5.2 Ideal gas molecules

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

Objective

Build the skills to answer exam questions on **gas pressure and temperature** : particles and pressure, absolute zero and the kelvin scale, pressure and temperature at constant volume, and pressure and volume at constant temperature.

You must be able to:

- explain gas pressure in terms of particles
- convert between °C and kelvin
- use $p_1/T_1 = p_2/T_2$ and $p_1V_1 = p_2V_2$
- plan an experiment linking the pressure and temperature of a gas

1 Key knowledge and worked examples

Gases

idea	equation or rule
gas pressure	particles hit the walls; each collision pushes on the wall
kelvin scale	T (K) = θ (°C) +273; absolute zero is 0 K = −273 °C
temperature	the average kinetic energy of the particles is proportional to the kelvin temperature
constant volume	$p_1 \div T_1 = p_2 \div T_2$ (temperature in K)
constant temperature	$p_1 \times V_1 = p_2 \times V_2$

Worked example 1: kelvin. Convert 27 °C and −73 °C to kelvin.

1. Known: 27 °C and −73 °C.
2. Rule: add 273.
3. Numbers: $27 + 273$; $-73 + 273$.
4. Result: 300 **K and** 200 **K**.

Worked example 2: squashing a gas. 200 cm^3 of gas at 100 kPa is squashed to 50 cm^3 at the same temperature. Find the new pressure.

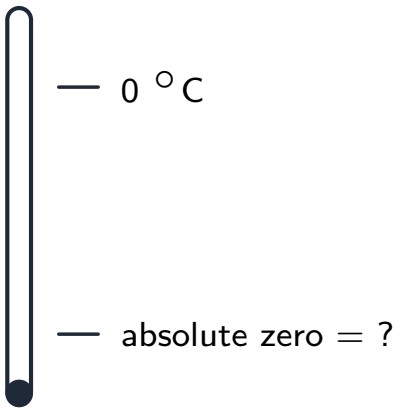
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1. Known: $p_1 = 100$ kPa; $V_1 = 200$; $V_2 = 50$.
2. Rule: $p_1 V_1 = p_2 V_2$.
3. Numbers: $100 \times 200 = p_2 \times 50$.
4. Result: $p_2 = 400$ **kPa**.

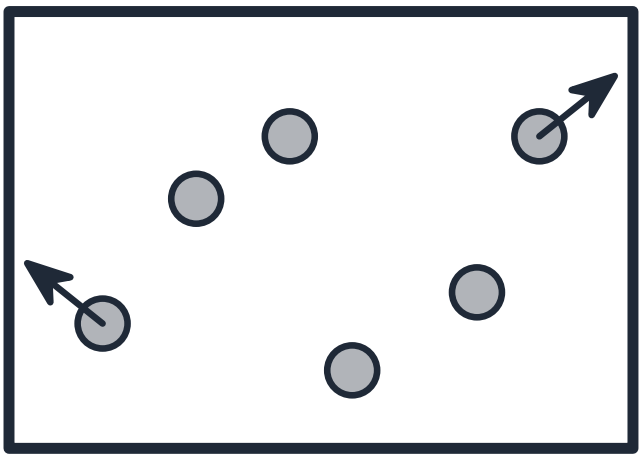
Answer shapes: always change °C to K before using $p \div T$.

2 Practice

2.1 What is absolute zero? Give its value in °C. [2]



2.2 Explain how a gas in a closed container exerts a pressure. [2]



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2.3 The gas in a sealed syringe is pushed into a smaller volume at constant temperature. Explain why its pressure rises. [2]



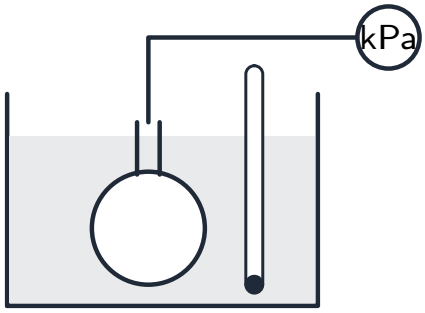
3 Exam-style questions

3.1 A bicycle pump holds 120 cm^3 of air at 100 kPa. The outlet is blocked and the piston is pushed in until the pressure is 250 kPa. The temperature does not change. Calculate the new volume. [3]



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3.2 A student heats air in a sealed flask in a water bath. A pressure gauge measures the pressure. At 17 °C the pressure is 100 kPa.



(a) Convert 17 °C and 77 °C to kelvin. [2]

(b) Calculate the pressure at 77 °C. [3]

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(c) Explain, using particles, why the pressure rises when the air is heated. [3]

(d) Describe how the student can investigate how the pressure of the air depends on its temperature, and how to show that p is proportional to the kelvin temperature. [6]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- the lowest possible temperature, where particles have the least (no) kinetic energy
- $-273\,^{\circ}\text{C}$

2.2

- the particles collide with the walls of the container
- each collision exerts a force on the wall; force per unit area is pressure

2.3

- the same number of particles is in a smaller space
- so they hit the walls more often, giving a larger pressure

3.1

- $p_1V_1 = p_2V_2$
- $100 \times 120 = 250 \times V_2$
- $V_2 = \mathbf{48}\ \text{cm}^3$

3.2

(a) $17 + 273 = \mathbf{290}$ K; $77 + 273 = \mathbf{350}$ K

(b) $p_1 \div T_1 = p_2 \div T_2$; $p_2 = 100 \times 350 \div 290 = \mathbf{121}$ kPa

(c) the particles gain kinetic energy and move faster; they hit the walls more often; and with more force each time, so the pressure rises

(d) points to include:

- put the sealed flask fully under the water; heat the water bath (K)
- stir the water and wait so the air reaches the water temperature before each reading (App)
- read the thermometer and the pressure gauge at about every $10\,^{\circ}\text{C}$ (K)
- keep the volume constant: the flask is sealed and the tube to the gauge is short (App)
- convert every temperature to kelvin and plot p against T (An)
- a straight line through the origin shows $p \propto T$; the line points back to $-273\,^{\circ}\text{C}$ (An)

Levels: **5–6** a full, logical answer with correct physics and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.

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