

Gas laws, kinetic theory and thermal energy

Physics grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Marks are given for correct unit conversions, a clear formula, a correct substitution and a final answer with its unit. Accept answers within rounding error. Method marks can be earned even if an earlier numerical error carries through.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB B.1-B.3

Question 1 Ideal gas assumptions (2 marks)

Any two: molecules have negligible volume compared with the container; there are no intermolecular forces except during collisions; collisions are perfectly elastic; molecular motion is random. **Two assumptions.**

Marking: 1 mark for each valid assumption.

Question 2 Helium cylinder (3 marks)

- a. $T = 290 \text{ K}$, $V = 2.5 \times 10^{-2} \text{ m}^3$. $n = pV / RT = (4.0 \times 10^5 \times 2.5 \times 10^{-2}) / (8.31 \times 290) =$
4.15 mol.
- b. $N = nN_A = 4.150 \times 6.02 \times 10^{23} =$ **2.50×10^{24} atoms.**

Marking: (a) 1 mark for converting to kelvin and m^3 , 1 mark for the answer. (b) 1 mark.

Question 3 Heating fourfold (3 marks)

- a. The temperature rises by a factor of 4 and $c_{\text{rms}} \propto \sqrt{T}$, so the speed increases by a factor $\sqrt{4} = 2$.
- b. $E = (3/2)kT = 1.5 \times 1.38 \times 10^{-23} \times 1200 =$ **$2.48 \times 10^{-20} \text{ J}$.**

Marking: (a) 1 mark. (b) 1 mark for the formula and substitution, 1 mark for the answer.

Question 4 Sealed can in a fire (2 marks)

On heating, the molecules gain kinetic energy and move faster. They hit the walls more often and with a larger change of momentum per collision. The force per unit area on the walls therefore increases, because the volume of the rigid can is constant. **Pressure rises.**

Marking: 1 mark for faster molecules, 1 mark for more frequent and harder collisions giving a larger force per area.

Question 5 Heating wax: melting (2 marks)

- a. The temperature is constant at **60 °C**.
- b. The energy supplied is used to break the bonds between particles, increasing their potential energy rather than their kinetic energy, so the temperature does not rise.

Marking: 1 mark each.

Question 6 Heating wax: solid (2 marks)

Energy supplied in the first 100 s = $Pt = 400 \times 100 = 40\,000$ J. The temperature rises by $60 - 20 = 40$ K. $c = Q / (m\Delta T) = 40\,000 / (0.50 \times 40) = \mathbf{2000 \text{ J/(kg K)}}$.

Marking: 1 mark for the energy, 1 mark for the substitution and answer.

Question 7 Heating wax: latent heat (2 marks)

The melting lasts from 100 s to 400 s, which is 300 s. $Q = Pt = 400 \times 300 = 1.2 \times 10^5$ J. $L = Q / m = 1.2 \times 10^5 / 0.50 = \mathbf{2.4 \times 10^5 \text{ J/kg}}$.

Marking: 1 mark for the energy, 1 mark for L.

Question 8 Kettle boiling dry (3 marks)

- a. $E = Pt = 2200 \times 90 = \mathbf{1.98 \times 10^5 \text{ J}}$.
- b. $m = E / L = 1.98 \times 10^5 / 2.26 \times 10^6 = \mathbf{0.088 \text{ kg}}$ (about 88 g).

Marking: (a) 1 mark. (b) 1 mark for the formula, 1 mark for the answer.

Question 9 No potential energy (1 mark)

The particles exert no forces on each other between collisions, so there is no potential energy stored. **Internal energy is only random kinetic energy.**

Marking: 1 mark.