

Chemistry for the Non-Chemist 2016 HHW/Used Oil Conference

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Class Objective

- Gain a basic understanding of the periodic table of the element
- Understand the difference between groups of elements
- Understand the difference between organic and inorganic chemicals
- Understand the importance of chemical compatibility
- Understand physical and chemical properties of chemicals

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Periodic Table

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Periodic Table

4

Number of Outer Shell Electrons: 1, 2, 3, 4, 5, 6, 7, 8

Alkali Metals, Alkaline Earth Metals, Metals, Non-Metals, Halogens, Noble Gases

The Periodic Table

metals
 non-metals
 noble gases

Common Chemical Symbols

- Carbon = C
- Chlorine = Cl
- Hydrogen = H
- Lithium = Li
- Nitrogen = N
- Oxygen = O
- Potassium = K
- Sodium = Na

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Basic Terms

- 1) Chemistry – study of the properties of materials (matter) and the changes that materials undergo.
- 2) Matter – anything that occupies space and has mass.
- 3) Atom – the smallest representative particle of an element.
- 4) Element – substance that cannot be separated into simpler substances by chemical means.
- 5) Compound – substance composed of 2 or more elements united chemically in definite proportions.

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4 States of Matter

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Isotopes

	Symbol	protons	neutrons	mass number
carbon-11	¹¹ C	6	5	11
carbon-12	¹² C	6	6	12
carbon-13	¹³ C	6	7	13

ca Almost 99% of the carbon found in nature consists of ¹²C.

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Atoms

- Electron
 - negatively charged (-) particle found outside of and surrounding the atomic nucleus to form a shell;
 - mass is 1,836x less than mass of proton.
- Proton
 - positively charged (+) particle found in the atomic nucleus
 - Atomic Number
- Neutron
 - neutral particle in atomic nucleus;
 - slightly more mass than protons.

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Simple Math

	relative mass	relative charge
proton	1	+1
neutron	1	0
electron	1/1836	-1

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Atomic Mass/Number

- Atomic Mass = #'s of Protons + #'s of Neutrons
- Atomic Number = #'s of Protons

Mass Number → 39

Atomic Number → 19

K ← Element symbol

- Protons = 19
- Neutrons = 39 - 19 = 20

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Valence Electrons

In general, the number of valence electrons of a representative element is equal to the group number

IUPAC →	1	2	13	14	15	16	17	18	← NA
	IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA	
	Li	Be	B	C	N	O	F	Ne	

IUPAC = International Union of Pure and Applied Chemistry
NA = North America

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Alkali Metals – Group 1

- Very Reactive
- Do not occur freely in nature
- One e⁻ in outer shell
- Soft, malleable, ductile, good conductor
- Can explode in contact with water





- Lithium, Sodium, Potassium, Rubidium, Cesium & Francium

Li
Na
K
Rb
Cs
Fr

Click [here](#) for alkali metals reacts with water
Click [here](#) for Na in explosive action!

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Danger from Batteries

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Alkaline Earth Metals – Group 2

- Very reactive
- Not freely found in nature
- Hard
- 2 e⁻ in outer shell

- Beryllium, Magnesium, Calcium, Strontium, Barium, Radium

4 Be 9.012182 Beryllium
12 Mg 24.3050 Magnesium
20 Ca 40.078 Calcium
38 Sr 87.62 Strontium
56 Ba 137.327 Barium
88 Ra [226] Radium

Click [here](#) for group 2 metals reacts with water!

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Half a gram of powdered magnesium. Note that the water isn't added until 00:14

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Transition Metals (Groups 3-12)

- Ductile & Malleable
- Conduct electricity and heat
- Metals commonly found in electronics

3	IIIB	4	IVB	5	VB	6	VIB	7	VII B	8	9	10	11	IB	12	IIB			
21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn
41	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd
72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg	81	Tl
104	Rf	105	Dh	106	Sg	107	Bh	108	Hs	109	Mt	110	Ds	111	Rg	112	Cn	113	Nh

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Halogens – Group 17

- VERY REACTIVE
- “Salt-former”
- Form acid when reacts w/ H₂
- 7 e⁻ outer shell
 - Needs only 1 e⁻ to complete the shell
- Fluorine, Chlorine, Bromine, Iodine, Astatine

17	VIIA
9	F
17	Cl
35	Br
53	I
85	At
117	Uus

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Noble Gases – Group 18

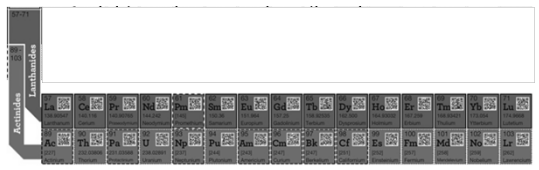
- Inert, stable elements except Kr, Xe & Rn
- Simple asphyxiants
- Maximum e⁻ in outer shell
 - All e⁻ has filled the outer shell
- Helium, Neon, Argon, Krypton, Xenon, Radon

18	VIIIA
2	He
10	Ne
18	Ar
36	Kr
54	Xe
86	Rn
118	Uuo

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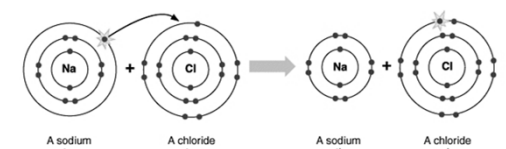
Rare Earth – Group 3

- 6th and 7th period
- Lanthanide and Actinide Series
 - Lanthanide series – soft silvery metals



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Ionic Bonding



A sodium atom + A chlorine atom → A sodium cation + A chloride anion
 $\text{Na} + \text{Cl} \rightarrow \text{Na}^+ + \text{Cl}^-$

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- The outer most valence e⁻ transfers from one atom to another.
- Bond forms mostly between elements in Group 1 (IA) or 2 (IIA) and elements Group 17 (VIIA).

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Covalent Bonding

bonds are formed by sharing e⁻

- Most elemental gases, e.g. F₂, H₂ & O₂
- Nonmetal only compound, e.g. CO₂, CH₄, H₂O

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Comparison

covalent bond ionic bond

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Chemical Reactions

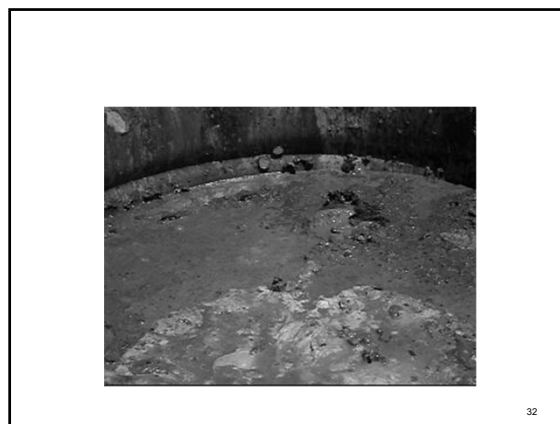
Chemical reactions always involve a change in energy

- Endothermic: energy is required for the reaction to occur
 - e.g. $\text{H}_2\text{O}(s) + \text{heat} \rightarrow \text{H}_2\text{O}(l)$
- Exothermic: energy is released in reaction (stored in chemical bonds)
 - e.g. $\text{NaOH}(aq) + \text{HCl}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l) + \text{heat}$

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April 16, 1947 – Texas City

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Major Chemical Groups

Salts and non-salts
Inorganic
Organic



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Difference

- Organic = compounds consists of carbon
 - Usually, in combination of hydrogen (hydrocarbon), oxygen, nitrogen, or sulfur
- Inorganic = all other compounds
 - Let's explore this type of compounds first

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Inorganic Chemicals

- Acids
 - Hydrochloric (muriatic), sulfuric, nitric acids
- Bases
 - Sodium hydroxide (lye), potassium hydroxide
- Salts
 - 6 types; binary salt, metal cyanide, metal oxide, metal hydroxide, metal peroxide, metal oxysalt (i.e. BaSO_4)

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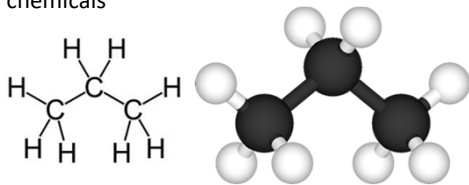
Inorganic Pesticides

- Compounds containing heavy metals
 - lead, mercury, zinc, copper
- Compounds containing metalloids
 - arsenic, boron
- Compounds containing nonmetals
 - sulfur, fluoride

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Organic Chemicals

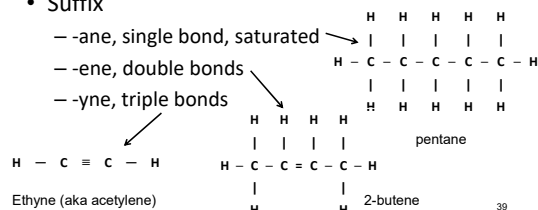
- Based on the chemistry of carbon
- Hydrocarbons are the root of most organic chemicals



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Naming Organic Chemicals

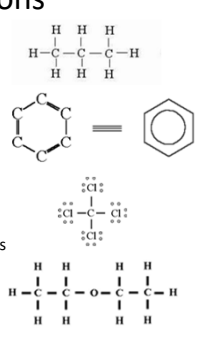
- Name tells you the structure
- Prefix
 - Meth-, eth-, prop-, but-, pent-, hex-, hep-, oct-
- Suffix



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Hydrocarbons

- Aliphatics
 - methane, propane, hexane
- Aromatics
 - benzene, xylene, toluene
- Halogenated Hydrocarbons
 - CFC's, PCB's
- Oxygenated Hydrocarbons
 - alcohols, aldehydes, ketones, ethers



Ethyl Ether
C₂H₅OC₂H₅

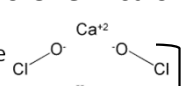


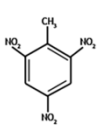
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Hazards of Organic Chemicals

- Many are flammable
 - Flammability characteristics should be known
- Many are Anesthetic
 - They should always be used in well-ventilated spaces
- Some are Carcinogenic
 - Toxicity limits should be known and appropriate PPE worn

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Dangerous Chemicals

- Calcium hypochlorite 
- Perchloric acid 
- Picric acid 
- Trinitrotoluene (TNT) 



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Properties of Chemicals

Physical Properties

- Measurable
 - Density, melting pt, boiling pt, solubility




Chemical Properties

- How chemicals react
 - Flammability, oxidation states, toxicity



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Physical States

- Solid 
- Liquid 
- Gas 

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Melting and Freezing Point

- Temperature at which the chemical will change state
 - Solid to a liquid (melting) or
 - Liquid to a solid (freezing)



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Boiling Point

- The temperature at which the vapor pressure is equal to atmospheric pressure
- Liquids boil at different temperatures



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Specific Gravity

- Specific Gravity is the ratio of the density of a substance compared to water
 - Unitless
 - Water = 1
 - Less than 1 will float
 - More than 1 will sink



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Densities and Specific Gravity's of Some Common Liquids

Substance	Density (gm/cm ³) @ 15°C	Specific Gravity
Gasoline*	0.7-0.8	0.7-0.8
Water	1.00	1.00
Chloroform*	1.498	1.498
Mercury	13.6	13.6

* Click [here](#) and [here](#) for gasoline information; click [here](#) for chloroform

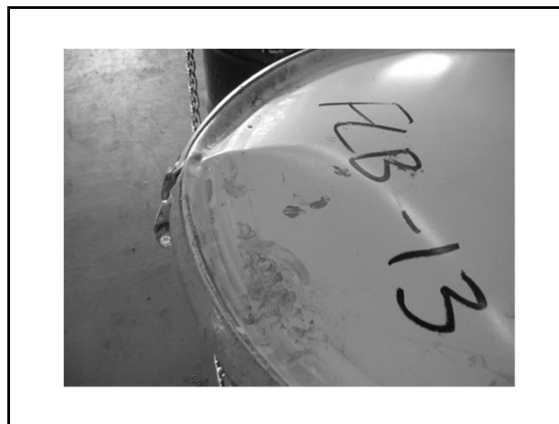
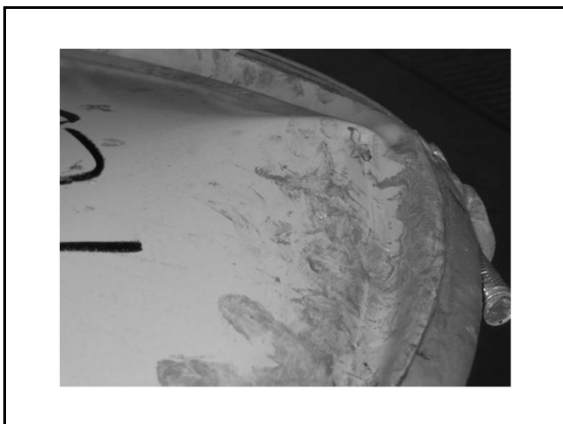
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Vapor Pressure

- Is the pressure exerted by the vapor that evaporates from a liquid in a closed space
- A measure of the rate of evaporation
- As temperature increases, the vapor pressure increases
- Temp ↑ = Pressure ↑



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Vapor Density

- Is the molecular weight of a gas or vapor divided by the molecular weight of air (28.9 atomic mass unit; amu)
- It tells us whether a gas is lighter or heavier than air
 - Unitless
 - Air =1
 - Greater than 1 will fall
 - Less than 1 will rise



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Flash Point

- Is the minimum temperature at which a substance gives off vapor sufficient to form an ignitable mixture with air
- Lower the flash point, higher the flammability

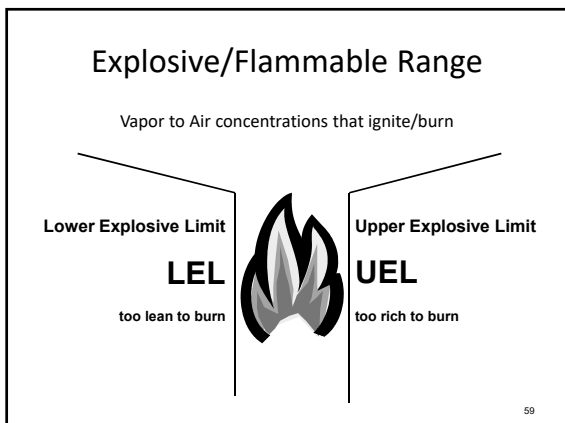


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Liquid Flammability Defined by Flash Point

100°F	140°F	141°F	200°F
Flammable		Combustible	DOT
Ignitable		EPA	
Flammable			OSHA
100°F (37.8°C)	140°F (60°F)	141°F	199.4°F (93°C)

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Physical Properties Related to Flammability*

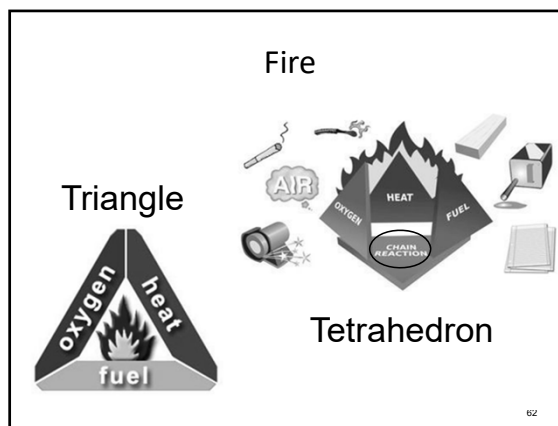
Liquids	Boiling Point	Flash Point	LEL	UEL
Acetone	133	0	2.5	12.8
Ethanol	173	55	3.3	19
Gasoline	102	-45	1.4	7.6

* NIOSH Pocket Guide 60

Auto Ignition Temperature

- Is the minimum temperature at which a substance ignites without application of a flame or spark
- Is usually considerably higher than the flash point

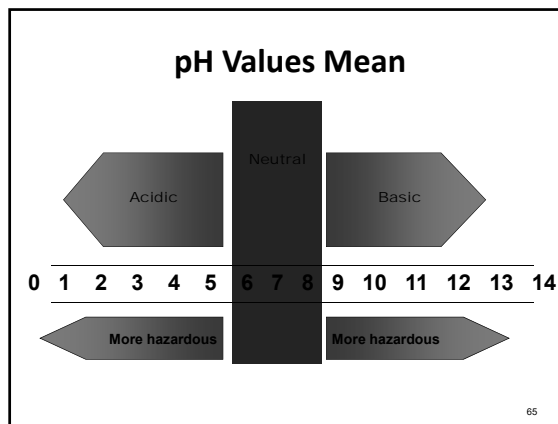
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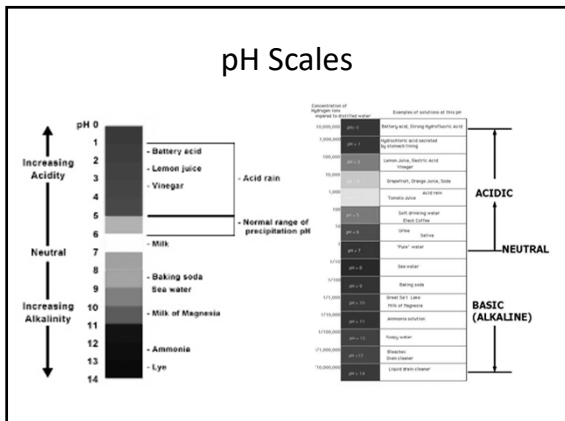


DOT Hazard Classes

- Explosives Class 1
- Gases, Class 2
- Flammable, Class 3
- Flammable, Class 4
- Oxidizers, Class 5
- Poisonous, Class 6
- Radioactive, Class 7
- Corrosives, Class 8
- Other, Class 9

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Corrosive

OSHA Definition:
 "A chemical that causes visible, destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact."

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Identifying Acids

- Have pH less than 7
 - Hazardous waste is ≤ 2
 - Practical < 4
- Taste tart
- React with metal to form hydrogen gas
- Often have "acid" in the name
- Often have a chemical formula that begins with "H"

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Acids

- Car batteries
- Muriatic acid
- Hydrochloric acid
- Flux
- Metal cleaner
- Rust removers
- Boric Acid
- Car Battery Acid
- Copper Cleaners
- Etching Solutions
- Ferric Chloride
- Drain cleaners can be either acid or base

- Hydrochloric Acid
- Hydrofluoric Acid
- Metal Cleaners
- Muriatic Acid
- Navel Jelly
- Phosphoric Acid
- Pool Acid
- Sheep Dip
- Sodium Bisulfate
- Sulfuric Acid
- Toilet Bowl Cleaners *

* Check Ingredients for proper classification 69

Identifying Bases

- Have a pH greater than 7
 - Hazardous waste is ≥ 12.5
 - Practical > 10
- Taste bitter
- Have a slippery, soapy feel
- May have "hydroxide", or "alkali", or "caustic" in the name
- Often has "OH" in the chemical formula

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Base/Alkaline/Caustic


- Alkaline batteries
- Bleach
- Sodium hydroxide (Lye)
- Drain cleaners can be either acid or base *
- Ammonia and Ammonia Based Cleaners
- Battery Terminal Cleaner

- Caustic Soda
- Cesspool Cleaners *
- Household cleaners *
- Lime
- Oven Cleaners *
- Window Cleaners

* Check Ingredients for proper classification 71


pH Summary

- It is a scale 
- It applies only to aqueous systems




- Low numbers (acids)
- High numbers (bases)
- Both corrosive

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Oxidizers



- Compounds which are capable of reacting with and oxidizing (giving off oxygen) other materials
- Usually contain O₂
- May cause or enhance the combustion of other materials

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Common Signal Words for Oxidizers

Oxidizer Identification Store away from other materials	
Oxidizer Key Word Prefix or Suffix	Examples
-ate	Ammonium nitrate Potassium permanganate
-ite	Calcium hypochlorite
-peroxide	Methyl ethyl ketone peroxide (MEKP)

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Safety Data Sheet (SDS)

- Required by OSHA
- Information was listed various from company to company.
Uniformly standardized for easy access
- Describes physical & chemical properties
- Lists safety requirements
- Shows primary hazards



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Sample SDS Layout: Benzene/HCl

1) Product/Company ID	9) Physical & Chemical Properties
2) Hazards ID	10) Stability & Reactivity
3) Composition	11) Toxicological Info.
4) First Aid Measure	12) Ecological Info.
5) Firefighting Measure	13) Disposal Consideration Measure
6) Accidental Release Measure	14) Transport Info.
7) Handling & Storage	15) Regulatory Info.
8) Exposure Controls/PPE	16) Other Info.

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SDS Limitations

- Specific to product, not mixtures or contamination
- Not all ingredients always listed
 - if % is low, trade secrets or not part of activity (i.e. inert ingredients)
- Environmental & disposal information very general

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The Invisible Killer

Dihydrogen monoxide is colorless, odorless, tasteless, and kills uncounted thousands of people every year. Most of these deaths are caused by accidental inhalation of DHMO, but the dangers of dihydrogen monoxide do not end there. Prolonged exposure to its solid form causes severe tissue damage. Symptoms of DHMO ingestion can include excessive sweating and urination, and possibly a bloated feeling, nausea, vomiting and body electrolyte imbalance. For those who have become dependent, DHMO withdrawal means certain death.

Dihydrogen monoxide:

- is also known as hydrox acid, and is the major component of acid rain.
- contributes to the "greenhouse effect."
- may cause severe burns.
- contributes to the erosion of our natural landscape.
- accelerates corrosion and rusting of many metals.
- may cause electrical failures and decreased effectiveness of automobile brakes.
- has been found in excised tumors of terminal cancer patients.

Quantities of dihydrogen monoxide have been found in almost every stream, lake, and reservoir in America today. But the pollution is global, and the contaminant has even been found in Antarctic ice. DHMO has caused millions of dollars of property damage in the midwest, and recently California.

Despite the danger, dihydrogen monoxide is often used:

- as an industrial solvent and coolant.
- in nuclear power plants.
- as a fire retardant.
- in the distribution of pesticides. Even after washing, produce remains contaminated by this chemical.
- as an additive in certain "junk-foods" and other food products.

Companies dump waste DHMO into rivers and the ocean, and nothing can be done to stop them because this practice is still legal. The impact on wildlife is extreme, and we cannot afford to ignore it any longer!

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Chemical Classification

- Hazardous Substance/Materials/Wastes
- DOT, EPA, OSHA
- Hazardous Characteristics
 - Corrosive
 - Toxic
 - Flammable
 - Oxidizer
 - Reactives
 - Others

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Hazardous

- Hazardous Substance
- Hazardous Materials
- Hazardous Wastes

The diagram consists of three nested shapes. An outer circle is labeled 'Hazardous Substances'. Inside it is a smaller circle labeled 'Hazardous Materials'. Inside the 'Hazardous Materials' circle is a downward-pointing triangle labeled 'Hazardous Waste'.

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DOT Hazard Classes

- Explosives Class 1
- Gases, Class 2
- Flammable, Class 3
- Flammable, Class 4
- Oxidizers, Class 5
- Poisonous, Class 6
- Radioactive, Class 7
- Corrosives, Class 8
- Other, Class 9

A collection of various hazard diamonds and labels representing different DOT hazard classes, including symbols for explosives, gases, flammability, oxidizers, toxicity, and radioactivity.

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Waste Identification



- Determining the classification of a hazardous waste to allow for safe storage and packaging.
- Required Waste Analysis Plan, Title 22
 - §66262.11 Hazardous Waste Determination.
 - §67450.25(A) (2) (A) PHHWCF Requirements

Waste Identification Steps

- Symbols
- Read product label
 - Signal words
- View container type
- Ask customer
- Testing



Identifying Acids

- Have pH less than 7
 - Hazardous waste is ≤ 2
 - Practical < 4
- Turns pH paper red
- Taste tart
- React with metal to form hydrogen gas
- Often have “acid” in the name
- Often have a chemical formula that begins with “H”

Identifying Bases

- Have a pH greater than 7
 - Hazardous waste is ≥ 12.5
 - Practical > 10
- Turn pH paper blue
- Taste bitter
- Have a slippery, soapy feel
- May have “hydroxide”, or “alkali”, or “caustic” in the name
- Often has “OH” in the chemical formula

Base/Alkaline/Caustic

- Alkaline batteries
- Bleach
- Sodium hydroxide (Lye)
- Drain cleaners can be either acid or base *
- Ammonia and Ammonia Based Cleaners
- Battery Terminal Cleaner

- Caustic Soda
- Cesspool Cleaners *
- Household cleaners *
- Lime
- Oven Cleaners *
- Window Cleaners

* Check Ingredients for proper classification

Common Hazardous Wastes

- Flammable
 - Propane
 - Gasoline
 - Solvents
- Corrosive
 - Car batteries (acid)
 - Muriatic acid
 - Alkaline batteries
 - Drain cleaner


- Poison/Toxic
 - Pesticide
 - Weed killer
- Reactive
 - Ammunition
 - Flares
 - Hydrogen Cyanide







HW - Corrosive

- (1) liquid with a pH less than or equal to 2 or greater than or equal to 12.5
- (2) it is a liquid and corrodes steel
- (3) solid that, when mixed with an equivalent weight of water, produces a solution having a pH less than or equal to 2 or greater than or equal to 12.5
- (4) solid, when mixed with an equivalent weight of water, produces a liquid that corrodes steel





CCR, Title 22 § 66261.22

Base/Alkaline/Caustic

- Alkaline batteries
- Bleach
- Sodium hydroxide (Lye)
- Drain cleaners can be either acid or base *
- Ammonia and Ammonia Based Cleaners
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- Caustic Soda
- Cesspool Cleaners *
- Household cleaners *
- Lime
- Oven Cleaners *
- Window Cleaners

* Check Ingredients for proper classification



HW - Flammable/Ignitability

(1) it is a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume, and has a flash point less than 60 °C (140 °F),

(2) solid capable of causing fire through friction, absorption of moisture or spontaneous chemical changes and, when ignited, burns so vigorously and persistently that it creates a hazard;


(3) it is an ignitable compressed gas

(4) it is an oxidizer





CCR, Title 22 § 66261.21

HW - Toxic





- Acute Oral Toxicity Criterion - LD50 <5,000 mg/kg body weight
- Acute Dermal Toxicity - - LD50 <4,300 mg/kg body weight
- Acute Inhalation Toxicity - - LD50 <10,000 g/kg in air
- Acute Fish Toxicity - 96 hour <500 mg/l of water
- Carcinogenicity - > 10 ppm
- Specific Compounds greater than limit



CCR, Title 22 § 66261.24



Oxidizers

- Compounds which are capable of reacting with and oxidizing (giving off oxygen) other materials
- Usually contain O₂
- May cause or enhance the combustion of other materials


Other Chemical Characteristics

- Pyrophoric
 - Materials that ignite spontaneously in air
- Water Reactive
 - Materials that react violently with water
- Explosives
- Radioactive


Explosive HHW Examples






Paint

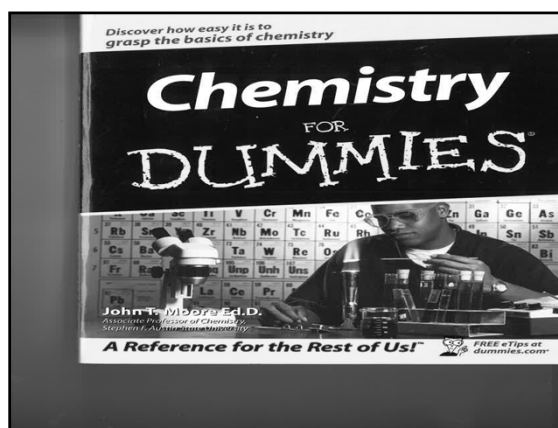
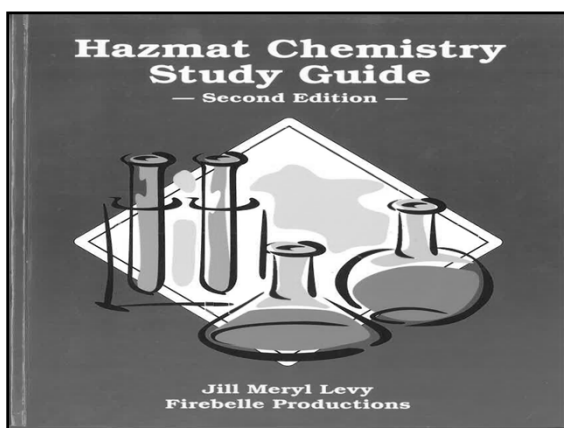
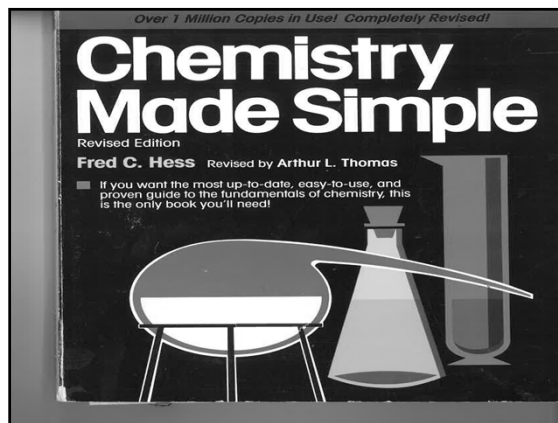
<ul style="list-style-type: none"> • Latex Paint <ul style="list-style-type: none"> – Water – Acrylic – Alcohol • Cleanup <ul style="list-style-type: none"> – Water and soap • Also <ul style="list-style-type: none"> – Mercury fungicide – PCBs 	<ul style="list-style-type: none"> • Oil-Based Paint <ul style="list-style-type: none"> – Flammable – Inflammable – Alkyd • Cleanup <ul style="list-style-type: none"> – Mineral spirits – Turpentine
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Summary

- The periodic table of the element
- Difference between groups of elements
- Difference between organic and inorganic chemicals
- Chemical compatibility/incompatibility
- Physical and chemical properties of chemicals
- DOT hazmat classification
- Resources

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Test

- Jeopardy

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