AP Chemistry
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Chapter 2 Notes - Atoms, Molecules and Ions

2.1 The Early History

Refer to the Chemistry History Timeline for this chapter

2.2 Fundamental Chemical Laws

A. Law of Conservation of Mass
   1. "Mass is neither created nor destroyed"
   2. Translation: In ordinary chemical reactions, the total mass of the reactants is equal to the total mass of the products

B. Law of Definite Proportion
   1. "A given compound always contains the same proportions of elements by mass"
   2. Translation: Compounds have an unchanging chemical formula

C. Law of Multiple Proportions
   1. "When two elements form a series of compounds, the ratios of the masses of the second element that combine with one gram of the first element can always be reduced to small whole numbers
   2. Translation: Sometimes two elements can come together in more than one way, forming compounds with similar, though not identical formulas

2.3 Dalton's Atomic Theory

A. Atomic Theory
   1. Each element is made up of tiny particles called atoms
   2. The atoms of a given element are identical
   3. Chemical compounds are formed when atoms combine with each other. A given compound always has the same relative numbers and types of atoms
   4. Chemical reactions involve reorganizations of the atoms. The atoms themselves are not changed in a chemical reaction

B. Avogadro's Hypothesis
   1. At the same conditions of temperature and pressure, equal volumes of different gases contain the same number of particles.

2.4 Early Experiments to Characterize the Atom

A. J.J. Thomson and the Electron
   1. Determined the charge to mass ratio of the electron
   2. Reasoned that all atoms must contain electrons
   3. Reasoned that all atoms must contain positive charges

B. Robert Millikan and the Oil Drop
   1. Oil drop experiments determined the charge on an electron
   2. With charge information, and Thomson's charge/mass ratio, he determined the mass of an electron (9.11×10^{-31} kg)

C. Radioactivity
    1. Gamma ($\cup$) rays - high energy light
    2. Beta ($\wp$) particles - high speed electrons
    3. Alpha ($\Re$) particles - nuclear particle with a 2+ charge
D. The Nuclear Atom - Rutherford's Metal Foil Experiment
    1. Most alpha particles pass straight through thin metal foil
    2. Some particles were greatly deflected ("like a howitzer shell bouncing off of a piece of paper")
        a. Could not have been deflected by electrons or single protons
        b. Must have been deflected by a positively charged object of substantial mass
            1) Supported concept of a small, central, positive nucleus where most of the atom's mass was concentrated
            2) Disproved Thomson's "plum pudding" model

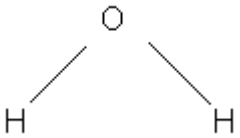
2.5 The Modern View of Atomic Structure: An Introduction

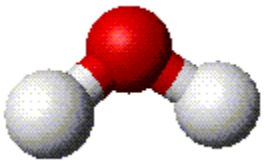
A. Nucleus
    1. Protons - positively charged
    2. Neutrons - no charge
    3. Small size, high density
        a. The mass of all of the cars in the United States in an object that would easily fit in a teaspoon
        b. A pea with the mass of 250 million tons
B. Electrons
    1. Negatively charged
    2. The source of varying reactivity of different elements
    3. Provide most of the atomic volume
C. Atomic Number
    1. Number of protons
D. Mass Number
    1. Number of protons + number of neutrons
E. Isotopes
    1. Atoms with the same number of protons (same element) but different numbers of neutrons (mass numbers)
F. Symbols for the Elements
    1. Mass Number → $^{23}_{11}Na$ ← Element symbol; Atomic Number →

2.6 Molecules and Ions

A. Chemical Bonding
   1. Covalent bonding - Sharing of electrons
   2. Ionic bonding - Attraction of oppositely charged ions due to a reaction in which electrons are transferred

B. Representing Molecules (Covalently bonded)
   1. Chemical formula
      a. Symbols for atoms and subscripts
         1) H_20
         2) CH_4
   2. Structural formula
      a. Bonds represented by lines





Ball and Stick Space Filling

C. Ions
   1. Cations
      a. Positive ions formed by the loss of electrons
   2. Anions
      a. Negative ions formed by gaining electrons

D. Ionic Bonding
   1. Bond formed by the attraction between oppositely charged ions
   2. Ionic bonding forms ionic solids (salts)
   3. Ions can be monatomic (one atom) or polyatomic (more than one atom)

2.7 An Introduction to the Periodic Table

A. Organization
   1. Horizontal row is called a "period" (or series)
   2. Vertical column is called a "group" or "family"
      a. Group 1A - Alkali metals
      b. Group 2A - Alkaline earth metals
      c. Group 7A - Halogens (Gr, "salt makers")
      d. Group 8A - Noble gases

B. Naming Elements 104 and beyond

Nil = 0	un = 1	bi = 2	tri = 3	quad = 4
Pent = 5	hex = 6	sept = 7	oct = 8	enn = 9

Element 109 = un (1) nil(0) enn(9) ium = unnilennium

2.8 Naming Simple Compounds

A. Ionic Compounds

1. Positive ion is always named first, negative ion second

<u>You were given a list of ions to memorize on the first day of class</u>

Tips for memorizing the polyatomics:

a. Find the "ate" ion (sulfate, for instance)

sulf<u>ate</u> = SO_4^{2-}

b. The "ite" ion always has one less oxygen than the "ate" ion

sulf<u>ite</u> = SO_3^{2-}

c. The prefix "per" (think hy<u>per</u>, meaning "above") is used with the "ate" prefix to indicate one more oxygen than the "ate" ion

persulfate = SO_5^{2-}

d. The prefix "hypo" (meaning "under" or "below") is used with the "ite" prefix to indicate one less oxygen than the "ite" ion

hyposulfite = SO_2^{2-}

Examples (Just because you can name it doesn't mean it exists!)

Perchlorate	ClO_4^-
Chlorate	ClO_3^-
Chlorite	ClO_2^-
hypochlorite	ClO^-

Pernitrate	NO_4^-
Nitrate	NO_3^-
Nitrite	NO_2^-
hyponitrite	NO^-

2. Metals with more than one oxidation state (transition metals) must have a roman numeral to indicate the oxidation state

Fe^{3+} = iron (III) Mn^{+2} = manganese (II)

B. Binary Covalent Compounds

1. Must contain two elements, BOTH nonmetals
   a. First element
      1) full element name
      2) prefix <u>only if there is more than one atom</u>
   b. Second element
      1) named as if it were an anion (-ide suffix)
      2) <u>always</u> gets a prefix

mono - 1 penta - 5 octa - 8
di - 2 hexa - 6 nona - 9
tri - 3 hepta - 7 deca - 10
tetra - 4

C. Naming Acids

1. Binary Acids (two elements - hydrogen + one other)
   a. prefix "Hydro" + root of second element + "ic" suffix
2. Oxyacids
   a. If the acid contains an anion whose name ends in "ate":
      Use root of anion name and an "ic" ending (H_2SO_4 = sulfuric acid)
   b. If the acid contains an anion whose name ends in "ite":
      Use the root of the anion name and an "ous" ending
      (H_2SO_3 = sulfurous acid)