

Exercise walk-through

5.2

Ideal gas molecules

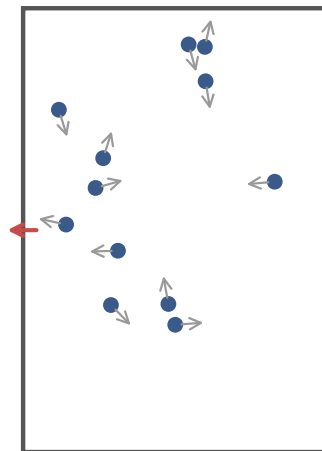
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The method

Method — Molecules make pressure

force on the wall:
pressure



molecules in random motion collide with the walls — each collision exerts a force; pressure is the total force per unit area

Gas molecules collide with the walls; total collision force per area is the pressure.

Method — Kelvin and the two laws

$K = ^\circ\text{C} + 273$; **absolute zero** $-273\text{ }^\circ\text{C} = 0\text{ K}$. Kelvin temperature $\propto$ average molecular kinetic energy.

$$p_1 V_1 = p_2 V_2 \text{ (constant } T) \qquad \frac{p_1}{T_1} = \frac{p_2}{T_2} \text{ (constant } V)$$

Worked check. 200 cm^3 of gas at 150 kPa and 300 K is warmed to 600 K in the same volume: $p_2 = 150 \times 600/300 = 300\text{ kPa}$; then released to double the volume at that temperature: $p = 300 \times 200/400 = 150\text{ kPa}$.

Exercises 2.1·2.3

2.1 State the value of absolute zero in $^{\circ}\text{C}$. [1]

2.2 Convert 50°C to kelvin and 0 K to $^{\circ}\text{C}$. [2]

2.3 A gas at 100 kPa in 6 dm^3 is compressed to 2 dm^3 at constant temperature. Calculate the new pressure. [2]

Exercises 2.1·2.3

2.1 State the value of absolute zero in °C. [1]

2.1 $-273\text{ }^{\circ}\text{C}$.

2.2 Convert $50\text{ }^{\circ}\text{C}$ to kelvin and 0 K to °C. [2]

2.2 323 K ; $-273\text{ }^{\circ}\text{C}$.

2.3 A gas at 100 kPa in 6 dm^3 is compressed to 2 dm^3 at constant temperature. Calculate the new pressure. [2]

2.3 $p_2 = 100 \times 6/2 = 300\text{ kPa}$.

Exercises 2.4·3.1

2.4 A fixed volume of gas at 200 kPa and 300 K is warmed to 450 K. Calculate the new pressure. [2]

2.5 State what happens to gas molecules' average speed when temperature rises. [1]

3.1 Explain, in terms of molecules, why a sealed can's pressure rises when it is heated. [3]

Exercises 2.4·3.1

2.4 A fixed volume of gas at 200 kPa and 300 K is warmed to 450 K. Calculate the new pressure. [2]

2.4 $p_2 = 200 \times 450/300 = 300 \text{ kPa}.$

2.5 State what happens to gas molecules' average speed when temperature rises. [1]

2.5 It increases.

3.1 Explain, in terms of molecules, why a sealed can's pressure rises when it is heated. [3]

3.1 Heating raises the molecules' average kinetic energy – they move faster; faster molecules collide with the walls more often and harder – greater force per collision; the total force per unit area – the pressure – rises.

Exercises 3.2-3.4

3.2 A sealed cylinder of gas at 180 kPa and 300 K is cooled to 200 K at constant volume. Calculate the new pressure, and state one assumption. [3]

3.3 Explain why pumping a bicycle tyre gets harder as it fills, using particle ideas. [3]

3.4 A balloon holds 12 dm³ of gas at 300 kPa at depth. It rises and expands to 40 dm³ at the same temperature. Calculate the gas pressure at the surface, stating one assumption. [4]

Exercises 3.2·3.4

3.2 A sealed cylinder of gas at 180 kPa and 300 K is cooled to 200 K at constant volume. Calculate the new pressure, and state one assumption. [3]

3.2 $p_2 = 180 \times 200/300 = 120$ kPa; assumption: the volume stays constant and no gas escapes.

3.3 Explain why pumping a bicycle tyre gets harder as it fills, using particle ideas. [3]

3.3 Each pump adds molecules, so more are packed into the same volume; collisions on the tyre walls come more frequently – pressure rises; with higher inside pressure, each stroke must push against a bigger force, so it feels harder.

3.4 A balloon holds 12 dm³ of gas at 300 kPa at depth. It rises and expands to 40 dm³ at the same temperature. Calculate the gas pressure at the surface, stating one assumption. [4]

3.4 $p_2 = p_1 V_1/V_2 = 300 \times 12/40 = 90$ kPa; assumption: constant temperature and no gas lost.