Formula Stoichiometry and Parallel Production of a Product

A 0.732-g mixture of methane, CH_4, and ethane, C_2H_6, is burned, yielding 2.064 g CO_2. What is the percent composition of this mixture, **(a)** by mass; **(b)** on a mole basis?

Solution:

$$m_{\text{mixture}} = 0.732\text{ g} = m_{\text{CH}_4} + m_{\text{C}_2\text{H}_6}$$

and...

$$n_{\text{CO}_2} = \frac{2.064\text{ g CO}_2}{44.01\frac{\text{g}}{\text{mol}}} = 0.046898\text{ mol CO}_2$$

so...

$$n_{\text{CO}_2} = 0.046898\text{ mol CO}_2 = \frac{m_{\text{CH}_4}}{16.043\frac{\text{g}}{\text{mol}}} \times \frac{1\text{ mol CO}_2}{1\text{ mol CH}_4} + \frac{m_{\text{C}_2\text{H}_6}}{30.070\frac{\text{g}}{\text{mol}}} \times \frac{2\text{ mol CO}_2}{1\text{ mol C}_2\text{H}_6}$$

substituting the mass balance equation...

$$0.046898\text{ mol CO}_2 = \frac{m_{\text{CH}_4}}{16.043\frac{\text{g}}{\text{mol}}} \times \frac{1\text{ mol CO}_2}{1\text{ mol CH}_4} + \frac{\left(0.732\text{ g} - m_{\text{CH}_4}\right)}{30.070\frac{\text{g}}{\text{mol}}} \times \frac{2\text{ mol CO}_2}{1\text{ mol C}_2\text{H}_6}$$

You can prove this easily: divide through by mol CO_2 and follow units on molar mass through, the m_{CH_4} will come out in grams. Knowing that the units will work if we did everything correctly...

$$0.046898 = 0.062332 m_{\text{CH}_4} + 0.048686 - 0.066511 m_{\text{CH}_4}$$

collect terms and solve...

$$0.0041795 m_{\text{CH}_4} = 0.001788$$

$$m_{\text{CH}_4} = 0.4278\text{ g CH}_4$$

$$m_{C_2H_6} = 0.732\text{ g} - 0.4278\text{ g CH}_4 = 0.3042\text{ g C}_2\text{H}_6$$

Percentage compositions:

(a) by mass...

$$\%\text{CH}_4 = \frac{0.4278\text{ g CH}_4}{0.732\text{ g}} \times 100 = 58.4\%\ {}^{\text{w}}\!/\!_{\text{w}}\ \text{CH}_4$$

$$\%C_2H_6 = \frac{0.3042\text{ g C}_2\text{H}_6}{0.732\text{ g}} \times 100 = 41.6\%\ {}^{\text{w}}\!/\!_{\text{w}}\ \text{C}_2\text{H}_6$$

(b) by moles...

$$n_{CH_4} = \frac{0.4278 \text{ g } CH_4}{16.043 \frac{g}{mol}} = 0.02667 \text{ mol } CH_4$$

$$n_{C_2H_6} = \frac{0.3042 \text{ g } C_2H_6}{30.070 \frac{g}{mol}} =$$

$$n_{total} = 0.02667 \text{ mol } CH_4 + 0.01011 \text{ mol } C_2H_6 = 0.03678 \text{ mol}$$

$$\text{mol percentage } CH_4 = \frac{0.02667 \text{ mol } CH_4}{0.03678 \text{ mol}} \times 100 = 72.5\%(\text{by mol}) \ CH_4$$

$$\text{mol percentage } C_2H_6 = \frac{0.01011 \text{ mol } C_2H_6}{0.03678 \text{ mol}} \times 100 = 27.5\%(\text{by mol}) \ C_2H_6$$