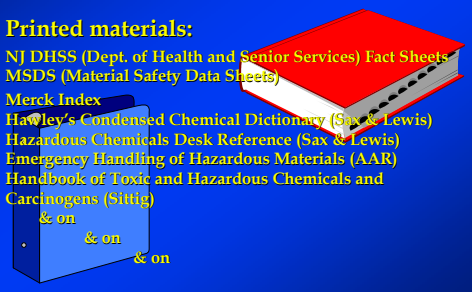

Computer Databases

- **NJ RTK** www.state.nj.us/health/eoh/odisweb/
- **CAMEO** (download)
  response.restoration.noaa.gov/cameo/toolkit.html
- **CHRIS Manual** www.chrismanual.com/toc.htm
- **NIOSH** www.cdc.gov/niosh/database.html
- **MSDS Search**
  MSDS.PDC.CORNELL.EDU/msdssrch.asp
- **ERG** hazmat.dot.gov/gydebook.htm
- **And many more on CD or the WWW**