Chapter 3: Stoichiometry

3.2: Atomic Masses:

Modern system of atomic masses is based on ^{12}C as the standard mass and is assigned a mass of exactly 12 amu (atomic mass unit). Other atomic weights of elements are compared to the standard as such.
Average Atomic Mass is a weighed average of the naturally occurring isotopes of the element.
Predict percent abundance from carbon's atomic mass is 2 major isotopes ^{12}C and ^{13}C exist.

Ex.
^{12}C = 12.0000 amu (98.89% abundance)
^{13}C = 13.0034 amu (1.11% abundance) (As mass ^{13}C/mass ^{12}C = 1.0836129)
^{14}C= negligibly small

  (12.000 x 0.9889)
+ (13.0034 x 0.011)
  12.01 *weighed average* of carbon (with decimal percent you avoid division by zero at the end)

Note: no atom of C has a mass of 12.011, but this is used for "counting" atoms by weighing.
P. 81, Sample Exercise 3.1 in class

3.3: The Mole (mol)

Number equal to the number of carbon atoms in exactly 12 grams of ^{12}C.
Avogadro's Number, N_A 1 mole of items contains 6.02×10^{23} items
A sample of a natural element with a mass equal to its atomic mass expressed in grams contains one mole of atoms, gram-atom. Or 1g = 6.02×10^{23} amu

Ex. Conversions: Determine mass, moles, and atoms of given element.

a.) 25.0 g Al = _________ atoms
b.) 0.024 mol of dysprosium = ____________ atoms
c.) 2.4×10^{18} atoms of Au to __________ grams

3.4: Molar Mass

Mass in grams of 1 mole of the compound.
Determined by summing the masses of atoms in compound.

Ex. Conversions:

a.) Convert 1.56×10^{-2} g juglone ($C_{10}H_6O_3$) to molecules
b.) A sample of 4.2 moles of sodium sulfate (Na_2SO_4) has what mass of sodium?
Formula Stoichiometry: if 1 mole of sodium sulfate contains 2 mol of sodium and one mole of sulfate, then the sample contains 4.2 mol x2 moles of sodium. Converting 8.4 moles of sodium to mass (x23 g/mol) = 190 g of sodium. Yes, percent composition could work for these solutions.
c.) P. 90, Ex. 3.8 (mol relations within compound)

3.5 Percent Composition (by mass) or Weight Percent

$$\frac{\text{Part of compound}}{\text{Total mass of compound}} \times 100 =$$

Ex. P .92, sample Exercise 3.10

3.6 Determining the Formula of a Compound **(Heath Video, VCR film)**

Method of decomposition into component elements such as CO_2, H_2O, NH_3, etc. and weighing amounts.
Empirical Formula: Simplest whole number ratio of atoms in the compound; ex. HO
Molecular Formula: Actual number of atoms in smallest unit that exists of the molecule; ex. H_2O_2

In Class Examples:

a) Compare empirical formula of $NPCl_2$ with its molecular formula if molar mass = 347.64 g/mol)
b) P. 98 3.13, Determine empirical formula of a substance if 49.48%C, 5.15% H, 28.87% N, 16.49% O by mass and molar mass of 194.2 g/mol

c) A 0.1156 g sample of a compound composed of carbon, hydrogen and nitrogen is analyzed by decomposition to yield the following: 0.1638 gram of CO_2 and 0.1676 g of H_2O. *The carbon in the sample was all converted to CO_2 and the hydrogen is all converted to H_2O.

Find mass of C:

$0.1638 \text{ g } CO_2 \times \frac{12 \text{ g C}}{44 \text{ g } CO_2} = 0.04467 \text{ g C}$

Find percent of carbon in compound:

$\frac{0.04467 \text{ g C}}{0.1156 \text{ g compound}} \times 100 = 38.64 \text{ \% C}$

Find mass of H:

$0.1676 \text{ g } H_2O \times \frac{2 \text{ g H}}{18 \text{ g } H_2O} \times 100 = 0.01862 \text{ g H}$

Find percent of H in compound:

$\frac{0.01862 \text{ g H}}{0.1156 \text{ g compound}} \times 100 = 16.11 \text{ \% H}$

Find mass and percent of N in compound:

By difference:

0.1156 g – (0.04467 g C + 0.01862 g H) = 0.5231 g N

$\frac{0.05231 \text{ g}}{0.1156 \text{ g compound}} \times 100 = 45.25 \text{ \%}$

Determine moles of each element in compound: (could use mass or percent info)

C: 38.67 / 12.01 = 3.223 mol C

H: 16.11 / 1.00 = 16.11 mol H

N: 45.25 / 14.0 = 3.232 mol N

Divide by smallest number of moles to find the whole number ratio:

It may be necessary to multiply by whole integers if numbers obtained in previous step are not whole numbers.

$C \frac{3.223}{3.223} \quad H \frac{16.11}{3.223} \quad N \frac{3.232}{3.223} = C_1H_5N_1 = \mathbf{CH_5N}$

3.7 Chemical Equations:

Reactants --> Products, Atoms rearrange to produce new substance(s) by breaking and forming new bonds. Mass and atoms are conserved in a chemical reaction.

Subscripts and Coefficients: 4 CH_4 represents 4 molecules of CH_4, 4 C atoms and 16 H atoms.

Coefficients represent relative numbers (moles, molecules, atoms, etc.) of the substance.

Phase notation: solid (s), liquid (l), gas (g), dissolved in water, aqueous solution (aq)

3.8 Balancing Chemical Equations: by inspection

Guidelines for balancing:

- Identify reactants and products. Write equation.
- Balance more complicated atoms first, balance Polyatomic ions together as a group if they appear on bot sides, balance H and O last.
- Reduce coefficients to lowest whole numbers

Ex. $(2\ NH_{3(g)} + 5/2\ O_{2)g)} \text{ --> } 2\ NO(g) + 3\ H_2O_{(g)}) \times 2 =$ 4, 5, 4, 6

Set 1, Practice Problems: P.117 #27, 32, 50, 63, 64, 66, 67, 68, 69, 71, 76, 79, 80, 88, 112, 114, 117, 125