Chemistry Review

Why Talk about Chemistry?

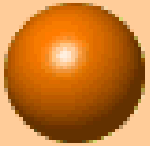
- Chemicals are the “stuff” we are all made out of.
- By understanding chemistry, we can predict how compounds will react with each other and with us.

Part 1 – The Atom

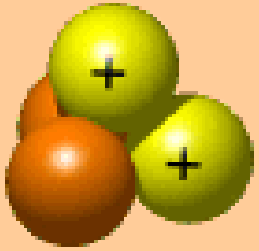
Parts of the Atom

Atoms are made out of three basic particles:

Protons – carry a positive charge



Neutrons – carry no charge



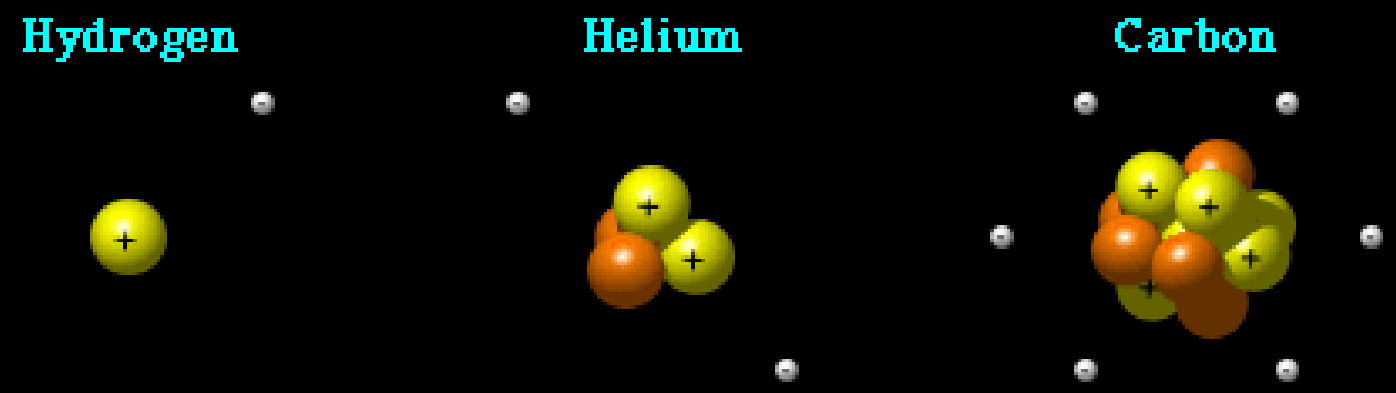
Protons and Neutrons join together to form the Nucleus – the central part of the atom

Electrons – carry a negative charge and circle the nucleus

Jefferson Lab Web Site http://education.jlab.org/atomtour/listofparticles.html

Parts of the Atom

Atoms always have as many electrons as protons.
Atoms usually have about as many neutrons as protons.

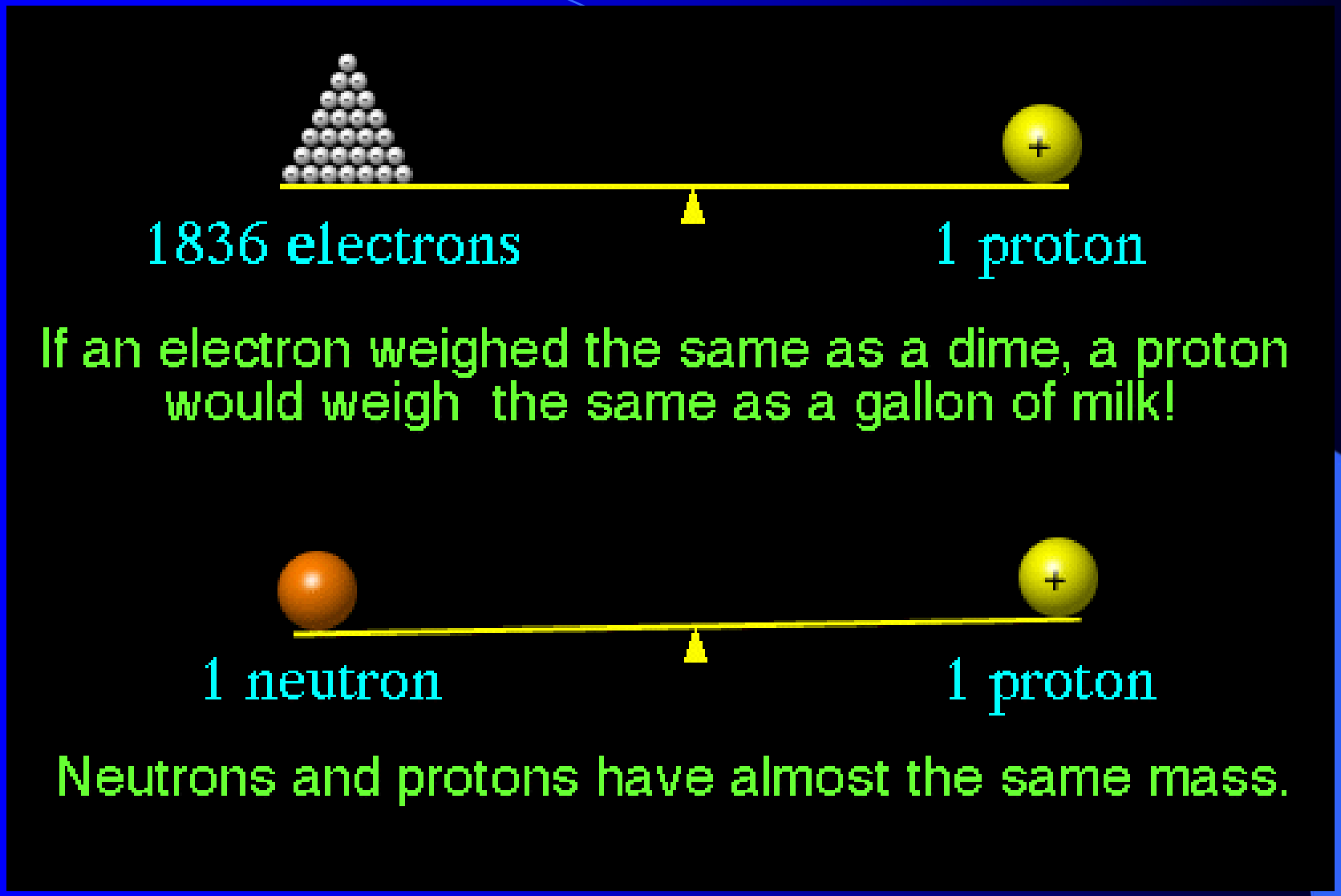


Hydrogen	Helium	Carbon
1 proton	2 protons	6 protons
1 electron	2 electrons	6 electrons
0 neutrons	2 neutrons	6 neutrons

Adding a proton makes a new kind of atom!
Adding a neutron makes an isotope of that atom, a heavier version of that atom!

Jefferson Lab Web Site http://education.jlab.org/atomtour/listofparticles.html

Parts of the Atom



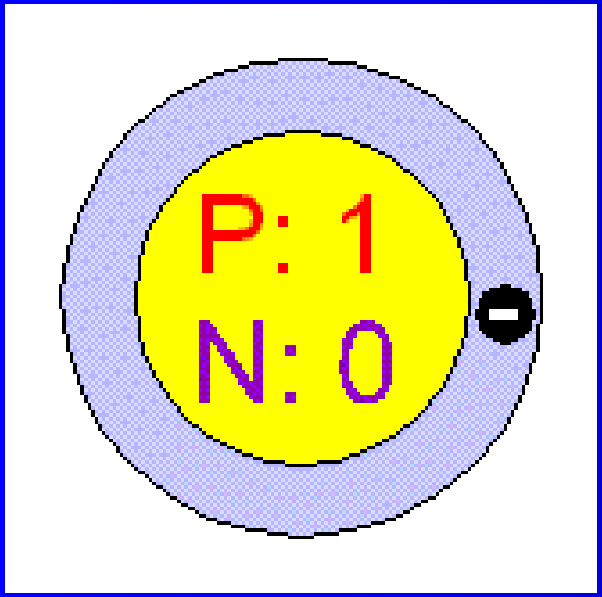
Jefferson Lab Web Site http://education.jlab.org/atomtour/listofparticles.html

The Atom

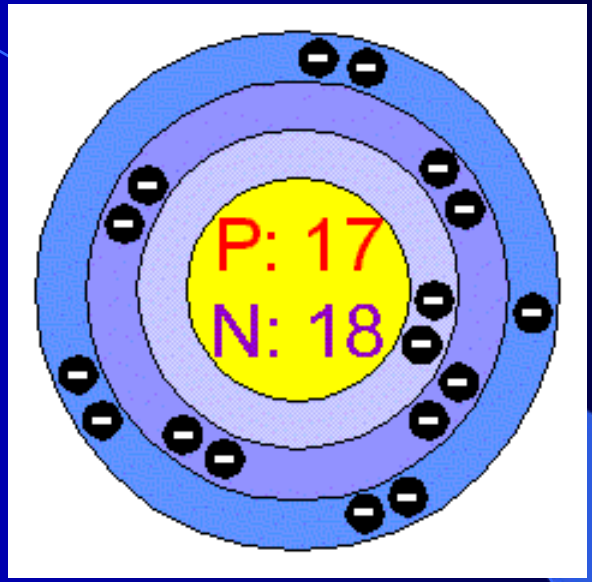
- Depending on the atom, there may be multiple shells filled with various amounts of electrons.

- The configuration of the atom, its nucleus size, the number of shells and the number of electrons in each shell determine an atoms chemistry and the way it will react with other atoms.

Models of Atoms



Hydrogen



Chlorine

Bentor, Yinon. Chemical Element.com - Hydrogen. Nov. 25, 2003 <http://www.chemicalelements.com/elements/h.html>.

The Atom

- Something to Ponder – If we blow up an atom to the size of Royals Stadium, the nucleus would be a small pea on the pitchers mound and the electrons would be floating around the upper deck.

The Atom

- Or……if a hydrogen atoms nucleus was blown up to a 1/2 inch diameter, the nearest electron would be 1/2 mile away.

The Atom

- There are 94 naturally occurring elements.
- Scientists have created 23 additional elements in the laboratory (as of 2008).
- Elements are arranged by atomic number into the Periodic Table of Elements.

Part 2 – The Periodic Table

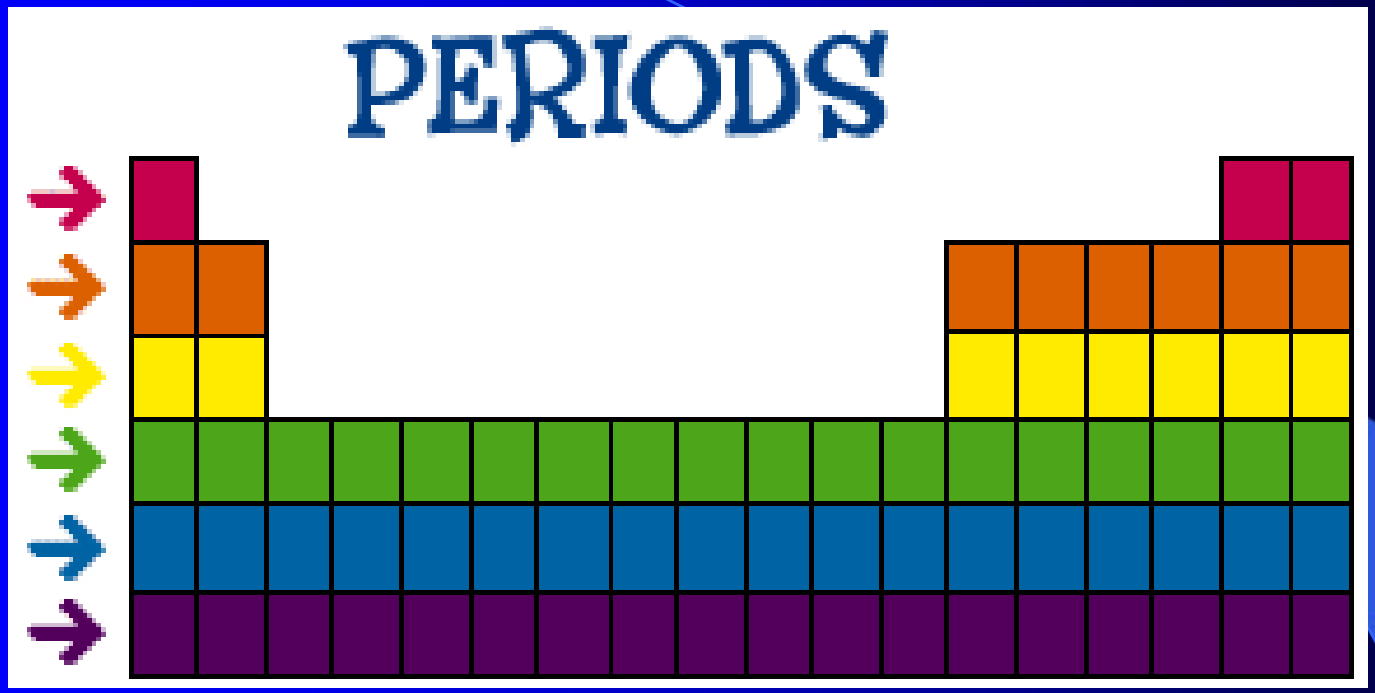
Periodic Table of Elements

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun								

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

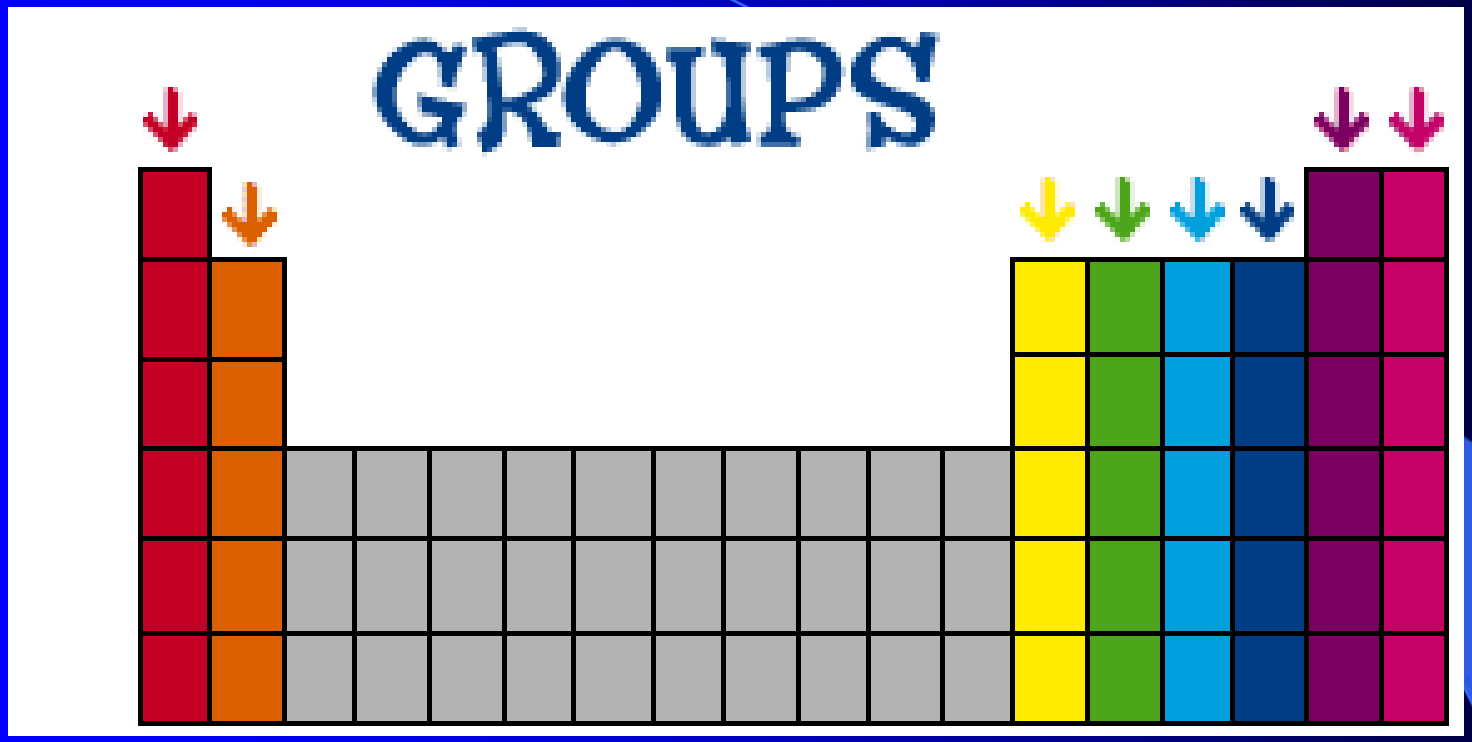
The Periodic Table of elements is arranged to illustrate patterns of recurring chemical and physical properties.

The Periodic Table -Rows



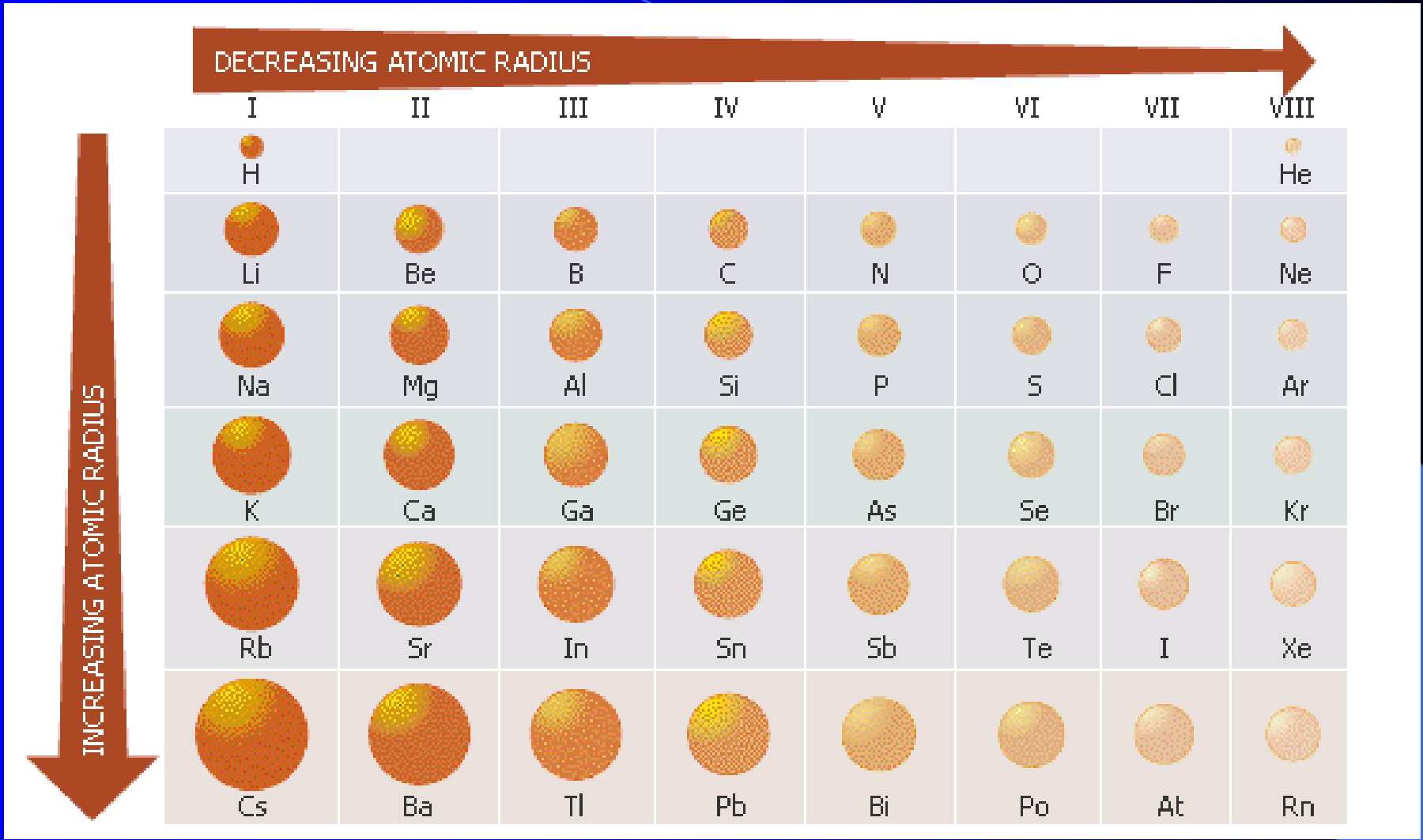
Elements in each row (or Period) of the table have the same number of electron shells. Each row down the periodic table adds a shell of electrons.

The Periodic Table – Groups



Elements in each group of the periodic table have the same number of electrons in the outer shell. They exhibit similar properties.

Size of Atoms



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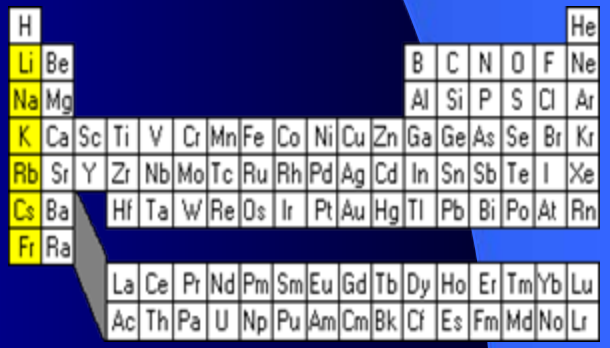
The Periodic Table

This arrangement of elements leads to groups of similar chemical which are often referred to by a family name.

Alkali Metals – Group 1

- Shiny, soft, low melting flammable metals.
- Reducing agents that react rapidly and often violently with water.
- Contain one electron in their outer shell.
- They are never found in nature in the pure state, but only in combination with other elements.

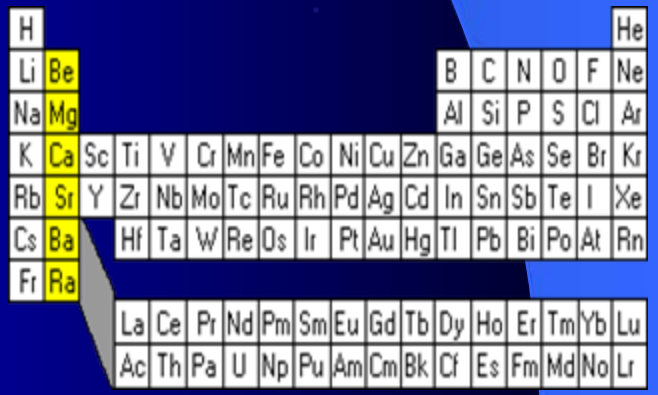
<u>H, Li, Na, K, Rb, Cs, Fr</u>



Alkaline Earth Metals – Group 2

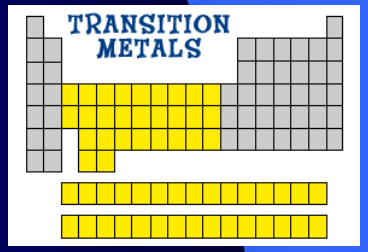
- Lustrous, silvery metals, less reactive than alkali metals.
- 2 electrons in outer shell.
- They are never found in nature in the pure state, but only in combination with other elements.

<u>Be, Mg, Ca, Sr, Ba, Ra</u>



Transition Metals – Groups 3-12

- All except Hg are solid at room temperature.
- Can be easily shaped (malleable) and drawn (ductile), good electrical conductors.
- Stable elements, some can cause long term environmental concerns



<u>39 elements plus the Rare Earth Series</u>

Non-Metals

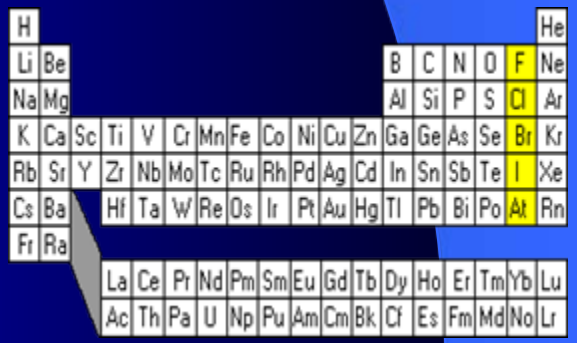
1. Do not conduct heat or electricity very well.
2. The solid non-metals are brittle.
3. Some of the most abundant elements on earth.

<u>H, C, N, O, P, S, Se</u>

Halogens – Group 17

1. Very reactive, 7 electrons in outer shell, corrosive and non-metallic.
2. All are found in nature, but only in combination with other elements.
3. Halogen comes from the Greek word *halos* meaning salt. Halogens commonly form salts.

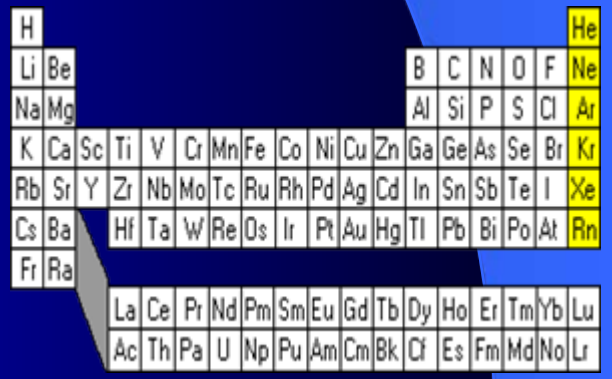
<u>F, Cl, Br, I, At</u>



Nobel Gases – Group 18

1. Very low reactivity, stable elements.
2. He, Ne, Ar don't combine with any other elements, Kr and Xe combine with very few.
3. 8 electrons in outer shell.

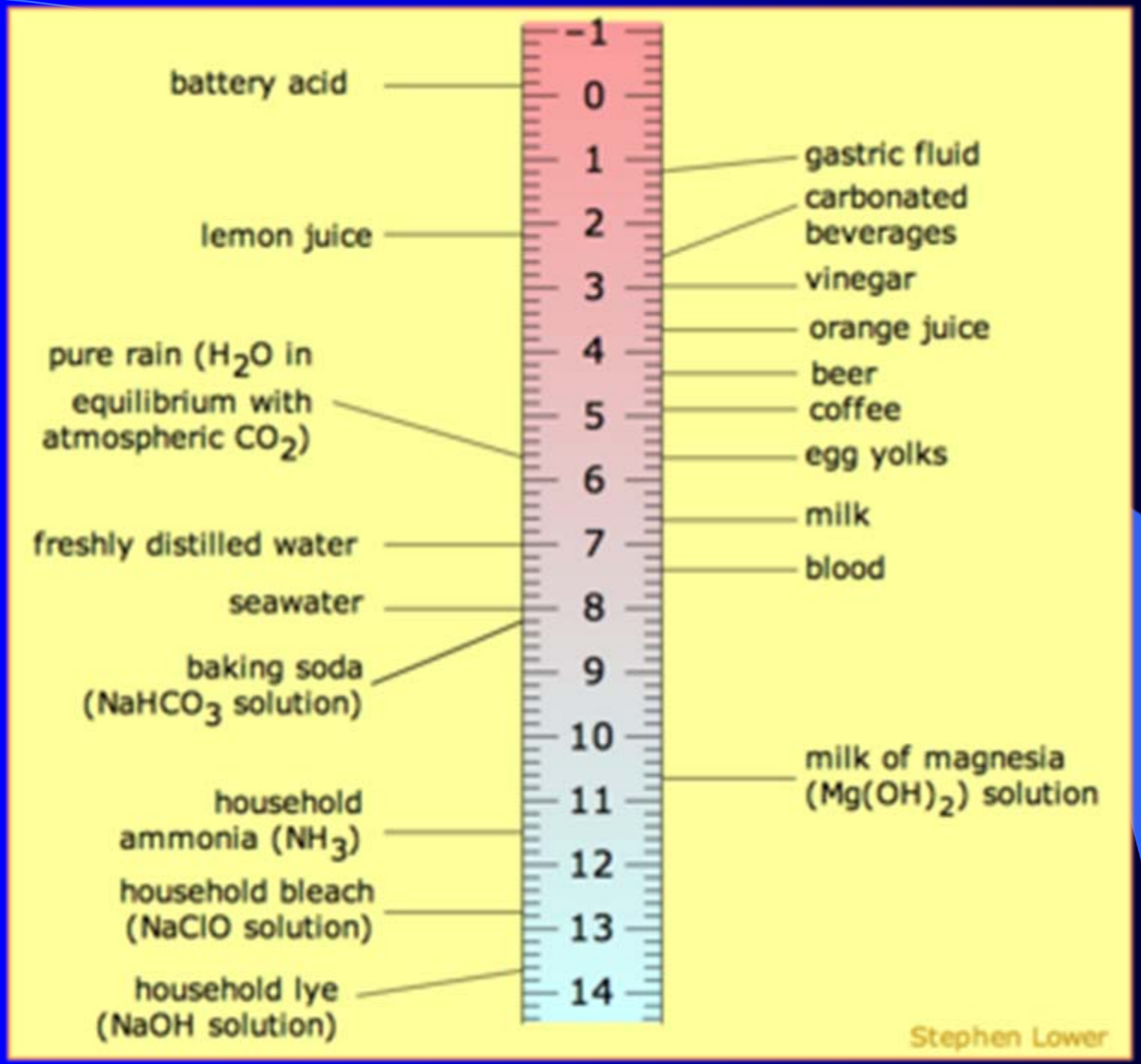
<u>He, Ne, Ar, Kr, Xe, Rn</u>



Part 3 - pH

pH

- pH is the measure of acidity or basicity of a solution.
- Most measured pH values will fall into the range of 0 – 14.
- A pH of 7 is considered neutral.
- A pH of less than 7 is considered an acid.
- A pH of greater than 7 is considered a base.

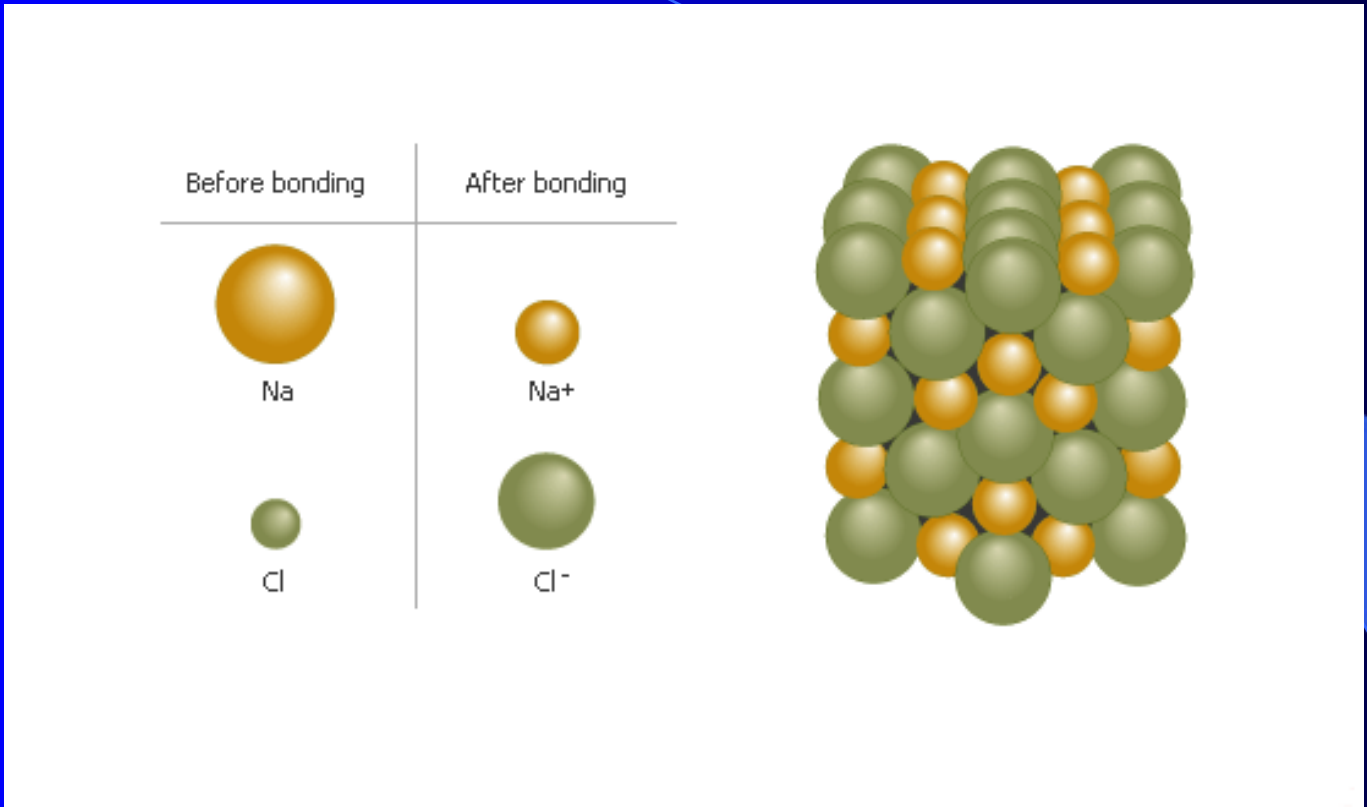

-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
battery acid
lemon juice
pure rain (H_2O in equilibrium with atmospheric CO_2)
freshly distilled water
seawater
baking soda ($NaHCO_3$ solution)
household ammonia (NH_3)
household bleach (NaClO solution)
household lye (NaOH solution)
gastric fluid
carbonated beverages
vinegar
orange juice
beer
coffee
egg yolks
milk
blood
milk of magnesia ($Mg(OH)_2$) solution
Stephen Lower

Part 4 – Molecules and Compounds

Molecules

- A molecule is two or more atoms linked by a chemical bond.
- If atoms share electrons, then the bond is a **covalent** bond.
- If an atom gives up an electron to another atom, then the bond is an **ionic** bond.

Ionic Bonding



Ionic bonds are held together by strong electrostatic attractions.

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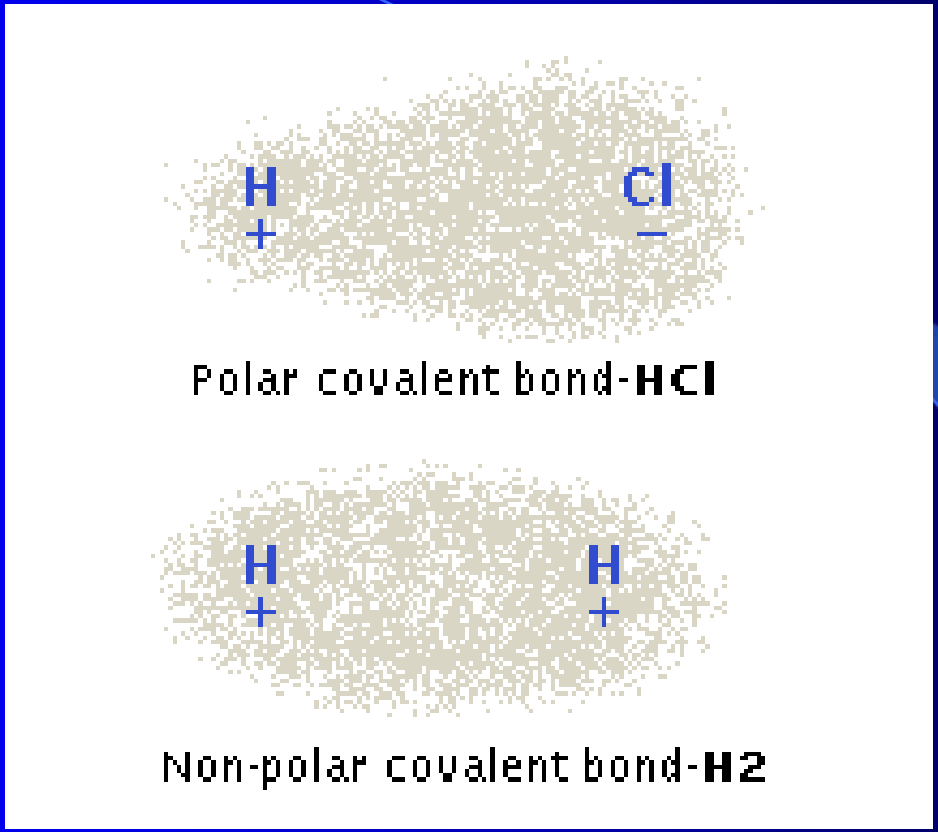
Covalent Bonding



In a covalent bond electrons are shared by atoms.

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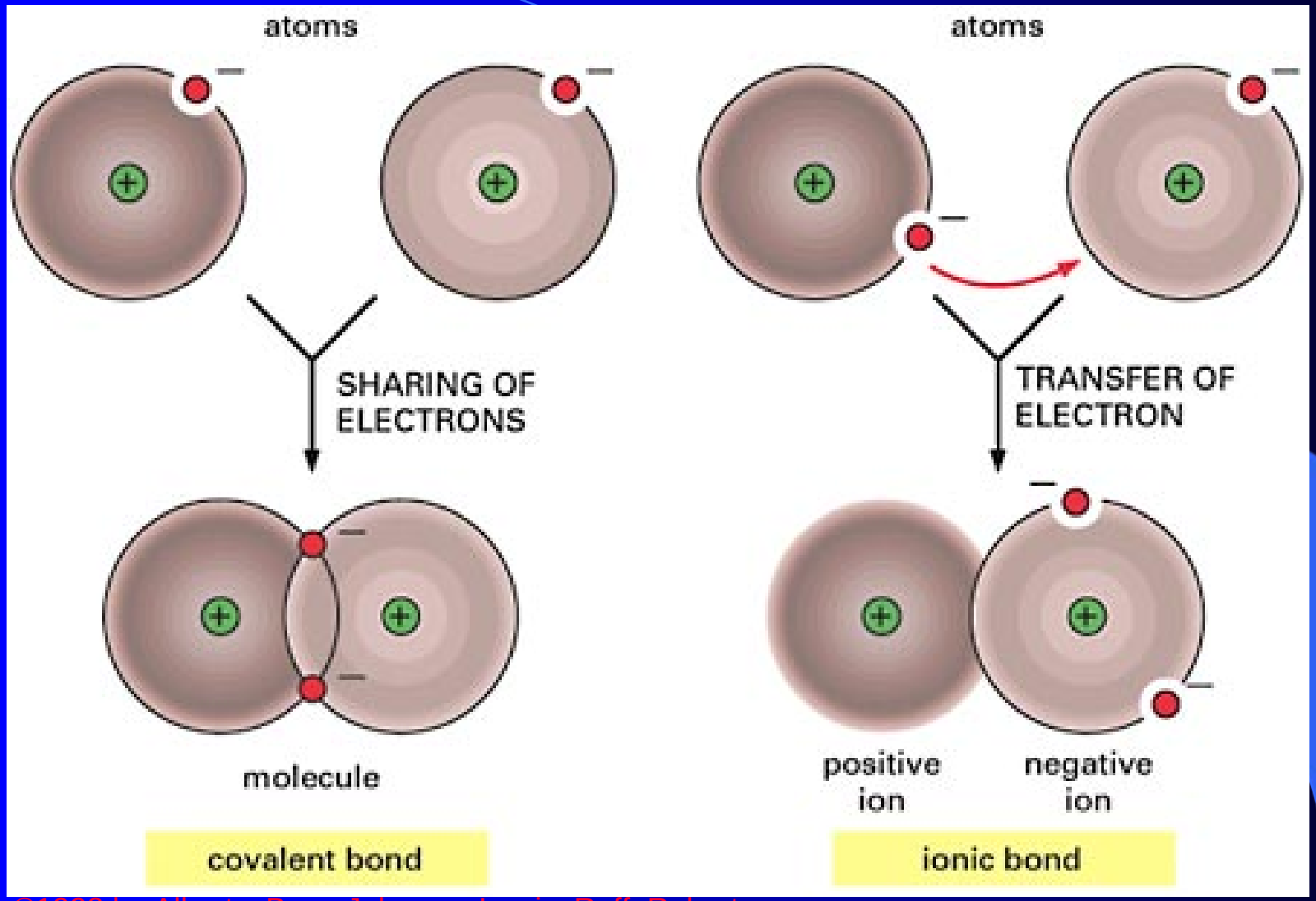
Ionic and Covalent Bonds



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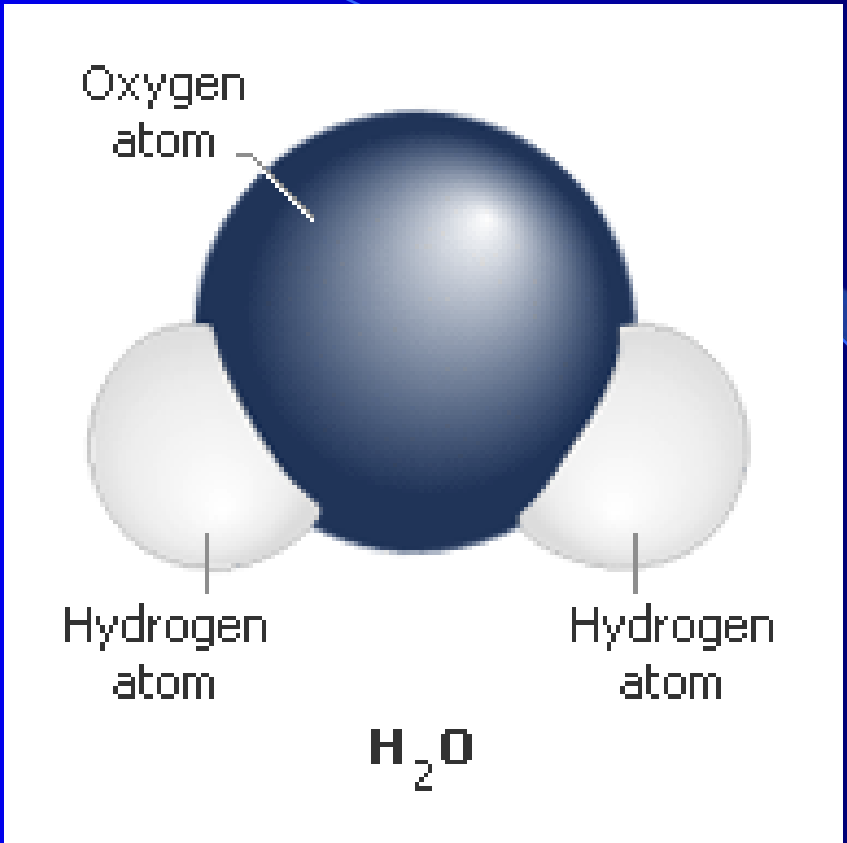
Water Molecule



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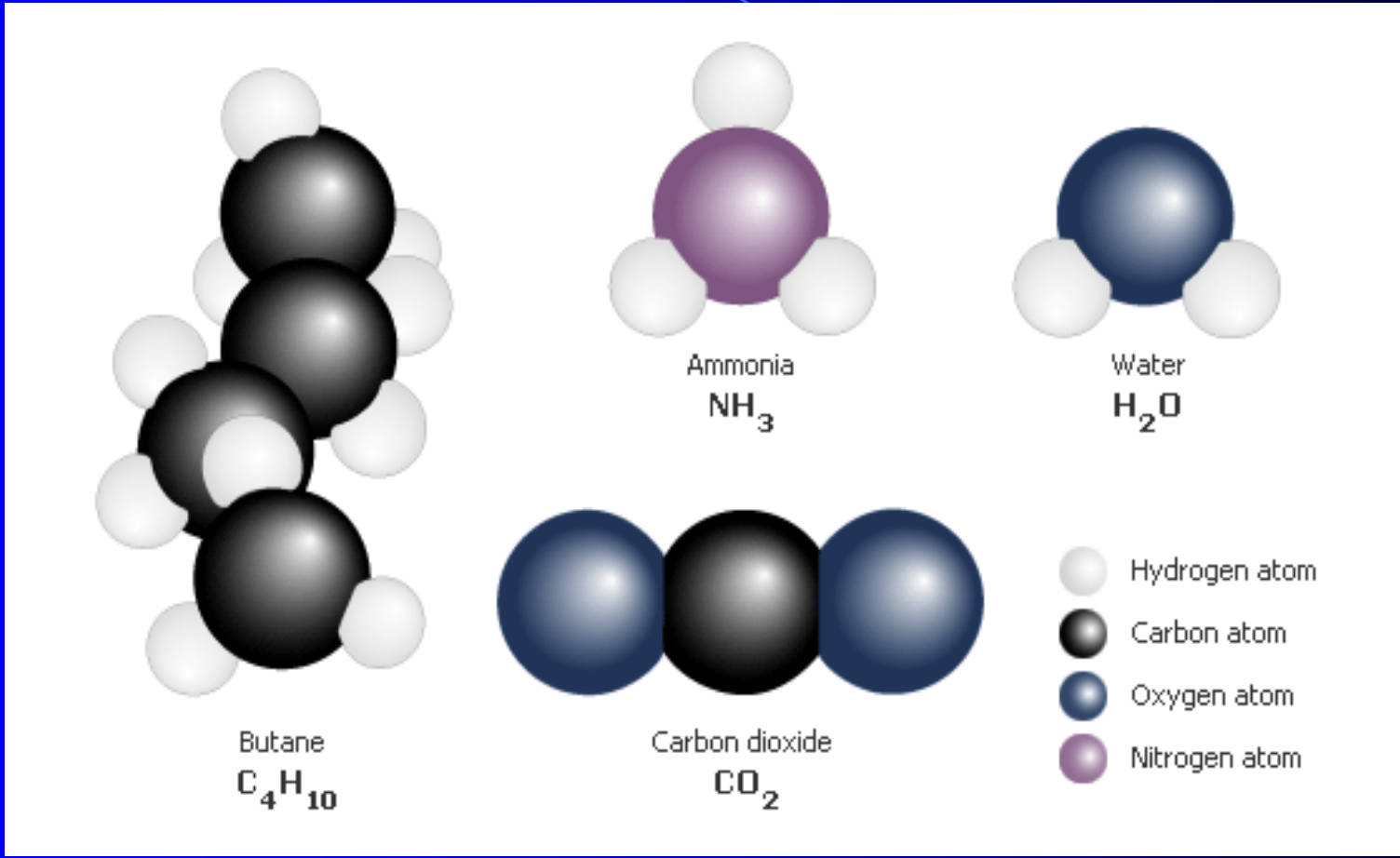
Various Molecules



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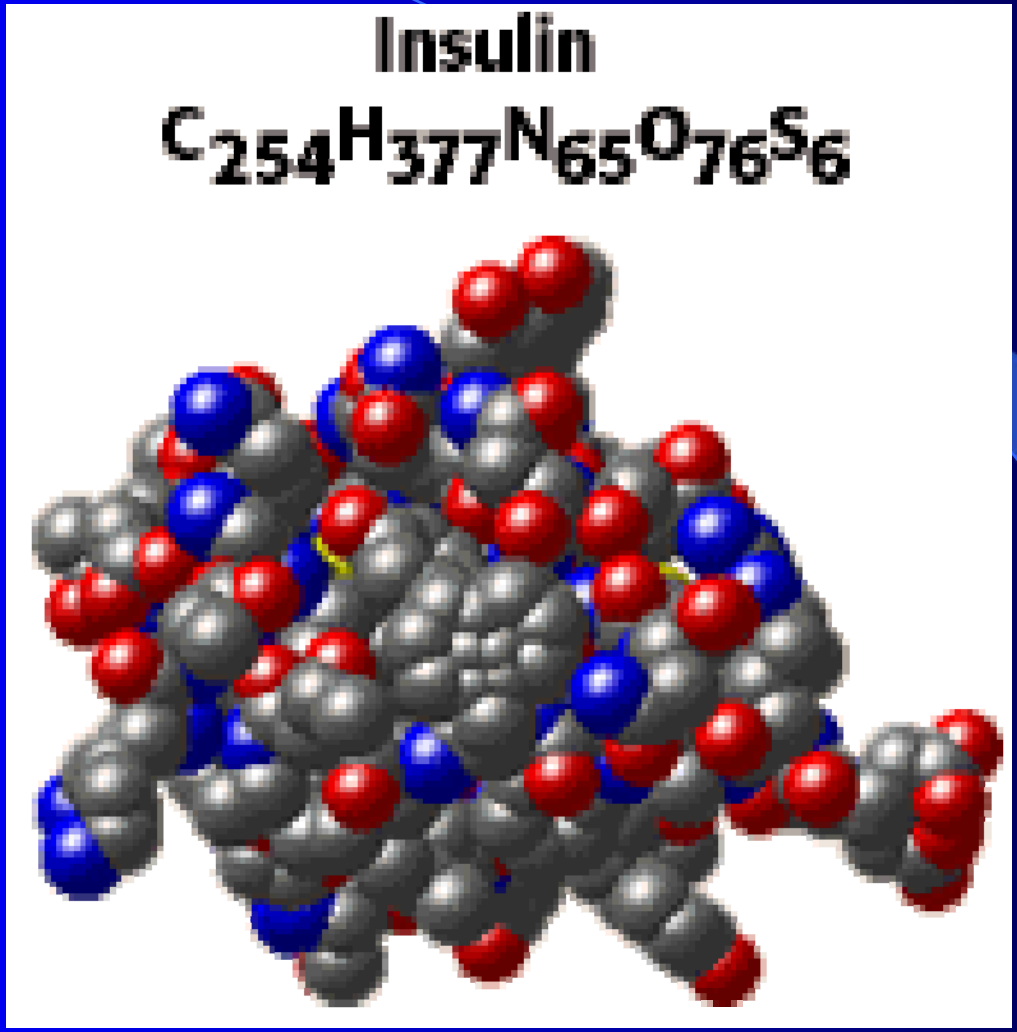
Insulin Molecule



http://www.biology.arizona.edu

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Inorganic Chemicals

- Chemical compounds that do not contain any hydrocarbons (hydrogen and carbon) bonded together in their structure.

Radicals or Ions

- Mostly nonmetals covalently bonded which act as a single element:

Formula	Common Name
H^{-1}	hydride
OH^{-1}	hydroxide
O^{-2}	peroxide
CN^{-1}	cyanide
NH_4^{+1}	ammonia
CO_3^{-2}	carbonate
PO_4^{-3}	phosphate
NO_3^{-1}	nitrate
SO_4^{-2}	sulfate
ClO_4^{-1}	perchlorate
ClO_3^{-1}	chlorate

Salts

- Metal + nonmetal
- Ionic bonds, mostly solid
- Often water soluble or water reactive
- Mostly noncombustible
- May be very toxic
- Most common oxidizers

Salts from mercury, barium, thallium, chromium or other transition metals

Binary Salts
(Metal + nonmetal ends in "–ide")

- Several are very toxic.
- Extremely water reactive.
- W/ water produce caustic solutions, flammable and/or toxic gas, heat.

NaH (sodium hydride)

AlP (aluminum phosphide)

Ca_2C (Calcium carbide)

Na_3N (sodium nitride)

Oxysalts

(metal + oxyradical ends in “–ate or –ite”)

- Strong oxidizers, water soluble, w/ fire release toxic gases.

KNO_3 (potassium nitrate)

$NaClO_4$ (sodium perchlorate)

NH_4NO_3 (ammonium nitrate)

$CaClO$ (calcium hypochlorite)

Peroxides
(metal + O_2 radical ends in “peroxide”)

- Strong oxidizers, extremely water reactive, w/ water produce: heat, O_2 gas, corrosive effect on skin.

Na_2O_2 (sodium peroxide)

K_2O_2 (potassium peroxide)

MgO_2 (magnesium peroxide)

Metal Oxides
(metal + O_2 ends in “oxide”)

- Water reactive, w/ water product: heat, caustic solutions.

Na_2O (sodium oxide)

K_2O (potassium oxide)

MgO (magnesium oxide)

CaO (calcium oxide)

Metal Cyanides

metal + cyanide ends in “cyanide”

- Poisonous, extremely toxic, w/ acid produces lethal gas (HCN).

NaCN (sodium cyanide)

KCN (potassium cyanide)

$Ca(CN)_2$ (calcium cyanide)

Metal Hydroxides (Bases)

(metal + OH ends in “Hydroxide”)

- Water reactive, corrosive, w/ water produces: heat, caustic solution.

NaOH (sodium hydroxide)

KOH (potassium hydroxide)

$Ca(OH)_2$ (calcium hydroxide)

Binary Nonsalts
(nonmetal + nonmetal ends in “-ide”)

- Mostly gases and liquids, may be very reactive with water – produce acid gas, toxic, may be flammable or nonflammable.

B_2H_6 (diboron)

NH_3 (ammonia)

PH_3 (phosphine)

Nonmetal Oxides

(nonmetal + 0_2 ends in "-oxide")

- Mostly gases, oxidizers, may be produced in fires, very toxic, produce "white cloud" fuming effect with water, mostly nonflammable, water reactive, skin reactive to form oxyacids.
- SO_2 (sulfur dioxide)
- SO_3 (sulfur trioxide)
- NO_2 (nitrogen dioxide)

Acids

(H + nonmetal (VI & VII), ends in “-ide” or “ic acid”)

- Very corrosive, very toxic, nonflammable.

- HCl (Hydrogen Chloride, Hyrdochloric Acid)
- HF (Hydrogen Fluoride, Hydrofluoric Acid)
- H_2SO_4 (sulfuric acid)
- HNO_3 (nitric acid)

Inorganic Peroxides
(nonmetal + O2 radical, ends in “peroxide”)

- Toxic in stronger concentrations, strong oxidizer, corrosive, not water reactive, w/ combustible material may burst into flame.

H_2O_2 (hydrogen peroxide)

Organic Chemicals

- Chemical compounds that do contain hydrocarbon bonds in their chemical structure.

Saturated Hydrocarbons
Alkane Family

- Contain twice as many H than C, single bonds, highly flammable, gases heavier than air (except methane), heavier compounds are very toxic and can be neurotoxin and cause partial paralysis.

CH_4 (methane)

C_2H_6 (ethane)

C_3H_8 (propane)

C_4H_{10} (butane)

Unsaturated Hydrocarbons Alkene and Akyne Family

- Not as many H to C as the alkanes, double bonds, polyunsaturated (more than one double bond), triple bonds, can spontaneously combust w/ air, can self polymerize, highly reactive, man made compounds.

C_2H_4 (ethene)

C_3H_6 (propene)

C_2H_2 (ethyne)

C_3H_4 (propyne)

Aromatic Hydrocarbons

- H to C ratio is almost even, form carbon rings or resonant bonds,very sweet and pleasant odor, very toxic, very unreactive, act as an anesthetic or narcotic.

C_6H_6 (benzene)

$C_6H_5CH_3$ (toluene)

$C_6H_4(CH3)_2$ (xylene)

Halogenated Hydrocarbons

- Hydrocarbons in which H is substituted for halogens, most are very toxic, can cause liver and nervous system damage, flammability decreases as you add halogens, generally insoluble in water, readily absorbed through the skin, can cause long term environmental problems.

- $CHCl_3$ (trichloromethane or chloroform)
- CH_2Cl_2 (dichloromethane or methylene chloride)
- $C_2F_4Cl_2$ (tetrafluordichloroethane or Freon 114)
- CCL_4 (tetrachloromethane or carbon tetrachloride)
- $C_{14}H_9CL_5$ (DDT)

Alcohols

- Characterized by the hydroxyl group (-OH) attached to the hydrocarbon group, liquids at room temperature, very flammable, water soluble up to five carbon chains, considered toxic by ingestion, inhalation, and skin absorption.

- CH_3OH (methanol)
- C_2H_5OH (ethanol)
- C_3H_7OH (propanol)
- $C_2H_4(OH)_2$ (ethane diol or ethylene glycol)

Ethers

- Two hydrocarbon chains connected by an oxygen molecule, highly flammable/explosive, spontaneous combustion possible, rapid rate of vaporization, lower chain ethers have a high vapor density and will collect in low lying areas.

- $CH_3OC_4H_{10}$ (methyl tert-butyl ether or MTBE)
- $C_2H_5OC_2H_5$ (ethyl ether or starting fluid)

Ketones

- Hydrocarbons with an oxygen double bond to one of the carbons in the chain, moderately toxic, flammable, shorter chain ketones are water soluble, larger ketones are slightly soluble.

- C_3H_6O (propanone or acetone)
- C_4H_8O (butanone or methyl ethyl ketone)

Aldehydes

- Very similar to ketones except the oxygen is bonded to the last carbon on the chain, many are toxic and flammable, water solubility similar to ketones.

- CH_2O (methanal or formaldehyde)
- C_2H_4O (ethanal or acetaldehyde)

Organic Acids

- Structured like an aldehyde with a hydroxyl (-OH) added next to it, corrosive but not as strong as the binary or oxy acids, flammable but difficult to ignite below 80% in water.

CH_2O_2 (methanoic acid or formic acid)

$C_2H_4O_2$ (ethanoic acid or acetic acid)

$C_4H_8O_2$ (butanoic acid or butyric acid)

Amines

- Have a nitrogen in or attached to the carbon chain; liquids at room temp, water solubility similar ketones, highly volatile, toxic, flammable, readily absorbed by the skin.
- CH_3NH_2 (methylamine)
- C_6H_5NH (benzenamine or aniline)
-

Cyanides or Nitriles

- Carbon chains with a –CN group attached; severe skin irritants, toxic but not to the degree of the CN salts, often flammable and can decompose to form CN gas, very reactive.

- CH_3CN (methyl cyanide or acetonitrile)
- C_2H_3CN (vinyl cyanide or acrylonitrile)

Nitro Compounds

- Identified by NO2 attached to a hydrocarbon chain; extremely unstable, flammable, toxic, readily absorbed through skin.

- CH_3NO_2 (nitromethane)
- $C_3H_5N_3O_9$ (nitroglycerine)
- $C_7H_5N_3O_6$ (tri-nitrotoluene)

Organophosphates

- Complex bonding structures involving carbon chains, rings, oxygen, sulfur and phosphorus atoms; oily liquids varying in water solubility, toxic to a wide range of insects and humans, affect the central nervous system, do not tend to bioaccumulate.

- $C_{10}H_{19}O_6PS_2$ (malathion)
- $C_{10}H_{19}NO_5PS_2$ (parathion)
- $C_{12}H_{21}N2O_3PS$ (diazinon)

Carbamates

- Complex bonding of hydrocarbon chains involving nitrogen; generally crystalline solids sparingly soluble in water, toxic but less toxic than organophosphates, have greater degradability then organophosphates.

- $C_{12}H_{11}NO_2$ (Carbaryl)
- Aldicarb
- Sevin

Dioxins

- The terms dioxins and dioxin-like compounds commonly refer to a broad class of highly toxic organic compounds that are long term persistent environmental pollutants.
- Most are dioxins are bi-products of the manufacturing process.
- 2,4,5 T herbicide
- Silvex herbicide
- Agent Orange