Problem Set 6: Quantifying Chemical Compounds

1) How many grams of carbon are in 10 g of caffeine ($C_8H_{10}N_4O_2$)?

Molar mass $C_8H_{10}N_4O_2$ =

$$\left(8 \times 12.01 \frac{\text{g}}{\text{mol}}\right) + \left(10 \times 1.01 \frac{\text{g}}{\text{mol}}\right) + \left(4 \times 14.01 \frac{\text{g}}{\text{mol}}\right) + \left(2 \times 16.00 \frac{\text{g}}{\text{mol}}\right) = 194.22 \frac{\text{g}}{\text{mol}}$$

$$10 \text{ g } C_8H_{10}N_4O_2 \times \frac{1 \text{ mol } C_8H_{10}N_4O_2}{194.22 \text{ g } C_8H_{10}N_4O_2} \times \frac{8 \text{ mols C}}{1 \text{ mol } C_8H_{10}N_4O_2} \times \frac{12.01 \text{ g C}}{1 \text{ mol C}} = 5 \text{ g C}$$

2) How many chlorine atoms are in a 25 g sample of nickel (II) chloride hexahydrate? ($NiCl_2$*$6H_2O$).

Molar mass $NiCl_2 \cdot 6H_2O$ =

$$\left(1 \times 58.69 \frac{\text{g}}{\text{mol}}\right) + \left(2 \times 35.45 \frac{\text{g}}{\text{mol}}\right) + \left(6 \times \left[\left(2 \times 1.01 \frac{\text{g}}{\text{mol}}\right) + \left(1 \times 16.00 \frac{\text{g}}{\text{mol}}\right)\right]\right) = 237.71 \frac{\text{g}}{\text{mol}}$$

$$25 \text{ g } NiCl_2 \cdot 6H_2O \times \frac{1 \text{ mol } NiCl_2 \cdot 6H_2O}{237.71 \text{ g } NiCl_2 \cdot 6H_2O} \times \frac{2 \text{ mols Cl}}{1 \text{ mol } NiCl_2 \cdot 6H_2O} \times \frac{6.022 \times 10^{23} \text{ Cl atoms}}{1 \text{ mol Cl}} = 1.3 \times 10^{23} \text{ atoms Cl}$$

3) A recent volcanic eruption yields a pungent toxic gas, analysis of a 2.30 g sample shows that it is 50.09 % sulfur and 49.91% oxygen? What is the empirical formula of the compound?

$$\text{mols S} = 0.5009\ (2.30 \text{ g}) \times \frac{1 \text{ mol S}}{32.07 \text{ g S}} = 0.03592 \text{ mols S}$$

$$\text{mols O} = 0.4991\ (2.30 \text{ g}) \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 0.071745 \text{ mols O}$$

$$\text{S mols } 0.03592 : \text{O mols } 0.071745 = \text{S}\frac{\text{mols } 0.03592}{\text{mols } 0.03592} : \text{O}\frac{\text{mols } 0.071745}{\text{mols } 0.03592} = S_1O_{1.99} = SO_2$$

4) During photosynthesis plants make glucose form carbon dioxide and sunlight. The empirical formula of glucose is CH_2O. What is the molecular formula of glucose given the molar mass of glucose is 180.16 g/mol.

Molar mass of CH_2O =

$$\left(1 \times 12.01 \frac{g}{mol}\right) + \left(2 \times 1.01 \frac{g}{mol}\right) + \left(1 \times 16.00 \frac{g}{mol}\right) = 30.02 \frac{g}{mol}$$

$$x(molar\ mass\ of\ CH_2O) = 180.16 \frac{g}{mol}$$

$$x\left(30.02\frac{g}{mol}\right) = 180.16\frac{g}{mol}$$

$$x = \frac{180.16\frac{g}{mol}}{30.02\frac{g}{mol}}$$

$$x = 6.0013 = 6$$

$$6 \times (CH_2O) = C_6H_{12}O_6$$

5a) Arrange in order of increasing radius. K, He, Cs, W, O.

He, O, W, K, Cs

→ increasing atomic radius

5b) Arrange in order of increasing electronegativity. S, Cl, Ni, K, Li, C.

K, Li, S, Ni, C, Cl

→ increasing electronegativity

5c) Arrange in order of increasing size. F^-, Na^+, Br^-, Al^{3+}, Mg, K^+.

F^-, Al^{3+}, Na^+, Mg, K^+, Br^-

→ increasing size

5d) Arrange in order of increasing ionization energy. P, Ge, Fr, He, K.

Fr, K, Ge, P, He

→ increasing ionization energy