Question 15

A mixture of ethane (C_2H_6) and ethene (C_2H_4) occupies 40 litres at 1.00 atm and at 400 K. The mixture reacts completely with 130 g of O_2 to produce CO_2 and H_2O. Assuming ideal gas behaviour, calculate the mole fractions of C_2H_4 and C_2H_6 in the mixture. ***(1995 - 4 Marks)***

Let the volume of ethane in mixture = x litre

$\therefore$ Volume of ethene = $(40 - x)$ litre

Combustion reactions of ethane and ethene are :

(i) $C_2H_6(g) + 3\frac{1}{2}O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$

or $2C_2H_6(g) + 7O_2(g) \longrightarrow 4CO_2(g) + 6H_2O(l)$

(ii) $C_2H_4(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(l)$

Volume of O_2 required for complete combustion of ethane

$= \frac{7x}{2}$ [For x litres]

Volume of O_2 required for complete combustion of ethene

$= (40–x) \times 3$ [For $(40 - x)$ L]

$\therefore$ Total volume of O_2 required $= \frac{7x}{2} + (40 - x)3\ l$

Calculation of number of moles (n)

$P = 1$ atm, $V = \frac{7x}{2} + (40 - x)3\ l$; $R = 0.082\ l$ atm K^{-1} mol^{-1};

$T = 400$ K

Since $n = \frac{PV}{RT} = \frac{1 \times \left[\frac{7x}{2} + (40 - x)3\right]}{0.082 \times 400} = \frac{7x + (40 - x)6}{2 \times 0.082 \times 400}$

Mass of n moles of O_2 $= \left[\frac{7x + (40 - x)6}{2 \times 0.082 \times 400}\right] \times 32 = 130$

or $130 = \left[\frac{7x + 240 - 6x}{65.6}\right] \times 32$

$\Rightarrow 8528 = 32x + 240 \times 32 \Rightarrow 32x = 848 \Rightarrow$ or $x = \frac{848}{32} = 26.5$

Hence mole fraction (%) of ethane $= \frac{26.5}{40} \times 100 =$ **66.25%**