

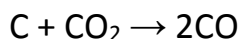
## Answer on Question #44507 – Chemistry – Organic Chemistry

### Question

One litre of CO<sub>2</sub> is passed through red hot coke. The volume becomes 1.4 litre. Find the composition of product.

### Solution

When CO<sub>2</sub> is passed through the red hot coke the red-ox reaction occurs, where CO<sub>2</sub> acts as an oxidant and the coke (C) acts as a reducer. The reaction results in carbon monoxide (CO) formation:



Thus, the product consists of formed CO and unreacted CO<sub>2</sub>.

The initial volume of CO<sub>2</sub>:

$$V_{\text{CO}_2}^0 = 1 \text{ litre}$$

The final volume of CO<sub>2</sub>:

$$V_{\text{CO}_2} = x \text{ litre}$$

The volume of CO:

$$V_{\text{CO}} = y \text{ litre}$$

The volume of the product mixture:

$$V_{\text{prod.}} = V_{\text{CO}_2} + V_{\text{CO}} = x + y = 1.4 \text{ litre}$$

The volume of CO<sub>2</sub> consumed (reacted) equals to the difference between the initial volume and the volume remained after the reaction:

$$V_{\text{CO}_2}^{\text{react.}} = V_{\text{CO}_2}^0 - V_{\text{CO}_2} = (1 - x) \text{ litre}$$

As is clear from the chemical equation, two moles of CO are formed when 1 mole of CO<sub>2</sub> reacts. Volume is proportional to the number of moles, so we can state:

$$V_{\text{CO}} = 2 \cdot V_{\text{CO}_2}^{\text{react.}}, \text{ i.e. } y = 2(1 - x)$$

Thus, we have the set of two equations with two unknown values:

$$\begin{cases} x + y = 1.4 \\ y = 2(1 - x) \end{cases}$$

The set can be easily solved by substitution method. Let us substitute the second equation into the first one:

$$\begin{aligned} x + 2 - 2x &= 1.4 \\ x - 2x &= 1.4 - 2 \\ x &= 0.6 \end{aligned}$$

Then

$$y = 2 - 2x = 2 - 2 \cdot 0.6 = 2 - 1.2 = 0.8$$

$$V_{\text{CO}_2} = x = 0.6 \text{ litre}, V_{\text{CO}} = y = 0.8 \text{ litre}$$

So, the 1.4 litre of product mixture consists of 0.6 litre of unreacted CO<sub>2</sub> and 0.8 litre of CO.

The product composition in % by vol. (or % by mol.) is as follows

$$\begin{aligned} \%_{\text{CO}_2} &= \frac{V_{\text{CO}_2}}{V_{\text{prod.}}} 100\% = \frac{0.6 \text{ l} \cdot 100\%}{1.4 \text{ l}} = 42.9\% \text{ by vol.} \\ \%_{\text{CO}} &= \frac{V_{\text{CO}}}{V_{\text{prod.}}} 100\% = \frac{0.8 \text{ l} \cdot 100\%}{1.4 \text{ l}} = 57.1\% \text{ by vol.} \end{aligned}$$

**Answer:**  $\%_{\text{CO}_2} = 42.9\% \text{ by vol.}$ ,  $\%_{\text{CO}} = 57.1\% \text{ by vol.}$