

Gas Mixtures and Gas Stoichiometry

Answer key with worked solutions

A. Partial pressures

1. Dalton's law.

The total pressure of a mixture of non-reacting gases is the **sum of the partial pressures**. At fixed V and T, each gas's pressure depends only on its number of moles ($P = nRT/V$), so its share of the pressure equals its share of the moles: $P_A = x_A P_{\text{total}}$.

2. Air.

$$\text{N}_2: 0.781 \times 1.00 \text{ atm} = \mathbf{0.781 \text{ atm} = 79.1 \text{ kPa}}$$

$$\text{O}_2: 0.209 \times 1.00 \text{ atm} = \mathbf{0.209 \text{ atm} = 21.2 \text{ kPa}}$$

$$\text{Ar}: 0.0093 \times 1.00 \text{ atm} = \mathbf{0.0093 \text{ atm} = 0.94 \text{ kPa}}$$

3. Helium and oxygen.

$$\text{(a) } n_{\text{He}} = \frac{2.00 \text{ g}}{4.003 \text{ g/mol}} = 0.4996 \text{ mol}; n_{\text{O}_2} = \frac{8.00 \text{ g}}{32.00 \text{ g/mol}} = 0.2500 \text{ mol}$$

$$\text{(b) } x_{\text{He}} = \frac{0.4996 \text{ mol}}{0.7496 \text{ mol}} = \mathbf{0.667}$$

$$\text{(c) } T = 27 + 273.15 = 300.15 \text{ K}$$

$$P_{\text{He}} = \frac{0.4996 \text{ mol} \times 0.08206 \frac{\text{L atm}}{\text{mol K}} \times 300.15 \text{ K}}{10.0 \text{ L}} \\ = \mathbf{1.23 \text{ atm}}$$

$$P_{\text{O}_2} \text{ (half the moles of He)} = \mathbf{0.616 \text{ atm}}; P_{\text{total}} = 1.23 \text{ atm} + 0.616 \text{ atm} = \mathbf{1.85 \text{ atm}}$$

B. Gases collected over water

4. Oxygen over water.

$$(a) P_{O_2} = 748 \text{ mmHg} - 19.8 \text{ mmHg} = 728.2 \text{ mmHg}; \frac{728.2 \text{ mmHg}}{760 \text{ mmHg/atm}} = \mathbf{0.9582 \text{ atm}}$$

$$(b) T = 22 + 273.15 = 295.15 \text{ K}$$

$$n = \frac{PV}{RT} = \frac{0.9582 \text{ atm} \times 0.500 \text{ L}}{0.08206 \frac{\text{L atm}}{\text{mol K}} \times 295.15 \text{ K}} \\ = \mathbf{0.0198 \text{ mol}}$$

$$\text{Mass: } 0.01978 \text{ mol} \times 32.00 \text{ g/mol} = \mathbf{0.633 \text{ g}}$$

C. Gas stoichiometry

5. Hydrogen from zinc.

$$n(\text{Zn}) = \frac{1.31 \text{ g}}{65.38 \text{ g/mol}} = 0.02004 \text{ mol} = n(\text{H}_2)$$

$$V = \frac{nRT}{P} = \frac{0.02004 \text{ mol} \times 0.08206 \frac{\text{L atm}}{\text{mol K}} \times 298.15 \text{ K}}{1.00 \text{ atm}} \\ = \mathbf{0.490 \text{ L}}$$

6. Propane.

Volume ratios equal mole ratios. (a) $2.00 \text{ L} \times 5 = \mathbf{10.0 \text{ L O}_2}$ (b) $2.00 \text{ L} \times 3 = \mathbf{6.00 \text{ L CO}_2}$

7. Molar volume.

$0.250 \text{ mol} \times 22.4 \text{ L/mol} = \mathbf{5.60 \text{ L}}$. 22.4 L/mol applies only at 0°C and 1 atm ; at 25°C the gas expands (24.5 L/mol), so use $PV = nRT$ instead.

D. Challenge

8. Airbag.

Moles of N_2 :

$$\begin{aligned}n &= \frac{PV}{RT} = \frac{1.10 \text{ atm} \times 60.0 \text{ L}}{0.08206 \frac{\text{L atm}}{\text{mol K}} \times 298.15 \text{ K}} \\&= 2.698 \text{ mol N}_2\end{aligned}$$

Moles and mass of NaN_3 ($2 \text{ NaN}_3 : 3 \text{ N}_2$):

$$\begin{aligned}2.698 \cancel{\text{mol N}_2} \times \frac{2 \cancel{\text{mol NaN}_3}}{3 \cancel{\text{mol N}_2}} \times \frac{65.02 \text{ g}}{1 \cancel{\text{mol NaN}_3}} \\&= 117 \text{ g NaN}_3\end{aligned}$$