

## 8.2 Gas laws and the kinetic model (full B.3)

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

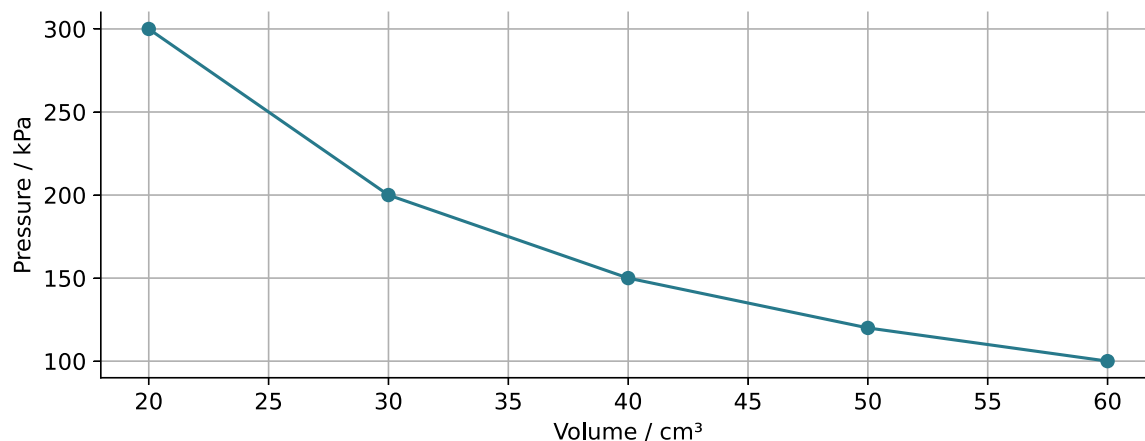
Total: 25 marks

**KEY WORDS** ideal gas • Avogadro constant • monatomic

### Objective

Practise the full guide B.3 toolkit: pressure as  $F/A$ ,  $n = N/N_A$ , the ideal gas law in both forms ( $PV = Nk_B T$  and  $PV = nRT$ ) with  $PV/T$  constant, the kinetic derivation link  $P = \frac{1}{3} \rho \langle v^2 \rangle$ , internal energy of a monatomic ideal gas, pressure–volume diagrams, and the conditions where the ideal gas approximates a real gas. Original practice; not an official IB paper.

### 1 Key knowledge and worked examples



#### ■ The B.3 equation set

$$P = \frac{F}{A} \quad n = \frac{N}{N_A} \quad \frac{PV}{T} = \text{constant} \quad PV = Nk_B T = nRT$$

$$P = \frac{1}{3} \rho \langle v^2 \rangle \quad U = \frac{3}{2} Nk_B T = \frac{3}{2} nRT$$

**Worked check.** 0.50 mol of an ideal gas at 250 K in  $8.0 \times 10^{-3} \text{ m}^3$ :  $P = nRT/V = 0.50 \times 8.31 \times 250 / 8.0 \times 10^{-3} = 1.3 \times 10^5 \text{ Pa}$ ;  $U = 1.5 \times 0.50 \times 8.31 \times 250 = 1.6 \times 10^3 \text{ J}$ .

Ideal  $\approx$  real at high temperature and low pressure; deviations grow near condensation.

## 2 Practice

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**2.1** State the two forms of the ideal gas equation, naming every symbol. [4]

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**2.2** A gas occupies  $3.0 \times 10^{-3} \text{ m}^3$  at 300 K and  $1.2 \times 10^5 \text{ Pa}$ . It is compressed to  $1.0 \times 10^{-3} \text{ m}^3$  at constant temperature. Calculate the new pressure. [3]

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**2.3** Calculate  $n$  for  $N = 1.2 \times 10^{24}$  molecules ( $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$ ). [2]

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**2.4** State the internal energy formula for an ideal monatomic gas. [1]

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**2.5** Under what conditions does a real gas behave most ideally? [2]

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## 3 Exam-style questions

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**3.1** A sealed cylinder holds 0.20 mol of an ideal monatomic gas at 200 K, with volume  $6.0 \times 10^{-3} \text{ m}^3$ . Calculate the pressure and internal energy; the gas is then heated at constant volume to 400 K – calculate the new pressure. [6]

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**3.2** Explain, using momentum change at the walls, why gas pressure rises with temperature at constant volume, referencing  $P = \frac{1}{3} \rho \langle v^2 \rangle$ . [4]

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**3.3** Sketch or describe the pressure–volume diagram for an isothermal compression, and explain why the hyperbola shape follows from  $PV/T = \text{constant}$ . [3]

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