CHEM 7: GASES

Example-1

What is the volume occupied by 13.7 g Cl_2 (g) at 45°C and 745 mmHg?

(Cl_2: 71 g/mol)

P → pressure R → gas constant

V → volume m → mass

n → no of moles Mr → molecular mass

T → temperature

d = density

$PV = nRT$ K

$n = \frac{m}{M_r}$

$PV = \frac{m}{M_r}RT \rightarrow \frac{m}{V} = d = \frac{MP}{RT}$

$d = \frac{MP}{RT}$

V = ? L ✓

m = 13.7 g

T = 45°C + 273.15 ⇒ 318.15 K

$P = \frac{745 \text{ mmHg}}{760 \text{ mmHg}} = 0.98 \text{ atm}$

1 atm = 760 mmHg
= 760 torr
= 101.325 kPa

V → L
P → atm
T → K

$M_{r\,Cl_2} = 71 \text{ g/mol}$

R = 0.0821

$PV = \frac{m}{M_r}RT$

$V = \frac{mRT}{PM_r} = \frac{13.7 \times 0.0821 \times 318.15}{0.98 \times 71} = 5.143 \text{ L}$

Example-2

How many moles of He(g) are in a 5.00 L storage tank filled with helium at 10.5 atm pressure at 30°C?

$n = ?$ ✓

$V = 5.00\ L$ ✓

$P = 10.5\ atm$ ✓

$T = 30^\circ C + 273.15 = 303.15\ K$

$R = 0.0821$

$$PV = nRT$$

$$n = \frac{RT}{PV} = \frac{0.0821 \times 303.15}{10.5 \times 5.00} = 2.11\ mol.$$

A glass vessel weighs 40.1305 g when clean, dry, and evacuated; it weighs 138.2410 g when filled with water at 25°C (density of water = 0.9970 g/mL) and 40.2959 g when filled with propylene gas at 740.3 mmHg and 24°C. What is the molar mass of propylene?

$m_{vessel} = 40.1305\ g$

$m_{vessel+H_2O} = 138.2410\ g \rightarrow t = 25^\circ C$, $d_{H_2O} = 0.9970\ g/ml$ } (V)

$m_{vessel+prop} = 40.2959\ g \rightarrow P = 740.3\ mmHg$, $T = 24^\circ C$, $M_r = ?$

✓ ✓ × ×
P, T, V, m

① finding (m) of propylene.

$m_{prop} = m_{vessel+prop} - m_{vessel}$

$= 40.2959 - 40.1305 = 0.1654\ g$ ✓

② finding (V) of propylene by calculating (V) of H_2O

$m_{H_2O} = m_{vessel+H_2O} - m_{vessel}$

$= 138.2410 - 40.1305 = 98.1105\ g$

$d = \frac{m}{V}$ $\quad V = \frac{m}{d} = \frac{98.1105}{0.9970} = 98.405\ ml$

$V = 98.405\ ml \div 1000 = 0.098405\ L$

$T = 24^\circ C + 273.15 = 297.15\ K$

$P = \frac{740.3}{760}\ mmHg = 0.974\ atm$

$R = 0.0821$ $\quad m = 0.1654$

$M_r = ?$

$PV = \frac{m}{M_r} RT$

$M_r = \frac{mRT}{PV}$

$= \frac{0.1654 \times 0.0821 \times 297.15}{0.974 \times 0.098405}$

$= 42.099 \simeq \underline{42.1\ g/mol}$

Example-4

- What is the density of oxygen gas (O_2) at 298 K and 0.987 atm?

(O_2: 32 g/mol)

$d = ?$

$M_r = 32$ g/mol ✓

$T = 298$ K ✓

$P = 0.982$ atm ✓

$R = 0.0821$ ✓

$$d = \frac{M_r P}{RT}$$

$$d = \frac{32 \times 0.982}{0.0821 \times 298} = 1.29 \text{ g/ml}$$

Example-5 (Gases in chemical reactions)

What volume of N_2, measured at 735 mmHg and 26 °C, is produced when 75.0 g NaN_3 is decomposed?

$2\,NaN_3(s) \xrightarrow{\Delta} 2\,Na(l) + 3\,N_2(g)$

(NaN_3: 65 g/mol)

P, V, n, T

$V_{N_2} = ?$

$m_{NaN_3} = 75.0\ g$

$P = 735\ mmHg$

$T = 26^\circ C$

① find (n) of NaN_3 by using the formula

$$n = \frac{m}{M_r} = \frac{75.0}{65} = 1.15\ mol$$

② find (n) of N_2 by using molar ratio

NaN_3	N_2
2	3
1.15	?

$$n_{N_2} = \frac{3 \times 1.15}{2} = 1.73\ mol$$

③ find (V) by using gas law

$PV = nRT$

$$V = \frac{nRT}{P} = \frac{1.73 \times 0.0821 \times 299.15}{0.967}$$

$= 43.9\ L \simeq 44\ L$

$P = \frac{735\ mmHg}{760} = 0.967\ atm$

$T = 26^\circ C + 273.15 = 299.15\ K$

$R = 0.0821$

Example-6

Dalton law

What is the pressure, in bar, exerted by a mixture of 1.0 g H_2 and 5.00 g He when the mixture is confined to a volume of 5.0 L at 20°C?

(H_2: 2 g/mol, He: 4 g/mol)

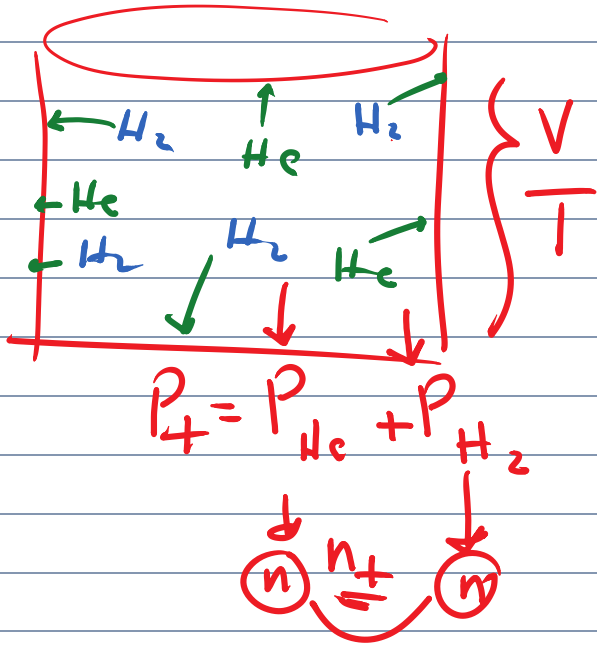
$P = ?$ bar

$m_{H_2} = 1.0\,g \rightarrow (n)$

$m_{He} = 5.00\,g \rightarrow (n) \rightarrow n_t$

$V = 5.0\ L$

$T = 20^\circ C + 273.15 = 298.15\ K$



① finding (n) of H_2, He

$$n_{H_2} = \frac{m}{Mr} = \frac{1.0\,g}{2\,g/mol} = 0.5\,mol$$

$$n_{He} = \frac{5.00}{4} = 1.25\,mol$$

$$n_t = 0.5 + 1.25 = 1.75\,mol.$$

$R = 0.0821$

② finding (P)

$$P = \frac{nRT}{V} = \frac{1.75 \times 0.0821 \times 298.15}{5}$$

$$= 8.4\ atm \times 1.01325 = 8.5113 \simeq 8.5\ bar$$

1 atm = 1.01325 bar