Answer on Question #44507 – Chemistry – Organic Chemistry

Question

One litre of CO_2 is passed through red hot coke. The volume becomes 1.4 litre. Find the composition of product.

Solution

When CO_2 is passed through the red hot coke the red-ox reaction occurs, where CO_2 acts as an oxidant and the coke (C) acts as a reducer. The reaction results in carbon monoxide (CO) formation:

$$C + CO_2 \rightarrow 2CO$$

Thus, the product consists of formed CO and unreacted CO_2.

The initial volume of CO_2:

$$V^0_{CO_2} = 1 \text{ litre}$$

The final volume of CO_2:

$$V_{CO_2} = x \text{ litre}$$

The volume of CO:

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

The volume of the product mixture:

$$V_{prod.} = V_{CO_2} + V_{CO} = x + y = 1.4 \text{ litre}$$

The volume of CO_2 consumed (reacted) equals to the difference between the initial volume and the volume remained after the reaction:

$$V^{react.}_{CO_2} = V^0_{CO_2} - V_{CO_2} = (1 - x) \text{ litre}$$

As is clear from the chemical equation, two moles of CO are formed when 1 mole of CO_2 reacts. Volume is proportional to the number of moles, so we can state:

$$V_{CO} = 2 \cdot V^{react.}_{CO_2}, \text{ i.e. } y = 2(1 - x)$$

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:

$$x + 2 - 2x = 1.4$$
$$x - 2x = 1.4 - 2$$
$$x = 0.6$$

Then

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

$V_{CO_2} = x = 0.6$ litre, $V_{CO} = y = 0.8$ litre

So, the 1.4 litre of product mixture consists of 0.6 litre of unreacted CO_2 and 0.8 litre of CO.

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

$$\%_{CO_2} = \frac{V_{CO_2}}{V_{prod.}} 100\% = \frac{0.6\ l \cdot 100\%}{1.4\ l} = 42.9\%\ by\ vol.$$

$$\%_{CO} = \frac{V_{CO}}{V_{prod.}} 100\% = \frac{0.8\ l \cdot 100\%}{1.4\ l} = 57.1\%\ by\ vol.$$

Answer: $\%_{CO_2} = 42.9\%\ by\ vol.,\ \%_{CO} = 57.1\%\ by\ vol.$