Gases: solutions to the exercises

① $\left[P_1 \times V_1 = P_2 \times V_2\right]_{T,n \text{ constant}}$

$$2\ atm \times 80\ L = P_2 \times 10\ L$$

$$P_2 = \frac{2\ atm \times 80\ L}{10\ L} = \boxed{16\ atm}$$

② $$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

$$\frac{10^5\ Pa \times 0.05\ L}{300\ K} = \frac{2.2 \times 10^5\ Pa \times V_2}{400\ K}$$

$$V_2 = \frac{10^5\ Pa \times 0.05 L \times 400\ K}{2.2 \times 10^5\ Pa \times 300\ K} = 3.03 \times 10^{-2}\ L = \boxed{30.3\ mL}$$

③ $P \times V = n \times R \times T$

$$n = 100\ g\ butane\ \frac{1\ mol}{58\ g} = 1.72\ mol\ of\ butane$$

$STP \rightarrow T = 273\ K;\ P = 1\ atm$

$$1\ atm \times V = 1.72\ mol \times 0.082\ \frac{atm.L}{K.mol} \times 273\ K$$

$$V = \frac{1.72\ mol \times 0.082\ \frac{atm.L}{K.mol} \times 273\ K}{1\ atm} = \boxed{38.5\ L}$$

④ $P_T = P_{H_2} + P_{CO_2}$

$P \times V = n \times R \times T$

$V = 10\,L$

$P_{H_2} = 2\ atm$

$P_{CO_2} = P_T - P_{H_2} = 3\ atm - 2\ atm = 1\ atm$

$T = 50 + 273 = 323\ K$

$P_{CO_2} \times V = n_{CO_2} \times R \times T$

$1\ atm \times 10\,L = n_{CO_2} \times 0.082\ \frac{atm.L}{K.mol} \times 323\ K$

$$n_{CO_2} = \frac{1\ atm \times 10\,L}{0.082\ \frac{atm.L}{K.mol} \times 323\ K} = \boxed{0.38\ mol\ CO_2}$$

⑤ $P \times V = n \times R \times T$

↓ two components

$P_T = P_{CO_2} + P_{O_2}$

↓

$M(CO_2) = (1 \times 12) + (2 \times 16) = 44\ g/mol$

$n(CO_2) = 26\ g\ CO_2 \dfrac{1\ mol\ CO_2}{44\ g\ CO_2} = 0.59\ moles\ CO_2$

$V = 0.01\ m^3 \dfrac{1000\ L}{1\ m^3} = 10\ L$

$$P_{O_2} = \frac{n_{O_2} \times R \times T}{V} = \frac{2.5\ moles \times 0.082\ \frac{atm.L}{K.mol} \times (273+30)K}{10L} =$$

$$= \boxed{6.21\ atm}$$

$$P_{CO_2} = \frac{n_{CO_2} \times R \times T}{V} = \frac{0.59\ mol \times 0.082\ \frac{atm.L}{K.mol} \times (273+30)K}{10L} =$$

$$= \boxed{1.47\ atm}$$

$$P_T = P_{O_2} + P_{CO_2} = 6.21\ atm + 1.47\ atm = \boxed{7.68\ atm}$$

⑥ $P_T = P_{CH_4} + P_{CO_2}$

$P \times V = n \times R \times T$

$n_{CO_2} = 100\ g\ CO_2 \dfrac{1\ mol\ CO_2}{44\ g\ CO_2} = 2.27\ mol\ CO_2$

$M = (1 \times 12) + (2 \times 16) = 44\ g/mol$

$V = 80\ L$

$P_T = P_{CH_4} + P_{CO_2} = 2\ atm$

$T = 300\ K$

$$P_{CO_2} = \frac{n_{CO_2} \times R \times T}{V} = \frac{2.27\ mol \times 0.082\ \frac{atm.L}{K.mol} \times 300K}{80L} \rightarrow$$

$\rightarrow P_{CO_2} = 0.7\ atm$

$P_T = P_{CH_4} + P_{CO_2} \rightarrow 2\ atm = P_{CH_4} + 0.7\ atm \rightarrow P_{CH_4} = 1.3\ atm$

$P_{CH_4} \times V = n_{CH_4} \times R \times T \rightarrow n_{CH_4} = \dfrac{P_{CH_4} \times V}{R \times T} \rightarrow$

$$n_{CH_4} = \frac{1.3\ atm \times 80\ L}{0.082\ \frac{atm.L}{K.mol} \times 300K} = 4.23\ mol\ CH_4$$

$M(CH_4) = (1 \times 12) + (4 \times 1) = 16\ \frac{g}{mol}$

Mass of methane gas:

$m = 4.23\ mol\ CH_4 \dfrac{16\ g}{1\ mol} =$ **67.68 g of CH_4**

Total mass:

$m_T = m_{CO_2} + m_{CH_4} = 100g + 67.68g = 167.68\ g$

Density of the gas mixture:

$d = \dfrac{m}{V} = \dfrac{167.68\ g}{80\ L} =$ **2.1 g/L**