Honors Bio/CP Chem
Mr. Dooner/CHS
Intro Chem Notes

INTRODUCTORY CONCEPTS

ELEMENT: one of the 107(+) presently known fundamental substances **that cannot be broken down** chemically into any simpler substance
NOTE: Only 90 are naturally occurring; the **"transuranium"(after Uranium) elements were synthesized** and identified in laboratory experiments through the use of nuclear accelerators

- most of the symbols are simply the first one or two letters of the element name, such as "H"(Hydrogen) and "Al"(Aluminum), but others("Na"= "natrium"= sodium) are derived from Latin or other language names

- although many of the elements may seem unfamiliar, at least 20 are essential for human life

- 99% of the elements comprising living organisms are:
  - C- CARBON
  - H- HYDROGEN
  - O- OXYGEN
  - N- NITROGEN
  - P- PHOSPHORUS
  - S- SULFUR

- the other 1% required in organisms are called TRACE ELEMENTS:

  - Calcium- Ca
  - Iron- Fe
  - Magnesium- Mg

ATOMS: the smallest and simplest piece that an element can be broken into while still maintaining the chemical properties of the element

SUBATOMIC PARTICLES: an elementary particle from which atoms are made

PROTON- a positively(+) charged subatomic particle found in the nucleus

NEUTRON- an electrically neutral subatomic particle found in the nucleus

ELECTRON- a negatively(-) charged subatomic particle found around the nucleus at a distance

ATOMIC MASS UNIT:(amu) a convenient unit of mass on the atomic scale; approximately equal to the mass of a proton or neutron

DALTON: an alternate name for Atomic Mass Unit

ATOMIC NUMBER: the primary characteristic that distinguishes atoms of different elements; it equals the number of PROTONS in an atom's nucleus

ATOMIC # = # of PROTONS

MASS NUMBER: the sum of an atom's PROTONS and NEUTRONS

MASS # = # PROTONS + # NEUTRONS

***** the most important characteristic of protons and electrons is that they are ELECTRICALLY CHARGED

- 2 protons REPEL each other
- 2 electrons REPEL each other
- a proton and an electron ATTRACT each other

****** each atom contains an EQUAL number of protons and electron so that overall they are electrically neutral; they have NO NET CHARGE(IN THEIR NATURAL STATE)

****** in general, atoms contain at least as many neutrons as protons, but there is no simple way to predict how many neutrons a GIVEN atom will have

ATOMS AND MOLECULES

MOLECULE: a group of atoms BONDED together in a DISCRETE UNIT

CHEMICAL REACTION: a chemical CHANGE brought about by making and breaking bonds between atoms

CHEMICAL COMPOUND: a chemical substance formed by joining together atoms of different elements

REACTANT: a STARTING substance that undergoes change in a chemical reaction

PRODUCT: a substance formed AS A RESULT of a chemical reaction

LAW OF DEFINITE PROPORTIONS

- every chemical compound is formed by a combination of elements in a DEFINITE PROPORTION
  - atoms join together in a definite composition to make molecules
  - this is one of the CORNERSTONES of Chemistry

  - elements NEVER combine in random to make compounds
  - All water molecules, for example, consist of 2 hydrogen atoms and 1 oxygen atom
  - ALL sucrose molecules, for example, consist of 12 carbon atoms, 22 hydrogen atoms, and 11 oxygen atoms

THE PERIODIC TABLE

PERIODIC TABLE: the standard chart displaying the elements in order of increasing atomic number so that elements with SIMILAR PROPERTIES fall into GROUPS

PERIOD: a HORIZONTAL ROW of elements in the Periodic Table; elements are listed in order of INCREASING ATOMIC NUMBER

GROUP: a VERTICAL column of elements in the Periodic Table

***** ELEMENTS IN A GROUP HAVE SIMILAR CHEMICAL PROPERTIES**

MAIN GROUP: an element on the FAR RIGHT(Groups 3A- 8A) or the FAR LEFT(Groups 1A- 2A) of the Periodic Table

TRANSITION METAL GROUP: an element group in the MIDDLE(1B- 10B) of the Periodic Table

ALKALI METAL: an element in Group 1A of the Periodic Table
(Li, Na, K, Rb, Cs, Fr)

ALKALINE EARTH METAL: an element in Group 2A of the Periodic Table
(Be, Mg, Ca, Sr, Ba, Ra)

HALOGEN: an element in Group 7A of the Periodic Table
(F, Cl, Br, I, At)

***** NOBLE GAS: an element in Group 8A of the Periodic Table**
(He, Ne, Ar, Kr, Xe, Rn)

METAL: a **MALLEABLE** element with a **LUSTROUS** appearance that is a good **CONDUCTOR** of heat and electricity

NONMETAL: an element on the RIGHT SIDE of the Periodic Table that is a **POOR CONDUCTOR** of heat and electricity

GROUP CHARACTERISTICS OF THE ELEMENTS

GROUP 1A: ALKALI METALS

- Lithium, sodium, potassium, rubidium, and cesium are **SHINY, SOFT, LOW MELTING METALS; ALL REACT VIOLENTLY WITH WATER**
- because of their HIGH REACTIVITY, the Alkali Metals are NEVER found in nature in the pure state but only in chemical combination with other elements

GROUP 2A: ALKALINE EARTH METALS

- Beryllium, magnesium, calcium, strontium, barium, and radium are also LUSTROUS, SILVERY METALS, but all are **LESS REACTIVE THAN THEIR NEIGHBORS IN GROUP 1A**

GROUP 7A: HALOGENS

- Fluorine, chlorine, bromine, iodine, and astatine are **REACTIVE, CORROSIVE, NONMETALS;** the halogens in nature are found only in combination with other elements, such as sodium in table salt(sodium chloride)
- the name "Halogen", in fact, derives from the Greek word "Hals" meaning "salt"

GROUP 8A: NOBLE GASES

- Helium, neon, argon, krypton, xenon, and radon are **gases of EXTREMELY LOW REACTIVITY**
- Helium, neon, and argon don't react with any other element; krypton, xenon, and radon react with very few

METAL/NONMETAL DIVIDING LINE

- the dividing line follows a ZIG-ZAG path angling from BORON at the top middle of the Table to the lower right hand corner

LEFT OF THE LINE: Metallic Properties

RIGHT OF THE LINE: non-metals(solid, liquid, and gas)

ISOTOPES: atoms of the SAME ELEMENT that have DIFFERENT numbers of NEUTRONS in their nuclei

*******ISOTOPES HAVE THE SAME ATOMIC NUMBERS BUT DIFFERENT MASS NUMBERS**

- for example, Hydrogen has three isotopes:

PROTIUM- one proton and NO Neutrons
MASS # = 1

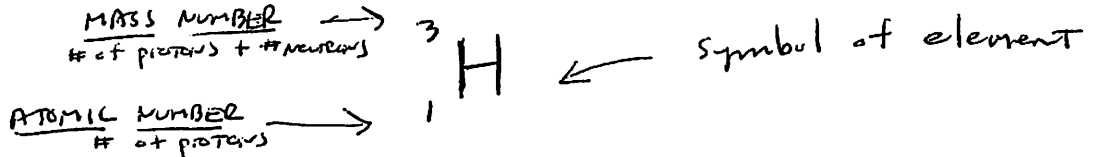
DEUTERIUM- one proton and one neutron
MASS # = 2

TRITIUM- one proton and two neutrons
MASS # = 3

*** if we had a large number of hydrogen atoms, we would find that 99.985 % of them had a Mass # 1(Protium) and 0.015 % had Mass # 2(Deuterium)

*****the AVERAGE mass of a large number of an element's atoms is called the element's ATOMIC WEIGHT(ATOMIC MASS)**
***** Hydrogen has an atomic mass of 1. 008**

- different isotopes are represented by a format in which the mass number is given as a SUPERSCRIPT and the atomic number is given as a SUBSCRIPT



*** the example above is an isotope of Hydrogen called Tritium which has one proton and two neutrons

NAMES AND SYMBOLS FOR SOME COMMON ELEMENTS

Al- Aluminum
Ar- Argon
Ba- Barium
B- Boron
Br- Bromine
Ca- Calcium
C- Carbon
Cl- Chlorine
F- Fluorine
Na- Sodium
He- Helium
H- Hydrogen
I- Iodine
Li- Lithium
Mg- Magnesium
Mn- Manganese
N- Nitrogen
O- Oxygen
P- Phosphorus
Si- Silicon
S- Sulfur
Zn- Zinc
Cu- Copper
Fe- Iron
Pb- Lead
Hg- Mercury
K- Potassium
Ag- Silver

The Structure of Atoms

TERMS:

Nucleus: the dense, positively charged mass at the center of an atom where protons and neutrons are located

ENERGY LEVEL(Shell): an imaginary layer surrounding an atom's nucleus where electrons are located

SUB- ENERGY LEVEL(Sub-Shell): a subregion of an Energy Level where electrons of the same energy are located

ORBITAL: a specifically shaped region of space around an atom, denoted by **s, p, d**, or **f,** where electrons of a specific energy level are found

ELECTON CONFIGURATION: the specific way that an atom's electrons are distributed into Energy Levels and orbitals

3 Rules for Determining Configurations

1. FIND THE ATOMIC NUMBER OF THE ELEMENT TO SEE HOW MANY ELECTRONS IT HAS.

2. BEGIN ASSIGNING ELECTRONS TO ORBITALS ACCORDING TO THE ORDER SHOWN ON THE CHART. FILL THE LOWEST ENERGY ORBITALS BEFORE MOVING TO HIGHER LEVELS. REMEMBER THAT EACH ORBITAL HOLDS ONLY 2 ELECTRONS AND NO MORE.

3. IF 2 OR MORE ORBITALS HAVE THE SAME ENERGY(FOR EXAMPLE, THE THREE "p" ORBITALS OR THE FIVE "d " ORBITALS, FILL ALL ORBITALS HALF-WAY BEFORE COMPLETELY FILLING ANY ONE OF THEM.

THE OCTET RULE

***** Atoms undergo reactions in order to attain a "noble- gas configuration" with 8(or 2 in the case of H and He)outer energy level electrons(i.e. "valence" electrons)**

- one way that atoms can attain a noble gas configuration is by either GAINING or LOSING an appropriate number of electrons

FOR EXAMPLE: when a Sodium atom loses one electron it becomes a positively charged Sodium "ION"

When a Chlorine atom gains an electron it becomes a negatively charged Chloride "ION"

***** Losing Electrons means the atom becomes a POSITIVE ION(+)**

***** Gaining Electrons means the atom becomes a NEGATIVE ION(-)**

IONS AND IONIC BONDS

ION: an electrically charged atom or group of atoms

CATION: a POSITIVELY CHARGED ION(+)

ANION: A NEGATIVELY CHARGED ION(-)

IONIC BOND: the electrical attraction between an ANION and a CATION

IONIC SOLID: a chemical compound held together by ionic bonds between ANIONS and CATIONS(i.e. NaCl)

IONIC COMPOUNDS: generally, metallic elements on the far left side of the Periodic Table are able to GIVE UP ELECTRONS and become POSITIVELY CHARGED CATIONS(Groups 1A, 2A)

- Non-metallic elements on the far right side of the Periodic Table are able to ACCEPT ELECTRONS and become NEGATIVELY CHARGED ANIONS(Groups 6A, 7A)

OXIDATION-REDUCTION REACTIONS

*** in describing the formation of IONS by the gain or loss of electrons, the terms OXIDATION and REDUCTION are often used

OXIDATION: the LOSS of electrons by a reactant in a chemical reaction

REDUCTION: the GAIN of electrons by a reactant in a chemical reaction

OXIDATION AGENT: the reactant that causes an oxidation by TAKING electrons

REDUCING AGENT: the reactant that causes a reduction by GIVING electrons

OXIDATION STATE: the charge of an ION

"REDOX" REACTIONS: a general term for a reaction by which oxidations and reductions occur

- Redox reactions are NOT limited to just the ALKALI and the ALKALINE EARTH METALS

- many of the TRANSITION METALS can also form CATIONS by giving up electrons

FOR EXAMPLE: ALUMINUM(Group 3A) gives up all 3 electrons in its outer energy level in reacting with Chlorine to form Aluminum Chloride, $AlCl_3$
NOTE: Al^{3+} has an OXIDATION STATE of +3)

COVALENT BONDS

- Ionic bonding does not account for the formation of all compounds

- for example, H, O, N, F, Cl, Br, and I all exist NOT as individual atoms but as DIATOMIC MOLECULES in which 2 atoms are bonded together-- H2, O2, N2, F2 etc

COVALENT BOND: a bond that results when 2 atoms **SHARE** one or more pairs of electrons

- Covalent Bonds are far more common that IONIC BONDS

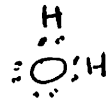
- almost all molecules in living things are held together by Covalent Bonds

COVALENCE: the number of **POSSIBLE** Covalent Bonds that could be formed by an atom of a particular element in a molecule

*** the number of possible bonds it could form is based on its Electron Configuration and its number of outer energy level(Valence) electrons; for example, CARBON in Group 4A with 4 Valence electrons has a Covalence of 4(8-4=4); HYDROGEN in Group 1A with 1 Valence electron has a Covalence of 1(2-1=1)

WAYS OF REPRESENTING MOLECULES:

LEWIS STRUCTURE: a way of representing molecules by using DOTS to represent outer energy level electrons



LINE BOND STRUCTURE: a way of respresenting molecules by using LINES between the element symbols to represent COVALENT BONDS

CONDENSED STRUCTURE: a shorthand way of representing molecules without showing individual bonds

H_2O

ELECTRO-NEGATIVITY:
*** the ability of an atom TO ATTRACT ELECTRONS to itself(i.e. within a molecule, one of the atoms will DISPROPORTIONATELY ATTRACT the electrons to itself because of its greater mass and more positively charged nucleus)
*** in an H2O molecule, we say that the OXYGEN atom is electronegative

POLAR COVALENT BOND:
*** a covalent bond in which one atom attracts bonding electrons MORE STONGLY than the other(s)

POLARIZED:

***** we say that a molecule is "Polarized" when it has a partial POSITIVE and partial NEGATIVE CHARGE as a result of being in a POLAR COVALENT BOND**

WATER IS A POLAR MOLECULE

HYRDOGEN BOND:
***** a WEAK attraction between a Hydrogen in one molecule and a nearby Oxygen, Nitrogen, or Fluorine in a nearby molecule**
***** it is an INTER-MOLECULAR ATTRACTION**
***** the negative side of one water molecule will be attracted to the positive side of an adjacent water molecule and this is called a HYDROGEN BOND**

WATER

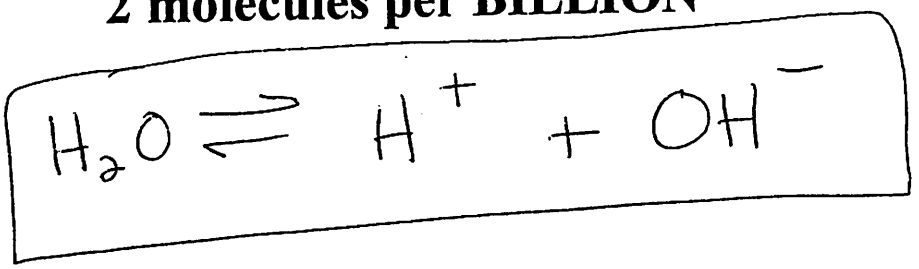
***** water molecules are POLAR and attracted to each other by HYDROGEN BONDS**
***** other types of molecules are characterized and defined by whether they are SOLUBLE(can dissolve) in water or not:**
1) HYDROPHILIC(water-loving); can dissolve; these are polar molecules
2) HYDROPHOBIC(water-fearing); cannot dissolve; nonpolar molecules

CHARACTERISTICS OF WATER:
1) Universal Solvent
2) Strong ADHESIVE and COHESIVE properties--i.e. surface tension
3) High heat capacity(specific heat)
4) High Boiling Point and Melting Point- it takes high energy input to change states
5) LESS Dense when it freezes than when liquid- i.e. ice floats
6) High thermal conductivity- i.e. distributes heat well

pH of a SOLUTION

*** pH is a measure of the ACIDITY or ALKALINITY of a solution
*** many molecules DISSOCIATE when dissolved in water-- they come apart and form IONS

*****Water molecules themselves DISSOCIATE(come apart) about
2 molecules per BILLION

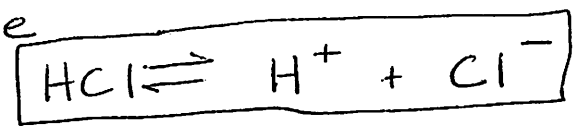


***pH measures how many H+(Hydrogen ions) are in a solution

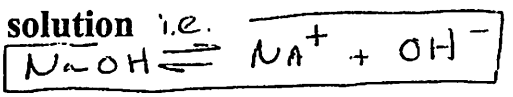
- molecules can be characterized as releasing hydrogens(H+) or Hydroxyls(OH-)

- pH was first described by a German chemist in 1909 and stands for "potenz" Hydrogen which means "power" or "Concentration" or "potential of" Hydrogen

ACIDS:
Release H+ when dissolved i.e.



BASES:
Release OH- when dissolved or "take up" H+ from a solution i.e.



PH Levels: Cells are VERY sensitive to ACIDITY levels

PH Scale:
***the scale is LOGARITHMIC; i.e. pH of 6 is TEN times more ACIDIC than a pH of 7
*** the scale goes from 0 to 14 with "7" being pure water in which the number of H+ is EQUAL TO the number of OH-
*** low pH values correspond to a strongly acidic solution
*** high pH values correspond to a strong basic solution

Some Common Acids:

Acetic Acid	**CH3COOH**
Hydrochloric Acid	**HCl**
Nitric Acid	**HNO3**
Phosphoric Acid	**H3PO4**
Sulfuric Acid	**H2SO4**

Some Common Bases:

Ammonia	**NH4**
Carbonate Ion	**HCO3**
Sodium Hydroxide	**NaOH**

CHEMICAL REACTIONS

- molecules interacting with each other to either MAKE or BREAK BONDS is what is occurring in Chemical Reactions; the molecules are in MOTION
- KINETIC ENERGY is the energy of MOTION
- the STATE of the MOLECULE(solid, liquid, gas) is largely dependent upon the amount of ENERGY they possess

***** CHEMICAL REACTIONS ARE EITHER SYNTHETIC or DEGRADATIVE**

1) SYNTHETIC REACTIONS: molecule building in which atoms bond together; Energy is required to form Bonds

2) DEGRADATIVE REACTIONS: bonds are broken(with input of energy) and energy is released(in living organisms a molecule called ATP(adenosine triphosphate) captures that energy for future use by the cell