

Chemistry Notes - The Mole and Gas Volume

1. The Mole and Gas Volume

The scientist Avogadro concluded that:

- Equal volumes of gases contain the same number of molecules when measured under the same conditions of temperature and pressure.

At STP (Standard Temperature and Pressure):

- Temperature: 273 K (0 °C)
- Pressure: 760 mmHg (1 atm)
- Molar gas volume: 22.4 L

At RTP (Room Temperature and Pressure):

- Temperature: 298 K (25 °C)
- Pressure: 760 mmHg (1 atm)
- Molar gas volume: 24 L

Definition of Molar Gas Volume:

The volume occupied by one mole of a gas under specific conditions of temperature and pressure.

- At STP → 22.4 L per mole
- At RTP → 24 L per mole

Worked Example:

Calculate the volume occupied by 1.6 g of methane (CH₄) at:

1. STP
2. RTP

Given:

- Molar mass of CH₄ = 16 g/mol
- Number of moles = Mass ÷ Molar mass = $1.6 \div 16 = 0.1$ mol

Solution:

- At STP: Volume = $22.4 \times 0.1 = 2.24$ L
- At RTP: Volume = $24 \times 0.1 = 2.4$ L

2. Molar Mass, Number of Molecules, and Molar Gas Volume

Relationship Summary:

- 1 mole of any substance contains 6.02×10^{23} particles (Avogadro's number).
- 1 mole of gas occupies:
 - 22.4 L at STP
 - 24 L at RTP

Gas	Molar Mass (g/mol)	Number of Molecules in 1 mol	Volume at STP	Volume at RTP
H ₂	2	6.02×10^{23}	22.4 L	24 L
N ₂	28	6.02×10^{23}	22.4 L	24 L
O ₂	32	6.02×10^{23}	22.4 L	24 L
CO ₂	44	6.02×10^{23}	22.4 L	24 L

Worked Example:

Calculate the number of moles, molecules, and volume of oxygen gas (O₂) in 10 g.

Given:

- Molar mass of O₂ = 32 g/mol

Solution:

1. Number of moles = mass ÷ molar mass = $10 \div 32 = 0.3125$ mol

2. Number of molecules = n × Avogadro's number = $0.3125 \times 6.02 \times 10^{23} = 1.88 \times 10^{23}$ molecules

3. Volume:

- At STP: $V = 0.3125 \times 22.4 = 7.0$ L

- At RTP: $V = 0.3125 \times 24 = 7.5$ L

3. More Applications on the Mole and Gas Volume

Worked Example (1):

Calculate the volume occupied by 4 g of hydrogen gas (H_2) at STP and RTP.

Given:

- Molar mass of $\text{H}_2 = 2 \text{ g/mol}$
- Mass = 4 g

Solution:

1. Number of moles = $4 \div 2 = 2 \text{ mol}$

2. Volume:

- At STP: $V = 2 \times 22.4 = 44.8 \text{ L}$
- At RTP: $V = 2 \times 24 = 48 \text{ L}$

Worked Example (2):

How many molecules are present in 11.2 L of carbon dioxide (CO_2) at STP?

Given:

- Molar volume at STP = 22.4 L/mol

Solution:

1. Number of moles = $11.2 \div 22.4 = 0.5 \text{ mol}$

2. Number of molecules = $0.5 \times 6.02 \times 10^{23} = 3.01 \times 10^{23} \text{ molecules}$

Worked Example (3):

Find the mass of nitrogen gas (N_2) present in 24 L at RTP.

Given:

- Molar mass of $\text{N}_2 = 28 \text{ g/mol}$
- Molar volume at RTP = 24 L/mol

Solution:

1. Number of moles = $24 \div 24 = 1 \text{ mol}$

2. Mass = $1 \times 28 = 28 \text{ g}$

Key Points Recap:

- 1 mole of gas occupies 22.4 L at STP, 24 L at RTP.
- 1 mole of gas contains 6.02×10^{23} molecules.
- Mass, moles, molecules, and volume are interrelated through molar mass and molar gas volume.