Chapter #3: Molecules, Compounds, and Chemical Equations

3.1 Hydrogen, Oxygen, and Water

- Hydrogen is a explosive gas and Oxygen is not flammable but needs to be present for combustion.
    - Both have low boiling points. (gas)
- Water (H2O) is nothing like its constituent elements. Liquid and smothers fire.
- Compounds and its elements have very different properties.
- Compounds has definite proportions while mixtures can mix in any proportion.

3.2 Chemical Bonds

- Compounds are atoms chemically bonded together.
    - Electrostatic forces create chemical bonds.
- There are two types of chemical bonds: ionic bonds, and covalent bonds.

Ionic Bonds

- Metal tend to lose electrons and non-metals gain electrons.
- Ionic bond is when a metal donates an electron to a non-metal.
    - Metal then becomes a cation and nonmetal becomes a anion and the ions are attracted to one another by electrostatic force.
- Ionic compounds form a lattice structure

Covalent Bond

- Covalent bond is a bond between two non-metals where they share electrons.
- Each covalent molecule is independent of other molecules.
    - Also called molecular compound.
- In covalent bonds, electrons hold the elements together by attracting the positive nuclei.
- Low potential energy and thus stable.
    - Lowest potential energy when a negative charge is between two positive.

3.3 Representing Compounds

Types of Chemical Formulas

- Empirical formula provides the relative amount of atoms for each element in a compound.
- Molecular formula provides the exact number of atoms for each element in a compound.
- Structural formula shows the how atoms are bonded together in a compound.

Molecular Models

- Ball-and-stick molecular model shows the geometry of the molecule by using the sticks to show the bonds and ball to show the elements.
- Space-filling molecular model shows how a molecule might be if it was visible.

3.4 Classification of Pure Substances

- Pure substances can either be elements or compounds.
- Elements can be categorized as atomic elements or molecular elements.
    - Atomic elements exist as single atoms as their basic unit in nature.
    - Molecular elements exist as molecules composed of the same element as their basic unit in nature. (diatomic or polyatomic molecules)

- Compounds can be either molecular or ionic compounds.
    - Molecular compounds are nonmetals covalently bonded together.
    - Ionic compounds are a metal (cation) and a nonmetal (anion) bonded together by ionic bonds. It exists as a lattice not discrete entity like molecular compounds.
- Polyatomic ion is an ion composed of two or more atoms.

3.5 Ionic Compounds

Ionic Formulas

- Ionic compounds are charge-neutral.
- Ionic compounds always have positive and negative ions.
- The sum of positive ions must equal sum of negative ions.
- Formula is in smallest whole number ratio.

Naming Ionic Compounds

- There are two categories of metal for ionic compounds: metal forms one type of ion and metal forms more than one type of ion.
    - If metal forms more than one type of ion, it need to be specified with roman numerals after the name.
- Binary ionic compounds with metal that forms only one ion can be named by stating the cation and then the anion with the suffix, -ide. (KCl - Potassium Chloride)
- Binary ionic compounds with metal that forms more than one ion is the name of the cation with the charge in roman numeral followed by the anion with ending -ide.
- If the ionic compound contains a polyatomic ion, name the polyatomic ion after the cation.

Hydrated Ionic Compounds

- Ionic compounds called hydrates contain water molecules with formula.
- Waters of hydration can be removed by heating compound.
- Add _____hydrate after compound name.
    - Prefixes for hydrate include heml (1/2), mono, di, tri, tetra, penta, hexa, hepta, octa.

3.6 Molecular Compounds

- Same combination of elements can form different compounds so naming is a bit different from ionic compound.

Naming Molecular Compounds

- Write the element with the smallest group number first.
- If elements are in same group, write element with largest row number first.
- If there is one atom of the first element, the prefix mono- can be omitted.
    - If there is one atom of the second element the prefix mono- has to be included. (e.x. carbon monoxide)
- Use prefix mono, di, tri, tetra, penta, hexa, hepta, octa, nona, deca to indicate number of atoms present.

Naming Acids

- Acids release H+ ions when dissolved in water.
    - Acids are compose of hydrogen and two or more nonmetals. (H written first)
- Aqueous solutions of compounds with H and nonmetals are acids.

- Acids can be categorized as binary acids and oxyacids.
- Binary acids are hydrogen and a nonmetal.
    - Use hydro(nonmetal with suffix -ic) acid to name compound. (e.x HBr- hydrobromic acid)
- Oxyacids include hydrogen and oxyanion (nonmetal and oxygen).
    - If oxyanion ends with -ate, use name of oxyanion with suffix -ic acid.
    - If oxyanion ends with -ite, use name of oxyanion with suffix -ous acid.

3.8 Formula Mass and Mole Concept for Compounds

- Average mass of molecule is molecular mass.
    - Molecular mass is the sum of the masses of all atoms in molecule.
- Molar mass of compound is molecular mass per mol.
- Same concept and calculation for molecules as elements.

3.9 Composition of Compounds

- To calculate the percentage of an element in a molecule, divide total molar mass of element by molar mass of molecule.
- To calculate amount (g) of element in a compound, use mass percent composition as a conversion factor.
- Ratio of moles can also be used as a conversion factor to find amount of element in a compound.

3.10 Chemical Formula from Experimental Data

- Can determine empirical formula from percent composition of elements.
    - To find molecular formula, the molar mass is also needed.
- Convert percentage and grams into moles to find ratio for empirical formula.
- Put the obtained moles as the subscript of the element and divide all by the smallest mole.
    - If subscript after division is not a whole number, multiply all subscripts by a whole number so all subscripts are whole numbers.
- For the molecular formula divide molar mass by empirical formula molar mass to find multiple.
    - Then multiply the multiple to all subscript in empirical formula

Combustion Analysis

- Used to determine an unknown substance.
- In combustion, sample is burned and all carbon is converted to carbon dioxide and all hydrogen is converted to water.
    - Using mole ratio to find amount of carbon and hydrogen in original compound.
- If there are other elements in compound other than carbon and hydrogen, subtract the mass of the carbon and hydrogen from the total mass of the sample to find the mass for the remaining element.

3.11 Balancing Chemical Equation

- Substances on right of chemical equation are reactants and on left are products.