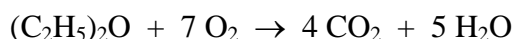
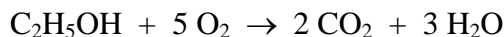


Reaction Stoichiometry Parallel Reactions

Problem 4-93

The manufacture of ethyl alcohol, C_2H_5OH , yields diethyl ether, $(C_2H_5)_2O$, as a by-product. The complete combustion of a 1.005-g sample of the product of this process yields 1.963 g CO_2 . What must be the mass percents of C_2H_5OH and of $(C_2H_5)_2O$ in this sample?

First, write the parallel reaction equations:



And for simplicity, let's define some abbreviations:



$$M_{EA} = 46.068 \frac{g}{mol} \quad M_{DE} = 74.122 \frac{g}{mol} \quad M_{CO_2} = 44.01 \frac{g}{mol}$$

$$m_{\text{sample}} = m_{EA} + m_{DE}$$

$$m_{CO_2} = m_{CO_2 \text{ from EA}} + m_{CO_2 \text{ from DE}}$$

$$m_{CO_2 \text{ from EA}} = \left(\frac{m_{EA}}{M_{EA}} \right) \times \frac{2 \text{ mol } CO_2}{1 \text{ mol EA}} \times M_{CO_2} \quad \text{and} \quad m_{CO_2 \text{ from DE}} = \left(\frac{m_{DE}}{M_{DE}} \right) \times \frac{4 \text{ mol } CO_2}{1 \text{ mol DE}} \times M_{CO_2}$$

so....

$$m_{CO_2} = \left(\frac{m_{EA}}{M_{EA}} \right) \times \frac{2 \text{ mol } CO_2}{1 \text{ mol EA}} \times M_{CO_2} + \left(\frac{m_{DE}}{M_{DE}} \right) \times \frac{4 \text{ mol } CO_2}{1 \text{ mol DE}} \times M_{CO_2}$$

$$m_{CO_2} = M_{CO_2} \left[\left(\frac{m_{EA}}{M_{EA}} \right) \times \frac{2 \text{ mol } CO_2}{1 \text{ mol EA}} + \left(\frac{m_{DE}}{M_{DE}} \right) \times \frac{4 \text{ mol } CO_2}{1 \text{ mol DE}} \right]$$

$$\frac{m_{CO_2}}{M_{CO_2}} = \left(\frac{m_{EA}}{M_{EA}} \right) \times \frac{2 \text{ mol } CO_2}{1 \text{ mol EA}} + \left(\frac{m_{DE}}{M_{DE}} \right) \times \frac{4 \text{ mol } CO_2}{1 \text{ mol DE}}$$

$$\frac{1.963 \text{ g } CO_2}{44.01 \frac{g \text{ } CO_2}{mol \text{ } CO_2}} = \left(\frac{m_{EA}}{46.068 \frac{g \text{ } EA}{mol \text{ } EA}} \right) \times \frac{2 \text{ mol } CO_2}{1 \text{ mol EA}} + \left(\frac{m_{DE}}{74.122 \frac{g \text{ } DE}{mol \text{ } DE}} \right) \times \frac{4 \text{ mol } CO_2}{1 \text{ mol DE}}$$

$$m_{DE} = m_{\text{sample}} - m_{EA} = 1.005 \text{ g} - m_{EA}$$

$$0.04460 \text{ mol CO}_2 = \left(\frac{m_{\text{EA}}}{46.068 \text{ g EA/mol EA}} \right) \times \frac{2 \text{ mol CO}_2}{1 \text{ mol EA}} + \left(\frac{1.005 \text{ g} - m_{\text{EA}}}{74.122 \text{ g DE/mol DE}} \right) \times \frac{4 \text{ mol CO}_2}{1 \text{ mol DE}}$$

$$0.04460 \text{ mol CO}_2 = 0.043414 \frac{\text{mol CO}_2}{\text{g EA}} \times m_{\text{EA}} + 0.054235 \text{ mol CO}_2 - 0.053965 \frac{\text{mol CO}_2}{\text{g DE}} \times m_{\text{EA}}$$

$$-0.009635 \text{ mol CO}_2 = -0.010551 \frac{\text{mol CO}_2}{\text{g EA}} \times m_{\text{EA}}$$

$$m_{\text{EA}} = 0.9132 \text{ g EA}$$

$$\% \text{C}_2\text{H}_5\text{OH} = \frac{0.9132 \text{ g EA}}{1.005 \text{ g sample}} \times 100 = 90.9\% \text{ C}_2\text{H}_5\text{OH}$$

$$\% (\text{C}_2\text{H}_5)_2\text{O} = 100 - 90.9\% = 9.1\% (\text{C}_2\text{H}_5)_2\text{O}$$