Combustion Analysis Problems (optional): Key

1. A hydrocarbon fuel is fully combusted with 18.214 g of oxygen to yield 23.118 g of carbon dioxide and 4.729 g of water. Find the empirical formula for the hydrocarbon.

$$\left.\begin{aligned} &23.118 \text{ g } CO_2 \times \frac{1 \text{ mol } CO_2}{44.011 \text{ g } CO_2}\frac{1 \text{ mol C}}{1 \text{ mol } CO_2} = 0.52528 \text{ mol C} \div 0.52515 \approx 1 \text{ mol C} \\ &4.729 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O}\frac{2 \text{ mol H}}{1 \text{ mol } H_2O} = 0.52515 \text{ mol H} \div 0.52515 = 1 \text{ mol H} \end{aligned}\right\} \boxed{\mathbf{CH}}$$

2. After combustion with excess oxygen, a 12.501 g of a petroleum compound produced 38.196 g of carbon dioxide and 18.752 of water. A previous analysis determined that the compound does not contain oxygen. Establish the empirical formula of the compound.

$$38.196 \text{ g } CO_2 \times \frac{1 \text{ mol } CO_2}{44.011 \text{ g } CO_2}\frac{1 \text{ mol C}}{1 \text{ mol } CO_2} = 0.86787 \text{ mol C} \div 0.86787 = 1 \text{ mol C}$$

$$18.752 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.016 \text{ g } H_2O}\frac{2 \text{ mol H}}{1 \text{ mol } H_2O} = 1.0817 \text{ mol H} \div 0.86787 = 2.3996 \text{ mol H}$$

$$\left.\begin{aligned} &1 \text{ mol C} \times 5 = 5 \text{ mol C} \\ &2.3996 \text{ mol} \times 5 = 11.998 \approx 12 \text{ mol H} \end{aligned}\right\} \boxed{\mathbf{C_5H_{12}}}$$

3. In the course of the combustion analysis of an unknown compound containing only carbon, hydrogen, and nitrogen, 12.923 g of carbon dioxide and 6.608 g of water were measured. Treatment of the nitrogen with H_2 gas resulted in 2.501 g NH_3. The complete combustion of 11.014 g of the compound needed 10.573 g of oxygen. What the compound's empirical formula?

$$\left.\begin{aligned} &12.923 \text{ g } CO_2 \times \frac{1 \text{ mol } CO_2}{44.011 \text{ g } CO_2}\frac{1 \text{ mol C}}{1 \text{ mol } CO_2} = 0.29363 \text{ mol C} \div 0.1468 \approx 2 \text{ mol C} \\ &6.608 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O}\frac{2 \text{ mol H}}{1 \text{ mol } H_2O} = 0.7334 \text{ mol H} \div 0.1468 \approx 5 \text{ mol H} \\ &2.501 \text{ g } NH_3 \times \frac{1 \text{ mol } NH_3}{17.04 \text{ g } NH_3}\frac{1 \text{ mol N}}{1 \text{ mol } NH_3} = 0.1468 \text{ mol N} \div 0.1468 = 1 \text{ mol N} \end{aligned}\right\} \boxed{\mathbf{C_2H_5N}}$$

4. 12.915 g of a biochemical substance containing only carbon, hydrogen, and oxygen was burned in an atmosphere of excess oxygen. Subsequent analysis of the gaseous result yielded 18.942 g carbon dioxide and 7.749 g of water. Determine the empirical formula of the substance.

$$\text{mass C} = 18.942\ \text{g CO}_2 \times \frac{1\ \text{mol CO}_2}{44.011\ \text{g CO}_2}\frac{1\ \text{mol C}}{1\ \text{mol CO}_2}\frac{12.011\ \text{g C}}{1\ \text{mol C}} = 5.1694\ \text{g C}$$

$$\text{mass H} = 7.749\ \text{g H}_2\text{O} \times \frac{1\ \text{mol H}_2\text{O}}{18.02\ \text{g H}_2\text{O}}\frac{2\ \text{mol H}}{1\ \text{mol H}_2\text{O}}\frac{1.016\ \text{g H}}{1\ \text{mol H}_2\text{O}} = 0.8669\ \text{g H}$$

$$\text{mass O} = 12.915\ \text{g} - 5.1694\ \text{g C} - 0.8669\ \text{g H} = 6.879\ \text{g O}$$

$$\left.\begin{array}{l} \text{mol C} = 5.1694\ \text{g C} \times \dfrac{1\ \text{mol C}}{12.011\ \text{g C}} = 0.43039\ \text{mol C} \div 0.4299 \approx 1\ \text{mol C} \\ \text{mol H} = 0.8669\ \text{g H} \times \dfrac{1\ \text{mol H}}{1.008\ \text{g H}} = 0.8600\ \text{mol H} \div 0.4299 \approx 2\ \text{mol H} \\ \text{mol O} = 6.879\ \text{g O} \times \dfrac{1\ \text{mol O}}{16.00\ \text{g O}} = 0.4299\ \text{mol H} \div 0.4299 = 1\ \text{mol O} \end{array}\right\} \boxed{\mathbf{CH_2O}}$$

5. 33.658 g of oxygen was used to completely react with a sample of a hydrocarbon in a combustion reaction. The reaction products were 33.057 g of carbon dioxide and 10.816 g of water. Ascertain the empirical formula of the compound.

$$33.057\ \text{g CO}_2 \times \frac{1\ \text{mol CO}_2}{44.011\ \text{g CO}_2}\frac{1\ \text{mol C}}{1\ \text{mol CO}_2} = 0.75111\ \text{mol C} \div 0.75111 = 1\ \text{mol C}$$

$$10.816\ \text{g H}_2\text{O} \times \frac{1\ \text{mol H}_2\text{O}}{18.016\ \text{g H}_2\text{O}}\frac{2\ \text{mol H}}{1\ \text{mol H}_2\text{O}} = 1.2007\ \text{mol H} \div 0.75111 = 1.5986\ \text{mol H}$$

$$\left.\begin{array}{l} 1\ \text{mol C} \times 5 = 5\ \text{mol C} \\ 1.5986\ \text{mol H} \times 5 \approx 8\ \text{mol H} \end{array}\right\} \boxed{\mathbf{C_5H_8}}$$