5.1 Ideal gases

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS ideal gas • pressure • molar volume • kelvin • real gas • gas constant

Objective

Build the skills to answer exam questions on **ideal gases** : the gas laws, the ideal gas equation, molar volume and real gases.

You must be able to:

- state the assumptions of the ideal gas model
- use the gas laws and $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$ with kelvin temperatures
- use $pV = nRT$ (SI units) and the molar volume 22.7 dm^3 mol^{-1} at STP
- explain when and why real gases do not behave ideally

1 Key knowledge and worked examples

The ideal gas model

Assumptions: particles move randomly in straight lines; their own volume is negligible; there are no forces between them except in collisions; collisions are elastic.

law	at fixed	relationship
Boyle	T, n	$p \propto \frac{1}{V}$
Charles	p, n	$V \propto T$ (kelvin)
Gay-Lussac	V, n	$p \propto T$ (kelvin)
combined	n	$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$
ideal gas equation	–	$pV = nRT$: p in Pa, V in m^3, T in K, $R = 8.31$ J K^{-1} mol^{-1}
molar volume	STP (273 K, 100 kPa)	22.7 dm^3 mol^{-1}

Real gases behave least ideally at **high pressure** (the particles' own volume matters) and **low temperature** (attractions between particles matter).

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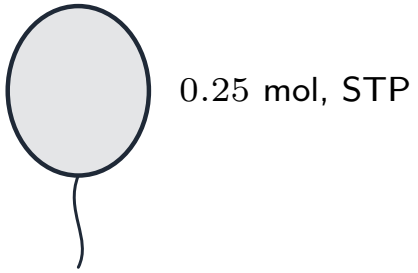
Worked example 1: units. 250 $\text{cm}^3 = 2.50 \times 10^{-4}$ m^3; 100 kPa $= 1.00 \times 10^5$ Pa.

Worked example 2: molar mass. 0.32 g of a gas occupies 224 cm^3 at STP: $n = \dfrac{0.224}{22.7} = 0.00987$ mol, so $M = \dfrac{0.32}{0.00987} = 32$ **g mol**$^{-1}$.

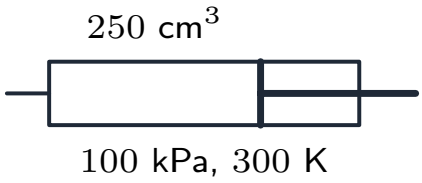
Answer shapes: convert to SI units before using $pV = nRT$.

2 Practice

2.1 Calculate the volume occupied by 0.25 mol of an ideal gas at STP. [2]

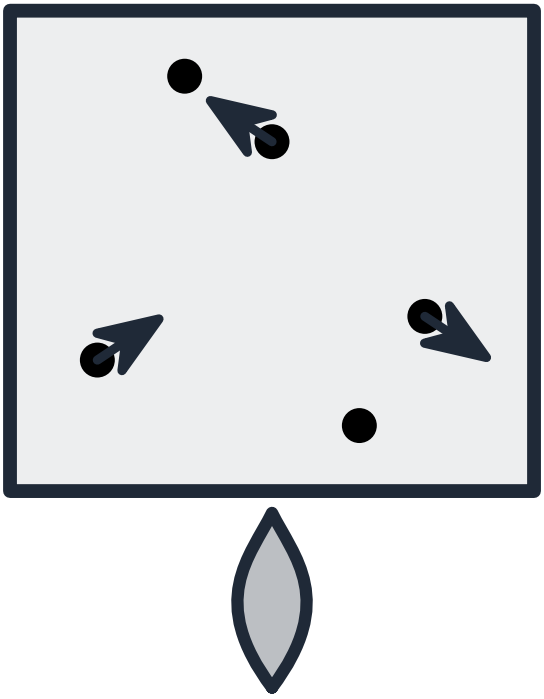


2.2 0.50 g of a gas occupies 250 cm^3 at 100 kPa and 300 K. Calculate its molar mass. [3]



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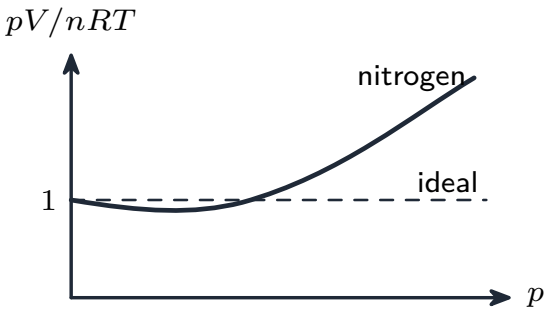
2.3 A sealed can of gas is heated. Use the kinetic model to explain why the pressure inside rises. [3]



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3 Exam-style questions

3.1 The graph shows $\frac{pV}{nRT}$ against pressure for nitrogen at 300 K, and for an ideal gas.



(a) State two assumptions of the ideal gas model. [2]

(b) Explain why nitrogen is far from ideal at very high pressure. [2]

(c) State the conditions of temperature and pressure at which nitrogen is closest to ideal. [1]

(d) Explain why real gases also move away from ideal behaviour at low temperature. [1]

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