

4.1 The gaseous state: ideal and real gases and $pV = nRT$

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS pressure 压强 • ideal gas 理想气体 • ideal gas equation 理想气体方程 • intermolecular forces 分子间作用力
• ion 离子

Objective

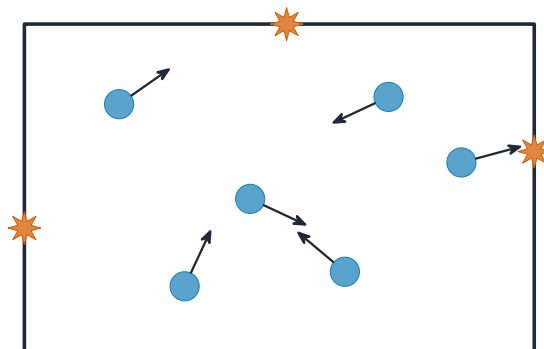
Build the skills to answer exam questions on **the gaseous state** — the origin of gas **pressure** 压强, the **ideal gas** 理想气体 model, and the ideal gas equation $pV = nRT$.

You must be able to:

- explain the origin of pressure in terms of collisions with the container walls
- state the assumptions of an ideal gas
- use $pV = nRT$ in calculations, including finding M_r

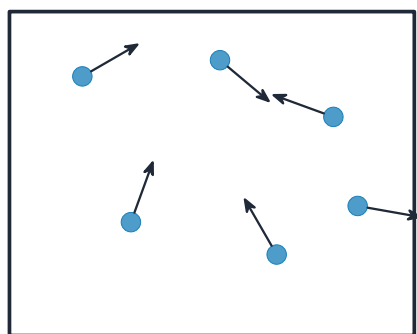
1 Worked examples

■ Gas pressure and the ideal gas

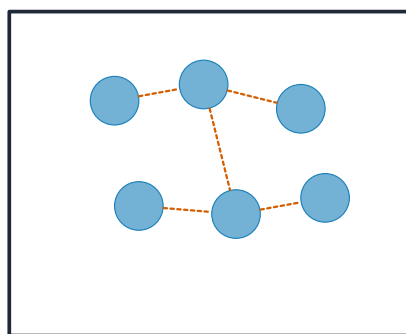


fast particles collide with the walls; the many pushes make the **pressure**

Pressure comes from the many collisions of fast gas molecules with the container walls



ideal gas (model)
point particles, *no* forces



real gas: high p , low T
real size + attractions (dashed)

An ideal gas has zero particle volume and no intermolecular forces — real gases obey it best at low pressure, high temperature

■ The ideal gas equation

$$pV = nRT$$

(p in Pa, V in m^3 , T in K, $R = 8.31 \text{ J K}^{-1}\text{mol}^{-1}$). **Convert first:** $^{\circ}\text{C} \rightarrow \text{K}$ (+273); $\text{cm}^3/\text{dm}^3 \rightarrow \text{m}^3$.

Example. Volume of 0.50 mol at 27°C , 100 kPa: $T = 300 \text{ K}$, $p = 1.00 \times 10^5 \text{ Pa}$; $V = nRT/p = (0.50 \times 8.31 \times 300)/(1.00 \times 10^5) = 0.0125 \text{ m}^3$.

Finding M_r . Since $n = m/M$: $M = \frac{mRT}{pV}$.

2 Practice

2.1 State the **two** assumptions made about an ideal gas.

[2]

2.2 Convert 25°C to kelvin.

[1]

3 Exam-style questions

3.1 A real gas behaves **most** like an ideal gas at:

[1]

- **A** high pressure and low temperature
- **B** low pressure and high temperature
- **C** high pressure and high temperature

- **D** low pressure and low temperature
-

3.2 In the equation $pV = nRT$, the temperature T must be in: [1]

- **A** °C
 - **B** kelvin
 - **C** °F
 - **D** joules
-

3.3 Calculate the volume, in m^3 , of 2.0 mol of an ideal gas at 127 °C and a pressure of 2.0×10^5 Pa. ($R = 8.31$). [3]

3.4 A gas of mass 1.32 g occupies 750 cm^3 at 100 kPa and 27 °C. Calculate its molar mass. ($R = 8.31$). [3]

Solutions

2.1 the particles have zero volume; there are no intermolecular forces of attraction.

2.2 $25 + 273 = 298 \text{ K}$.

3.1 B. Low pressure and high temperature (particles far apart, forces negligible).

3.2 B. Temperature must be in kelvin.

3.3 $T = 400 \text{ K}$; $V = nRT/p = (2.0 \times 8.31 \times 400)/(2.0 \times 10^5) = 0.0332 \text{ m}^3$.

3.4 convert: $V = 7.50 \times 10^{-4} \text{ m}^3$, $T = 300 \text{ K}$, $p = 1.00 \times 10^5 \text{ Pa}$; $M = \frac{mRT}{pV} = \frac{1.32 \times 8.31 \times 300}{(1.00 \times 10^5)(7.50 \times 10^{-4})} = 43.9 \text{ g mol}^{-1}$.