Exercise walk-through

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

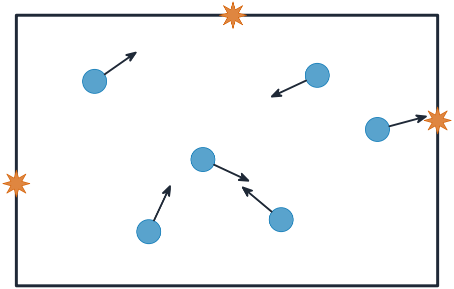
eXercise

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

Method — Gas pressure and the ideal gas

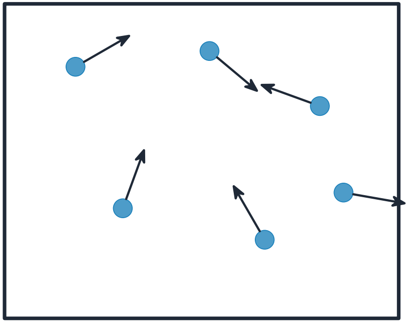
An ideal gas has zero particle volume and no intermolecular forces — real gases obey it best at low pressure, high temperature



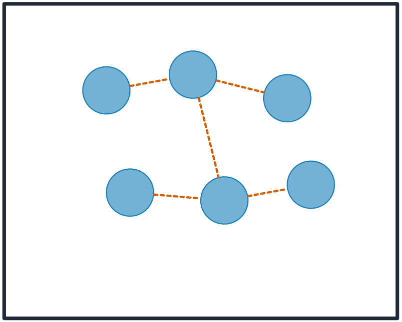
fast particles collide with the walls; the many pushes make the **pressure**

Fast-moving particles in a box, some striking the walls

Method — Gas pressure and the ideal gas



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



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

Method — The ideal gas equation

$$pV = nRT$$

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

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

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

Practice 2.1 ▪ 2 marks

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

Solution 2.1

Worked steps

the particles have zero volume **B1**; there are no intermolecular forces of attraction **B1**.

Practice 2.2 ▪ 1 mark

Convert 25 °C to kelvin.

Solution 2.2

Worked steps

$25 + 273 = 298$ K B1.

Exam-style 3.1 ▪ 1 mark

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

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

Solution 3.1

Method: Gas pressure and the ideal gas

A high pressure and low temperature

B low pressure and high temperature ✓

C high pressure and high temperature

D low pressure and low temperature

Worked steps

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

Exam-style 3.2 ▪ 1 mark

In the equation $pV = nRT$, the temperature T must be in:

A °C

B kelvin

C °F

D joules

Solution 3.2

A °C

B kelvin ✓

C °F

D joules

Worked steps

B. Temperature must be in kelvin.

Exam-style 3.3 ▪ 3 marks

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. ($R = 8.31$).

Solution 3.3

Worked steps

$T = 400$ K **M1**; $V = nRT/p = (2.0 \times 8.31 \times 400)/(2.0 \times 10^5)$ **M1** $= 0.0332$ m^3 **A1**.

Exam-style 3.4 ▪ 3 marks

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

Solution 3.4

Worked steps

convert: $V = 7.50 \times 10^{-4}$ m^3, $T = 300$ K, $p = 1.00 \times 10^5$ Pa **M1**; $M = \dfrac{mRT}{pV} = \dfrac{1.32 \times 8.31 \times 300}{(1.00 \times 10^5)(7.50 \times 10^{-4})}$ **M1** $= 43.9$ g mol^{-1} **A1**.