Determining Formulas

1. Nickel reacts with sulfur to form a metal sulfide. If 2.986 g of nickel reacts with enough sulfur to form 5.433 g of the metal sulfide, what is the simplest formula of the metal sulfide? Determine the name of the metal sulfide.

$$\underset{2.986\,g}{Ni} + \underset{2.447\,g}{S} \rightarrow \underset{5.433\,g}{Ni_xS_y}$$

$\therefore EF = Ni_2S_3$

nickel (III) sulfide

mass of S = 5.433 g − 2.986 g = 2.447 g S

$$\frac{2.986\,g\,Ni \mid 1\,mol\,Ni}{58.69\,g\,Ni} = 0.050877 \;/\; 0.050877 = \frac{1\,mol\,Ni \times 2}{2\,mol\,Ni}$$

$$\frac{2.447\,g\,S \mid 1\,mol\,S}{32.07\,g\,S} = 0.07630 \;/\; 0.050877 = \frac{1.5\,mol\,S \times 2}{3\,mol\,S}$$

2. A 0.507 g sample of a compound containing only carbon, hydrogen, and oxygen is burned in oxygen gas to produce 0.698 g of CO_2 and 0.571 g of H_2O. The compound has a molar mass of 64 g/mol. Determine the correct empirical formula for this compound. What is the molecular formula of this compound?

$$\underset{0.507\,g}{C_xH_yO_z} + O_2 \rightarrow \underset{0.698\,g}{CO_2} + \underset{0.571\,g}{H_2O}$$

$$\frac{\text{Mass of C}}{\text{Total mass of } CO_2} = \frac{MM\ C}{MM\ CO_2}$$

$$\frac{\text{Mass of C}}{0.698\,g\,CO_2} = \frac{12.01\,g\,C}{44.01\,g\,CO_2}$$

Mass of C = 0.191 g C in $C_xH_yO_z$

$$\frac{\text{Mass H}}{0.571\ g\ H_2O} = \frac{2.02\ g\ H}{18.02\ g\ H_2O}$$

mass H = 0.0639 g H in $C_xH_yO_z$

mass O = 0.507 g − 0.191 g − 0.0639 g = 0.2521 g O in $C_xH_yO_z$

$$\frac{0.571\ g\ H_2O \mid 1\ mol\ H_2O \mid 2\ mol\ H \mid 1.008\ g\ H}{18.02\ g\ H_2O \mid 1\ mol\ H_2O \mid 1\ mol\ H} = 0.0639\ g\ H \text{ in } C_xH_yO_z$$

$$\frac{0.191\ g\ C \mid 1\ mol\ C}{12.01\ g\ C} = 0.01590 / 0.01576 = 1\ mol\ C$$

$$\frac{0.0639\ g\ H \mid 1\ mol\ H}{1.008\ g\ H} = 0.06339 / 0.01576 = 4\ mol\ H$$

$$\frac{0.2521\ g\ O \mid 1\ mol\ O}{16\ g\ O} = 0.01576 / 0.01576 = 1\ mol\ O$$

∴ Empirical Formula = CH_4O

$$\frac{MM_{MF}}{MM_{EF}} = \frac{64\ g/mol}{32.04\ g/mol} = 2$$

$\therefore$ Molecular Formula = $(CH_4O)_2$ = $\boxed{C_2H_8O_2}$

3. Oxygen reacts with carbon to form a molecular cpd. If 58.16 g of oxygen reacts with enough carbon to form 80.00 g of the cpd, what is the empirical formula of this compound?

O_2 + C $\longrightarrow$ C_xO_y

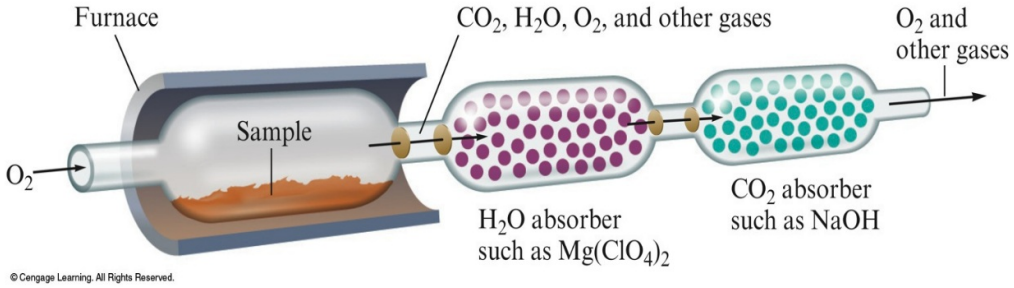
58.16g 21.84g 80.00g

$$\frac{58.16\ g\ O_2 \mid 1\ mol\ O_2 \mid 2\ mol\ O}{\mid 32\ g\ O_2 \mid 1\ mol\ O_2} = 3.635 / 1.81848 = 2\ mol\ O$$

$$\frac{21.84\ g\ C \mid 1\ mol\ C}{\mid 12.01\ g\ C} = 1.81848 / 1.81848 = 1\ mol\ C$$

$\therefore$ Empirical Formula = $\boxed{CO_2}$

4. A popular pain reliever is made up of carbon, hydrogen, and oxygen. When a 5.000 g sample of this pain reliever is burned in oxygen 13.86 g of CO_2 and 3.926 g of H_2O are obtained. The compound has a molar mass of 206 g/mol. What is the simplest formula (empirical formula) of this pain reliever? What is the molecular formula of the pain reliever?



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$C_xH_yO_z + O_2 \rightarrow CO_2 + H_2O$

5.000 g 13.86 g 3.926 g

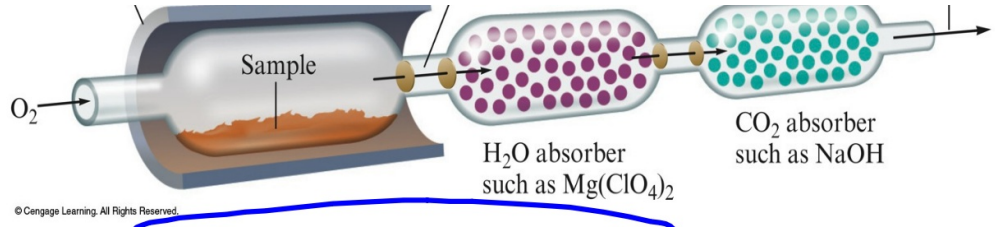
$$13.86\text{ g } CO_2 \left|\frac{1\text{ mol } CO_2}{44.01\text{ g } CO_2}\right|\frac{1\text{ mol C}}{1\text{ mol } CO_2}\left|\frac{12.01\text{ g C}}{1\text{ mol C}}\right. = 3.7823\text{ g C in } C_xH_yO_z$$

$$\frac{\text{Mass of H}}{3.926\text{ g } H_2O} = \frac{2.016\text{ g H}}{18.02\text{ g } H_2O}$$

$\therefore$ mass of H in $C_xH_yO_z$ = 0.4392 g H

Mass of O in $C_xH_yO_z$ = 5.000 g − 3.7823 g − 0.4392 g

= 0.7785 g O in $C_xH_yO_z$



$\therefore EF = C_{13}H_{18}O_2$

$$\frac{3.7823\text{ g C} \mid 1\text{ mol C}}{\mid 12.01\text{ g C}} = 0.3149 / 0.04866 = 6.5 \times 2 = 13 \text{ mol C}$$

$$\frac{0.4392\text{ g H} \mid 1\text{ mol H}}{\mid 1.008\text{ g H}} = 0.4357 / 0.04866 = 9 \times 2 = 18 \text{ mol H}$$

$$\frac{0.7785\text{ g O} \mid 1\text{ mol O}}{\mid 16\text{ g O}} = 0.04866 / 0.04866 = 1 \times 2 = 2 \text{ mol O}$$