BIG CHEM REVIEW NOTES

ACCURACY comparison to an accepted standard.

PRECISION gives consistent results. (Something can be precisely inaccurate.)

SIGNIFICANT DIGITS those that can be accurately measured. An answer can have no more significant digits than the least number of them in the data.

DENSITY is equal to mass/volume.

HETEROGENEOUS materials are not uniform throughout.

HOMOGENEOUS materials are the same throughout. All solutions are homogeneous.

PHYSICAL PROPERTIES are such things color, density, hardness, ductility, malleability, solubility, heat conduction, electrical properties, melting and boiling point.

CHEMICAL PROPERTIES are such things as reactivity, oxidation states, flammability, and corrosiveness.

CHEMICAL SYMBOLS are abbreviations for the elements.

CHEMICAL FORMULAS show which elements are present and their ratios.

CHEMICAL EQUATIONS show what reacts with what, what new substances are formed, and their reacting ratios.

*** PRACTICE balancing all types of equations & REDOX!

OXIDATION NUMBERS or VALENCES are the number or electrons lost, gained or shared in a chemical reaction. Free

elements have zero as an oxidation number.

EMPIRICAL FORMULA is the simplest whole number ratio of elements in a compound, ie CH_2.

MOLECULAR FORMULA shows the actual number of atoms in compound. Ex. C_2H_4.

THE MOLE is the number of atoms in the atomic mass of an element or the number of molecules in the molecular mass of a compound. It = 6.02×10^{23} atoms or molecules.

PERCENTAGE COMPOSITION can be found by totaling the atomic masses of the atoms in the formula, dividing each mass by the total, and changing the results to %-age.

WRITING and BALANCING equations should be reviewed in your Big Chem notebook. Try them with the solutions covered, then check your results.

PROBLEM SOLVING can best be reviewed by working the examples in your chemistry notebook. Try them first without peeking at the solutions. Then spend your time on those that you failed to solve.

ACTIVATION ENERGY is the minimum energy required to start a chemical reaction.

EXOTHERMIC REACTION gives out more energy than was put in to start the reaction. It has a negative delta H. It keeps going after it is started. An example is a fire.

ENDOTHERMIC REACTION takes more energy to start it than it gives back. It has a positive delta H. It needs energy to keep it going. An example is cooking. (Chippers a baking!)

ENTHALPY is the heat of reaction, either exo- or endothermic. It is measured either in kilocalories/mole or kilojoules/mole.

DALTON'S LAW of DEFINITE PROPORTIONS states that every compound has a definite composition by weight. Ah, the formulas.

THE LAW of CONSERVATION of MATTER states that matter cannot be created nor destroyed, but only changed in form. For example matter and mass can be interchanged.

THE LAW OF CONSERVATION of ENERGY states that energy cannot be destroyed nor created, but only changed in form. Ex. heat --> electricity --> light, etc.

THE LAW of MULTIPLE PROPORTIONS shows that some compounds have formulas that are whole number multiples of atoms Ex. NO_2, N_2O_4; H_2O, H_2O^2; FeO, Fe_2O_3.

AN ELEMENT is the simplest form of matter.

A COMPOUND is two or more elements chemically combined.

AN ATOM is the smallest particle of a chemical element.

A MOLECULE is the smallest particle of a chemical compound. It contains two or more atoms.

ATOMIC NUMBER is the number of protons in the nucleus of an atom. It is the whole number on the periodic chart. It is also the number of electrons in a neutral atom (where protons = electrons).

ION is a charged atom or group of atoms. Ionization is caused by a gain or loss of electrons. A loss leaves a positive charge, a gain leaves a negative charge.

MASS NUMBER is the relative mass of the isotopes compared to that of Carbon-12 whose mass is 12.0000 g/mol. It is not shown on the periodic chart. It is also equal to the sum of protons + neutrons inasmuch as protons and neutrons each have an atomic mass of 1 g/mol (amu - atomic mass unit).

ISOTOPES are the same elements with different mass numbers. This is caused by having a different number of neutrons in the nucleus.

ATOMIC MASS is the average mass of the isotopes of an element. It is the decimal number on the periodic chart. It depends upon both the isotopes' masses and the amount of each isotope present.

MOLAR (molecular) MASS is the sum of the atomic masses of all the atoms in a molecule.

PROTON is a basic particle with a charge of +1 and a mass of 1g/mol (amu).

ELECTRON is a basic particle whose charge is -1 and whose mass is 1/1837 g/mol (amu).

NEUTRON is a basic particle whose charge is 0 and whose mass is 1 g/mol (amu).

NUCLEON refers to the particles in the nucleus-- Protons and Neutrons.

BETA PARTICLES are electrons produced in nuclear reactions. They are Electrons.

ALPHA PARTICLES are helium nuclei (no electrons) produced in nuclear reactions. They are helium ions, He^{+2}.

GAMMA RAYS are electromagnetic radiations beyond the X-rays in frequency. They are usually produced in nuclear reactions.

POSITRONS are electrons with a +1 charge. They are found in cosmic rays and in nuclear reactions. They are antimatter. When they meet an electron there is complete annihilation to give pure energy in the form of gamma rays. This is total matter and energy conversion by $E = mc^2$.

SIR JJ THOMPSON'S "J" tube determined the charge to mass ratio of electrons and ions. This led to the discovery of isotopes.

THE CANAL RAY TUBE showed that ions are produced by electron bombardment. The simplest positive ion, H^{+1}, is the PROTON.

THE MILLIKAN OIL DROP EXPERIMENT measured the actual charge on an electron.

THE MASS OF AN ELECTRON and ions were determined by using the charge/mass ratio and the actual charge (Millikan). The electron's mass is 10^{-31} kg.

THE MASS SPECTROMETER is a refined Sir JJ Tube in which the masses of particles, ions, and isotopes are measured. It separates isotopes according to charge and mass.

X-RAYS are electromagnetic radiations above the Ultra Violet in frequency that are produced when electrons strike a metal target. They are used to determine the atomic number of elements and the structure of crystals.

THE SIZE OF THE ATOM can be measured by oil slick experiments or by calculating how many atoms lie along the side of a cube of a known number of moles of atoms.

THE SIZE OF THE NUCLEUS was measured by Lord Rutherford using the scattering patterns of alpha particles passing through gold foil. It is 10^{-15} meter.

THE RATIO OF THE ATOMIC DIAMETER TO THE NUCLEAR DIAMETER is 10^5. The volume ratio is 10^{15}. It would require 10^5 nuclei to fill an atom! -- *The flea in Yankee Stadium*.

SPECTROSCOPY is the analysis of the lines of light emitted from excited atoms as the electrons drop back through their orbitals. These lines give the energy and distances of the electronic orbitals.

ORBITALS are the probability distributions of where electrons may be found in their atoms, s -orbitals are spherical, p - orbitals are dumbbell shaped.

THERMIONIC EMISSION is the boiling off of electrons from heated metals. It gives a source of electrons for cathode ray tubes.

RECTILINEAR PROPAGATION is the principle that electromagnetic radiations like light travel in straight lines.

THE PHOTOELECTRIC EFFECT is the emission of electrons from metal when the metal is struck by light.

LIGHT has both wave and particle properties.

ELECTRONS have both wave and particle properties.

De BROGLIE'S HYPOTHESIS states that electrons around atoms are in wave formation.

SCHROEDINGER'S WAVE EQUATION explains the shapes of the orbitals of the electrons around an atom. They are probability distributions. That is, there is a probability of finding an electron's position in a "cloud" around an atomic nucleus. The electron appears to be *spread out* as it orbits, filling its cloud.

QUANTUM NUMBERS describe the distance, shape, and orientation of the electronic orbitals.

THE PRINCIPAL QUANTUM NUMBER, n, gives the energy of the ? orbital. This is determined by the distance of the ? electron from the nucleus.

THE SECOND QUANTUM NUMBER, l, describes sublevels. The sublevels are called, s, p, d, f. s orbitals are spherical in shape. p orbitals are dumbbell shaped. For other orbitals, see diagrams pp 162-164.

THE PAULI EXCLUSION PRINCIPLE states that no two electrons may have the same quantum numbers. Only two electrons may occupy an orbital, but they must have opposite spins.

THE PERIODIC TABLE (first worked out by Mendeleev in 1869) is organized by the regularly repeating pattern of chemical properties of the elements. Each column is a family of elements having similar properties. The properties are a periodic function of the atomic numbers. Atomic number is symbolized "**Z**". The table is based on the electron configuration of the atoms.

... The first column is the Alkali metals, they react vigorously with water to give hydrogen gas. They are lithium, sodium, potassium, rubidium, cesium, and francium. Francium is a man-made radioactive element.

... The second column is the Alkaline Earth elements. They are active, but much less so than the previous column.

... The transition metals have electrons filling d sublevels. They, used alone or as alloys, are our principal structural metals. An alloy is a mixture of metals, a solid solution.

... The seventh column is the Halogens (salt formers). These are the deadly fluorine, chlorine, bromine, iodine, and astatine. Astatine is a man-made radioactive element.

... The eighth column is the noble gases. These loafers are most inactive. Only extreme measures can make them react. They are helium, neon, argon, krypton, xenon, and radon.

... The Lanthanides and Actinides are the two rows at the bottom of the chart. Each of these two series fit into one spot (Lanthanides in the the lanthanum place, and Actinides into the actinium place). The reason for this is because electrons are being added to the 4f sublevel instead of to a sublevel of the sixth or outer level. Hence they all have the same oxidation state (valence) and similar properties.

IONIZATION ENERGY is the minimum energy needed to remove an electron from an atom.

... FIRST IONIZATION ENERGY takes off the first (outermost) electron.

... SECOND AND SUBSEQUENT IONIZATION ENERGIES remove more electrons. The factors that determine the ionization energies are:

... distance from the nucleus (inverse square law)

... whether the orbital is filled or half-filled

... whether there is a noble gas structure

... the shielding effect of electrons in lower orbitals

....the ratio of protons to remaining electrons (guards to prisoners ratio).

METHODS OF IONIZATION include photoionization (using light energy like ultraviolet rays), thermionic emission (using high temperature to boil off electrons), and electron bombardment (kick 'em out with a stream of electrons from another source).

THE IONIC BOND is formed by electron transfer (the rip off). An element whose electrons are loosely held (first and second columns of chart) surrenders its outer ? electron(s) to an element with high ionization energy (that therefore has a high electron affinity). The latter are the right hand side of the chart (like the halogens). When the transfer is completed, we have ions produced. The unlike charges of the ions holds them together electrically. Hence, the ionic bond. Elements from opposite sides of the chart have very different ionization energies, so that one atom is strong enough to rip off electrons from the other.

NEGATIVE IONS are those which have gained electrons and therefore have more negative charges than positive charges ? (protons).

POSITIVE IONS are those which have lost electrons and therefore have fewer negative charges than positive charges (protons).

ONLY ELECTRONS FLOW to produce ions. The protons are deep down in the nucleus and stay there. (Except in nuclear

reactions, but that's another story). So electrons are either added or subtracted to make ions.

THE COVALENT BOND is the sharing of electrons. There is no rip off because the ionization energies of the atoms are not drastically different in magnitude. The result is neither atom is strong enough to remove the electron from the other atom. (Like two kids of equal strength trying to take a ball away from each other. They both can only hold on to it, neither succeeding in taking it and thus they are bonded).

VAN DER WAALS FORCES, INTRA-MOLECULAR FORCES, are weak interactions between **MOLECULES**. (Note: chemical bonds are the forces between **ATOMS** in a molecule whereas van der waals forces are between **MOLECULES**). These weak forces are caused by the attraction between protons in one molecule and electrons in an adjacent molecule. Because of the greater distance between the particles in one molecule and another, van der waals forces are only 1/100 as strong as the covalent bond.

MELTING AND BOILING TEMPERATURES are caused by the van der waals interaction. Solids melt and liquids evaporate when the van der waals forces between molecules are broken.

THE HYDROGEN BOND is a special situation that exists between the hydrogen atom in one molecule (like water) and the oxygen atom in another molecule (like another water molecule). This bond is ten times weaker than the covalent bond, and ten times stronger than the van der waals force. The hydrogen bond caused water to have its unusual properties of high boiling point, high melting point, high surface tension, and its formation of the six-sided ring structure in ice. The latter causes water to expand upon freezing, become less dense, and float in water.

REGELATION is the process of melting ice by pressure. Inasmuch as water expands upon freezing, pressure will reverse the process, forcing water to melt. Then when the pressure is released, the water re-freezes (re-gells).

*** ORGANIC CHEMISTRY ***

It will be necessary for you to use your organic notes from big chem and check out a chem book and go through the chapters on organic.

THE MEANING OF ORGANIC -- Originally it meant from Living Substances-- ***The Vital Force*** (force of life) was thought to be needed to create organic substances. But in l828 Woller synthesized Urea from non-vital materials.

Now Organic Chemistry is the study of CARBON COMPOUNDS.

COMPARISON OF THE NUMBER OF ORGANIC vs INORGANIC COMPDS:

... INORGANIC, about 100,000.

... ORGANIC, over 8 million and increasing by 300,000/year.

REASONS WHY THERE ARE SO MANY ORGANIC COMPOUNDS:

... 1-- Carbon forms stable bonds with itself to make chains....

... 2-- Carbon forms stable bonds with most other elements.

... 3-- Carbon forms branched chains.

... 4-- Carbon forms ring chains.

... 5-- Carbon forms double bonds.

... 6-- Carbon forms triple bonds.

... 7-- Carbon forms cis-trans isomers.

... 8-- Other elements may interrupt the chain.

... 9-- All of the above may occur together.

ORGANIC FORMULAS:

... MOLECULAR formulas-- show ratio of atoms, ie C_5H_{12}

... STRUCTURAL formulas-- show arrangement of atoms.

... CONDENSED STRUCTURAL formulas-- reduces to one line.

... ISOMERS-- same molecular formula with a different structure. ex. $C_{40}H_{82}$ has 60 trillion isomers!

COMPARISON OF ORGANIC vs INORGANIC COMPOUNDS:

INORGANIC ORGANIC:

... High melting point Low melting point

... High boiling point Low boiling point

... Non-volatile Volatile liquids

... Soluble in aqueous solvents Insoluble in aqueous solvents

... Insoluble in organic solvents Soluble in organic solvents

... Have fast reactions Have slow reactions

... Electrical conductors in Non-conductors in solution or the molten state when molten Ionic Bonding Covalent bonds & Van Der Waals forces between molecules.

THE GENERAL TYPES OF ORGANIC COMPOUNDS:

... SATURATED HYDROCARBONS: THE ALKANES:

THE HOMOLOGOUS SERIES:

... The first decalog--

..... Methane, CH_4

..... Ethane, C_2H_6

..... Propane, C_3H_8

..... Butane, C_4H_{10}

..... Pentane, C_5H_{12}

..... Hexane, C_6H_{14}

..... Heptane, C_7H_{16}

..... Octane, C_8H_{18}

..... Nonane, C_9H_{20}

..... Decane, $C_{10}H_{22}$

..... "Ma Eats Pot Brownies, Pa Has Hash Only, No Dope"

For all of the following you will need to see examples in your Big Chem notes and in the text book.

*** PRACTICE IN WRITING naming of organic compounds from your Big Chem notes.

NAMING ALKANES--

... End in -ane

ALKANE REACTIONS--

... MOSTLY INERT-- No reaction with strong acids, bases, & redox agents. ex. plastics.

... HALOGEN SUBSTITUTION-- With ultraviolet light to break strong covalent bonds. Then halogens can replace the hydrogens.

... NITRATION-- Nitric acid HO-NO_2 replaces hydrogens with nitro groups -NO_2. These are the nitro compounds.

... COMBUSTION ("burn it")-- Add oxygen and get CO_2 and H_2O. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

... PYROLYSIS (Cracking)-- Heating sans oxygen ---> various decomposition products.

... THE WURTZ REACTION TO LENGTHEN THE CHAIN--

..... A) Do a Halogen Substitution to put chlorine on the chain. Let R = any alkyl group (alkane, alkene, alkyne).

R-H + Cl_2 -----> R-Cl + HCl Ultra violet light is needed.

B) The WURTZ:

... Sodium rips off the chlorines so that two R groups will join together to form a compound of double the number of carbons.

2 R-Cl + 2 Na ----> R-R + 2 NaCl

ALKENES:

THE CARBON-CARBON DOUBLE BOND-- These compounds end in -ene.

THE STRUCTURE OF THE DOUBLE BOND-- "Wienie with bun top and bottom."

PROPERTIES OF THE DOUBLE BOND:

... Highly reactive because-- The carbons are closer together, the double bond prevents rotation and allows the formation of CIS-TRANS ISOMERS,

... Extra pair of electrons are not so strongly held (greater dist, from nucleus).

... Energy of extra pair not needed for bonding so their energy is available for reacting.

... The extra pair (buns) is out where the action is.

NAMING ALKENES-- End in -ene.

ALKENE REACTIONS--

HALOGEN ADDITION-- Halogens will break the second bond and add thereto.

THE TEST FOR THE DOUBLE BOND:

... Add bromine and the red colour disappears as the bromine is added to the double bond as in the above reaction.

POLYMERIZATION-- Building up large molecules from small repeating units using a catalyst to cause polmerization. Examples are plastics, synthetic fibers, and rubber.

... n = a very large number (thousands of units).

n H_2C=CH ----> --(-CH_2-CH-)--$_n$ PVC (poly vinyl chloride). (plastic pipe)

Polytetrafluoroethene-- "TEFLON", A completely halogenated and saturated hydrocarbon--

PETROLEUM PROCESSING:

SEPARATION OF CRUDE OIL INTO ITS FRACTIONS:

FRACTIONAL DISTILLATION-- Each compound has its own boiling point and can be separated by distillation. Groups of compounds are called boiling fractions.

BOILING FRACTIONS: Because these are ranges, there is an overlap of the number of carbons.

... Bottle gases, CH_4 to C_4H_{10} Methane, Ethane, Propane, Butane.

... Petroleum Ethers, C_5H_{10} to C_6H_{12} Highly volatile liquids for solvents.

... Gasoline, C_7 to C_{12}

... Kerosene and Jet Fuel, C_{12} to C_{16}

... Lubricating Oils, C_{16} to C_{20}

... Greases, C_{20} to C_{30}

... Asphalt, C_{60} and up

CRACKING-- Breaking up large oil sized molecules into smaller gasoline molecules in order to increase the amount of gasoline produced.

... C_{16} ------> $2C_8$, this is done by A) Thermal Pyrolysis (heating sans oxygen so it won't burn), B) Catalytic action, The "Cat Cracker"

POLYMERIZATION-- Building large molecules from smaller ones (changing butane into gasoline to increase the yield of the latter). 2 C_4 -----> C_8

REFORMING-- Rearranging molecules to increase ***octane rating***. Branched and ring chains burn more slowly to increase engine performance.

CATALYTIC-- ISOMERIZATION-- Branching the chain to increase ***octane rating***.

... Octane -----> 2,2,4-trimethyl pentane (100 octane gasoline)

ADDITIVES-- Chemicals added to improve performance.

OCTANE RATING-- The comparison of fuel performance in a standard test engine. The octane rating scale calls Heptane "0 octane" and 2,2,4 -trimethyl pentane "100 octane". Modern fuels can exceed "100 octane".

ALKYNES--

THE CARBON-CARBON TRIPLE BOND--

THE SITUATION OF THE TRIPLE BOND-- Sigma and pi bonds--(The wienie with buns top/bottom, front/back).

REACTIONS-- are like those of the alkenes except they may happen twice-- once for each of the extra bonds.

PREPARATION OF ALKYNES--

Coke + lime -----> calcium carbide + carbon monoxide at 3000^{o}C.

$$\mathbf{3\ C + CaO \text{ --------> } CaC_2 + CO}$$

$$\mathbf{CaC2 + 2H2\ O \text{ ----> } H\text{-}C \equiv C\text{-}H + Ca(OH)_2}$$

On burning it's, "Ah, the LIMELIGHT"

$$\mathbf{2C_2H_2 + 5O_2 \text{ ----> } 4CO_2 + 2H_2O}$$

DIENES, TRIENES, etc. Have more than one set of double or triple bonds.

RUBBER-- 2-methyl-1,3-butadiene polymerizes like this:

$$n\ CH_2=CH\text{-}C(CH_3)=CH_2 \text{ ----------> } \text{--}(CH_2\text{-}CH=C(CH_3)\text{-}CH_2)\text{--}_n$$

VULCANIZING RUBBER-- Cross links long chains (with sulfur chains so they won't come apart when pulled.

AROMATIC HYDROCARBONS-- The Benzene Ring, a conjugated system of alternate double and single bonds. The electrons are delocalized, that is spread out to give a uniform electron cloud around the molecule.

BENZENE-- C_6H_6, the beginning substance of an enormous number of organic chemicals and biological substances.

TOLUENE-- 1-methylbenzine, the starting compound for many useful organic compounds. Ex 2,4,6-trinitrotoluene, "TNT".

NAPHTHALENE-- Two benzine rings attached together. The beginning substance for a multitude of important compounds such as dyes.

OLDER SYSTEM OF NAMING BENZENES--

Para, ortho, and meta positions on the benzine ring. ie. paradichloro benzene, moth crystals.

PHENOLS-- have the -OH group attached to the benzene ring. Starting compounds for another huge family of organic substances. An alkyl group is any Alkane, Alkene, or Alkyne. An Aromatic group is any compound having a Benzene structure.

ETHERS-- have an oxygen separating two or more alkyl groups. R-O-R', R-O-Ar, etc. The oxy's. ie. methoxyethane, CH_3-O-CH_2CH_3. Hospital ether is ethoxyethane (or diethyl ether).

THE CARBONYL COMPOUNDS-- have a double bonded oxygen attached to a carbon.

ALDEHYDES-- have the carbonyl group at the end of the chain.

KETONES-- have the carbonyl group not at the end of the chain.

ALDOHEXOSE -- SUGARS See Text pg. 626

ALCOHOLS, *evil spirits* -- have an -OH group on the carbon chain.

COMMON ALCOHOLS-- methanol, CH_3OH, "wood alcohol". Ethanol, CH_3CH_2OH, "booze". 2-propanol, "rubbing alcohol".

NAMING ALCOHOLS-- number where it is and it ends in -ol.

DENATURED ALCOHOL-- has government poisons added to discourage drinking it. This is done to industrial ethanol so that the liquor tax is not charged for industrial usage. You must pay to play!

ABSOLUTE ALCOHOL-- is 100% pure ethanol. This can only be accomplished by a chemical process to remove the last 5% of water. It is used for special chemical reactions where water must be absent. (At 95%, the water-ethanol mixture becomes *azeotropic* which means that the common boiling points prevent further separation by distillation).

PROOF OF ALCOHOL-- a test used by early California miners to be sure the barkeep had not watered down the whiskey. Gun powder soaked in whiskey will burn if it is at least 50% ("good stuff"). This is **"proof"** that all is OK. Since a score of "100" was given for good work, 50% was "100 proof" that there was no foul play. Hence proof is twice the percentage. (Another typical US measurement!).

PREPARATION OF ALCOHOL--

Fermentation of carbohydrates-- with yeast enzymes

$$\mathbf{C_6H_{12}O_6 \text{ ----------> } 2\ CH_3CH_2\text{-}OH + 2CO_2}$$

ORGANIC ACIDS--

THE CARBOXYLIC ACID GROUP-- -oic acid

COMMON ACIDS-- Methanoic acid (formic acid)-- bee stings, Ethanoic acid (acetic acid)-- vinegar, Butanoic acid (yuk)-- essence of barf.

SALICYLIC ACID-- Phenol with an acid group attached. Part of aspirin.

ESTERS-- are compounds derived from the reaction of a organic acid reacting with an alcohol.

acid + alcohol -----> ester + water

Esters are the compounds that give fruits their characteristic? flavors and odors. ie. methyl salycilate is "Oil of Wintergreen".

AMINES-- have the NH_2 group, R-NH_2 -amine. As in VITAMINES.

Click here for a complete review of Oganic Chemistry

*** HERE ENDETH THESE NOTES ***

Return to Notes and Reviews Page