# Exercise walk-through

## Ideal Gas Law ▪ 3.4

eXercise

# You must be able to

- use $PV = nRT$ with $R = 0.08206$ L atm $\text{mol}^{-1}\text{K}^{-1}$
- convert temperature to **kelvin** 开尔文 and match units
- combine states with $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

# Method — The ideal gas law

$$PV = nRT.$$

Use consistent units: $P$ in atm, $V$ in L, $n$ in mol, $T$ in **kelvin** ($T_K = T_C + 273$), with $R = 0.08206$ L atm $\text{mol}^{-1}\text{K}^{-1}$.

## Method — A worked calculation

Find the volume of $2.0$ mol of gas at $1.0$ atm and $300$ K:

$$V = \frac{nRT}{P} = \frac{(2.0)(0.08206)(300)}{1.0} = 49.2 \text{ L}.$$

## Method — Always convert to kelvin

A temperature in °C must become K first. $25°\text{C} = 298$ K. Forgetting this is a common lost mark.

## Method — The combined gas law

When $n$ is fixed and conditions change,

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}.$$

Solve for the unknown, keeping temperatures in kelvin.

## Practice 2.1 ▪ 1 mark

Convert $27°$C to kelvin.

# Solution 2.1

Method: Always convert to kelvin

**Worked steps**

$27 + 273 = 300$ K **B1**.

## Practice 2.2 ▪ 3 marks

Find $n$ for a gas with $P = 2.0$ atm, $V = 10.0$ L, $T = 300$ K.

# Solution 2.2

**Worked steps**

$$n = \frac{PV}{RT} = \frac{(2.0)(10.0)}{(0.08206)(300)} \quad \text{M1}\ \text{M1} \quad = 0.81 \text{ mol} \quad \text{A1}.$$

## Practice 2.3 ▪ 2 marks

A gas at $1.0$ atm and $2.0$ L is compressed to $0.5$ L at constant $T$. Find the new pressure.

# Solution 2.3

**Worked steps**

$$P_2 = \frac{P_1 V_1}{V_2} = \frac{(1.0)(2.0)}{0.5} = 4.0 \text{ atm} \quad \text{M1} \; \text{A1}.$$

## Exam-style 3.1 ▪ 1 mark

In $PV = nRT$, the temperature must be in

**A** °C

**B** kelvin

**C** °F

**D** any unit

# Solution 3.1

Method: Always convert to kelvin

**A** °C

**B** kelvin ✓

**C** °F

**D** any unit

## Worked steps

**B** — kelvin.

## Exam-style 3.2 ▪ 3 marks

A $5.0$ L container holds $0.25$ mol of gas at $350$ K.
(a) Find the pressure in atm.
(b) State what happens to the pressure if the temperature is doubled at constant volume.

# Solution 3.2

**Worked steps**

(a) $P = \dfrac{nRT}{V} = \dfrac{(0.25)(0.08206)(350)}{5.0}$ M1 M1 $= 1.44$ atm A1. (b) The pressure doubles B1.

## Exam-style 3.3 ▪ 3 marks

A balloon has volume $2.0$ L at $300$ K. Find its volume at $360$ K if the pressure is unchanged.

# Solution 3.3

Method: A worked calculation

**Worked steps**

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \text{M1}; \; V_2 = 2.0 \times \frac{360}{300} \quad \text{M1} = 2.4 \text{ L} \quad \text{A1}.$$