#1

3. (a) Give the definition of the *specific heat capacity* of a material. [1]

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(b) An insulating flask contains 0.6×10^{-3} m^3 of water at 19.5 °C. A volume 1.6×10^{-3} m^3 of boiling water at 100.0 °C is poured into the flask.

(specific heat capacity of water, c = 4 200 J kg^{-1} °C^{-1}; density of water, ρ = 1 000 kg m^{-3})

(i) Determine the final temperature of the water in the flask. [3]

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(ii) Calculate the heat lost by the boiling water. [3]

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(iii) Justify the statement that no work is done on/by the boiling water as it cools. No further calculations are needed. [1]

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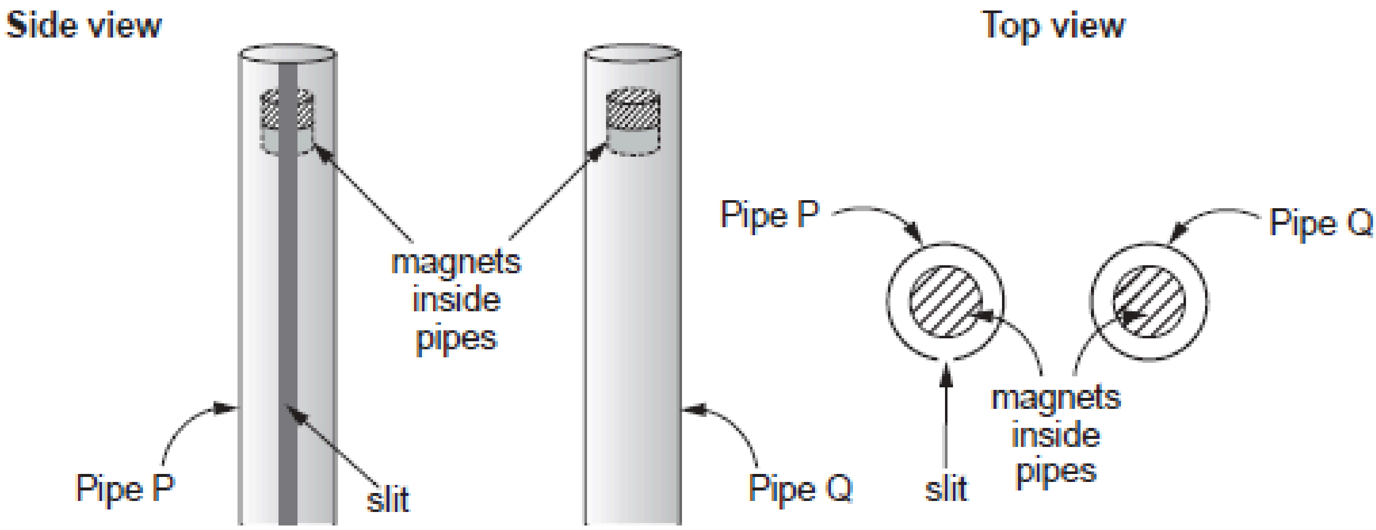
Question taken from WJEC examination paper 242701, June 2018

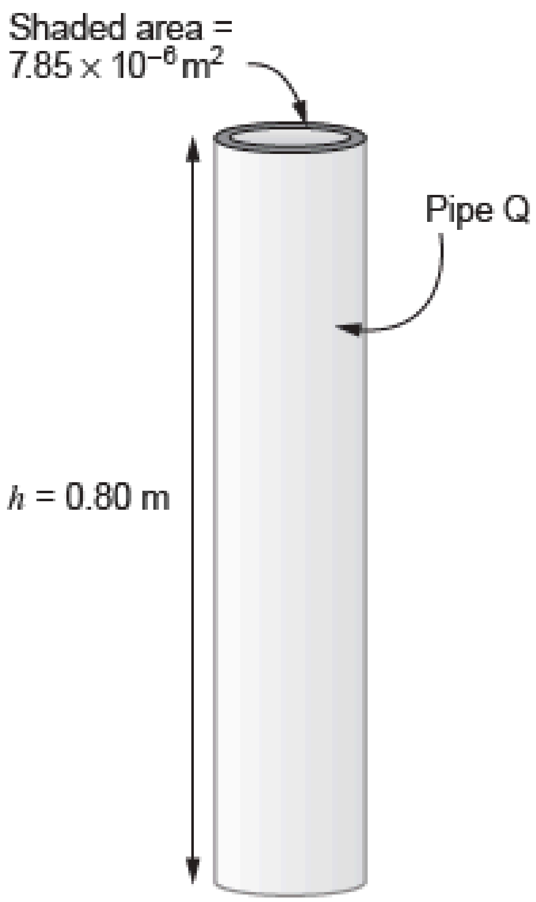
5. *(a)* State the laws of Faraday and Lenz for electromagnetic induction. [2]

(b) Two strong bar magnets are dropped through two copper pipes (P and Q). Pipe P has a slit running along its length but Q is complete. When the magnet is dropped through pipe P it accelerates almost uniformly but the magnet dropped through pipe Q quickly reaches a very low terminal velocity. Explain these observations. [6 QER]



(c) By applying the principle of conservation of energy, calculate the temperature increase of pipe Q after the magnet has fallen at constant speed. [4]

Data:
- mass of magnet = 0.300 kg,
- cross-sectional area of the copper walls of pipe Q = $7.85 \times 10^{-6}\,m^2$ (see diagram)
- density of copper = $8960\,kg\,m^{-3}$
- specific heat capacity of copper = $385\,J\,K^{-1}\,kg^{-1}$.



#3

2. Kinetic theory for an ideal gas gives an expression that can be written as:

$$pV = \frac{1}{3}\, nN_A m\overline{c^2}$$

(a) State the meaning of the terms: [2]

(i) m ....

(ii) $\overline{c^2}$ ....

(b) Defining both symbols, explain what quantity is given by nN_A. [3]

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(c) The product of pressure and volume for an ideal gas may also be expressed as $pV = nRT$. Show in clear steps that the total translational kinetic energy of one mole of the gas is $\frac{3}{2}RT$. [4]

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(d) An ideal monatomic gas, initially at a pressure of 115 kPa and temperature of 294 K, expands at constant pressure from a volume of $2.20 \times 10^{-3}\,\text{m}^3$ to $2.60 \times 10^{-3}\,\text{m}^3$. Calculate the change in the internal energy of the gas. [3]

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#4

(a) Heat is supplied to an ideal gas in a sealed container of fixed volume. Explain carefully the physical processes that cause an increase in the **temperature and pressure** of the gas. [6 QER]

(b) A container of fixed volume contains oxygen gas at a temperature of 293 K.

(i) Five oxygen molecules have speeds 400, 425, 450, 550 and 625 $m\,s^{-1}$. Determine their rms speed. [2]

(ii) Using an appropriate calculation, determine whether or not the rms speed calculated in part *(b)*(i) is consistent with the expected rms speed of the molecules of the gas at this temperature. (Relative molecular mass of oxygen gas = 32.) [3]

at this temperature. (Relative molecular mass of oxygen gas = 32.) [3]

(iii) If the gas in the container is heated and the pressure of the gas increases by 20% of its initial value, determine the rms speed of the molecules of the gas. [2]

#5

(a) The first law of thermodynamics is given by:

$$\Delta U = Q - W$$

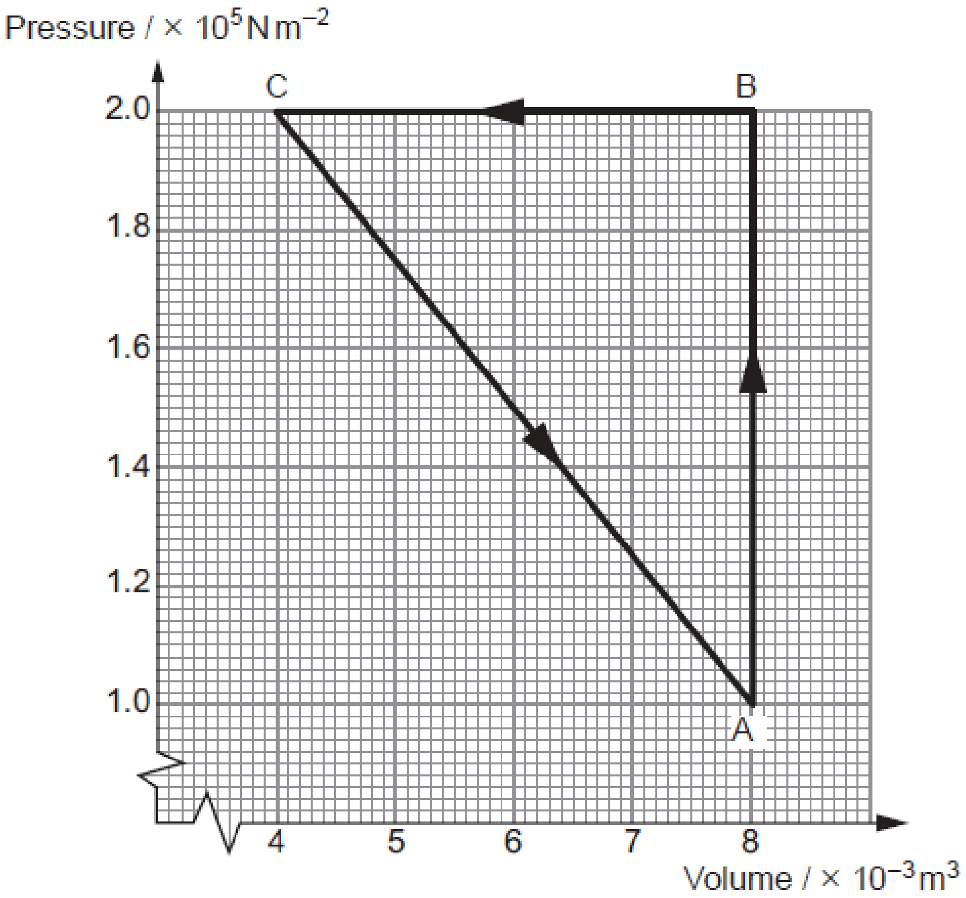
State what is represented by: [3]

ΔU ....

Q ....

W ....

(b) A fixed mass of gas is taken around the closed cycle A → B → C → A.



(i) Complete the table by describing each process in terms of pressure and volume. The description for process A → B is already inserted. For each process state if any work is done, and if so indicate if it is done *on* or *by* the gas. *No calculations are required.* [5]

Process	Description of process	Work done on / by gas (if any)
A → B	Increase in pressure at constant volume	
B → C		
C → A		

(ii) Determine the net work done on the gas during the entire cycle. [2]

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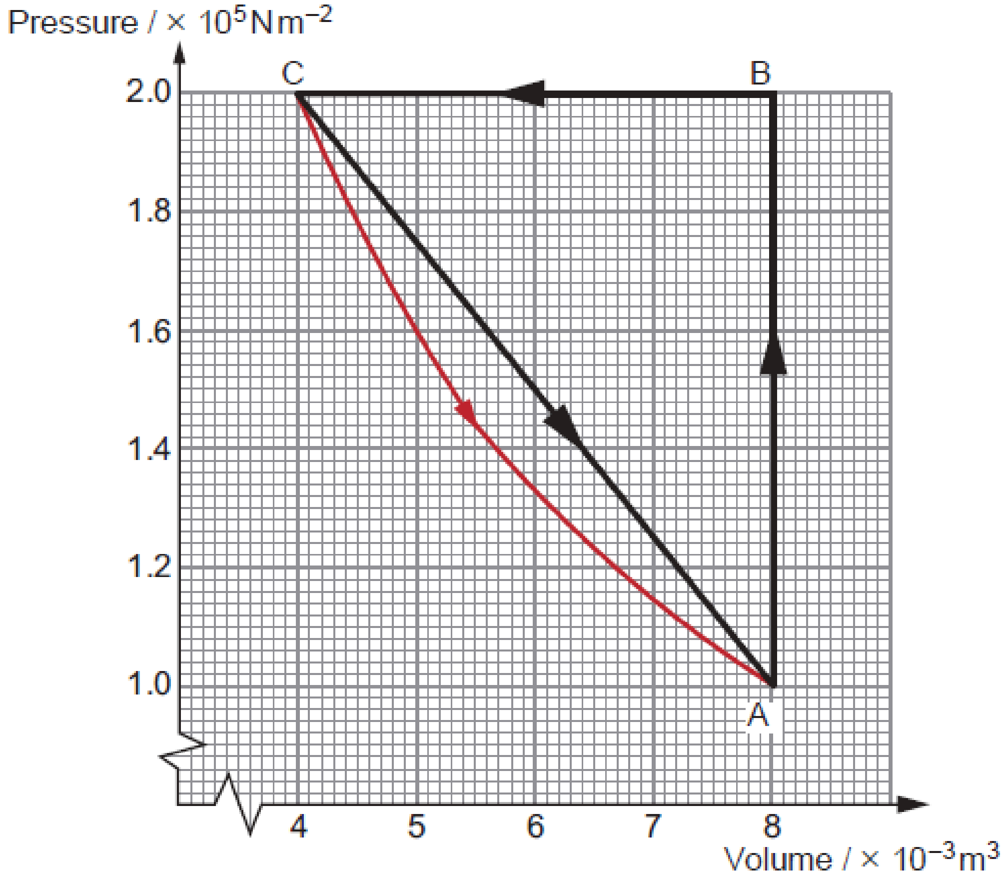
(c) The same mass of gas is taken around the cycle A → B → C → A for a second time. For this cycle the temperature is kept constant between C and A. The new path from C to A is shown in red on the graph below, together with the original path.



(i) Show that the temperature is constant along the new path from C to A. [3]

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(ii) Estimate the difference in the net work done in the two cycles. [2]

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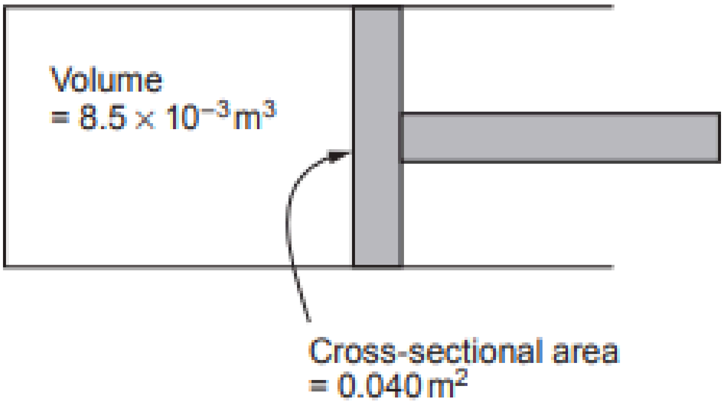
Question taken from WJEC examination paper 242701, June 2017

#6

5. A sealed container with a leakproof piston of cross-sectional area $0.040\,m^2$ at one end has an initial volume of $8.5 \times 10^{-3}\,m^3$. It contains oxygen gas at a pressure of $5.0 \times 10^5\,Pa$ and a temperature of 285 K.

(Relative molecular mass of oxygen = 32)



(a) Calculate:

(i) the number of moles of oxygen gas in the container; [2]

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(ii) the number of molecules in the container; [1]

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(iii) the rms speed of the molecules; [3]

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(iv) the force exerted by the gas on the piston. [1]

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(b) The gas is allowed to expand at a constant temperature of 285 K to a volume of $10.2 \times 10^{-3}\,m^3$.

(i) Calculate the final pressure of the gas. [2]

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(ii) During the process the gas does 773 J of work. Determine the heat flowing into the gas, explaining your reasoning. [2]

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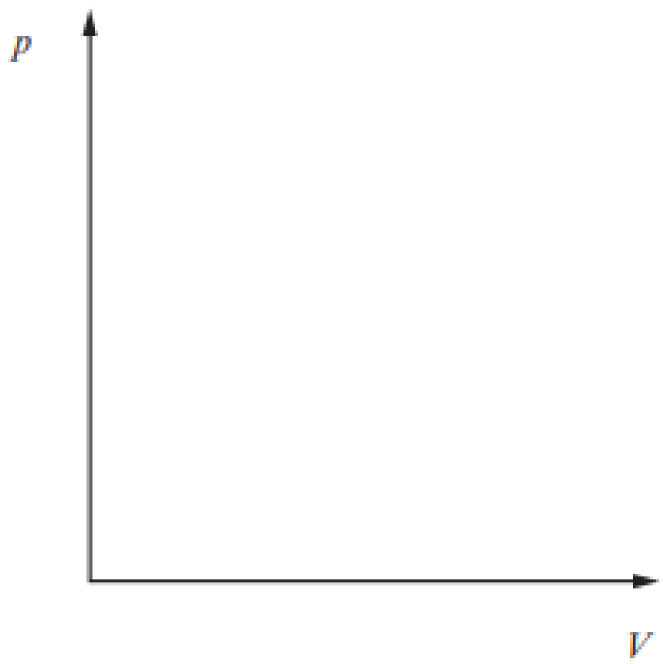
(iii) Following the expansion the gas is returned to its initial state by a two-stage process:

– a decrease in volume at constant pressure;

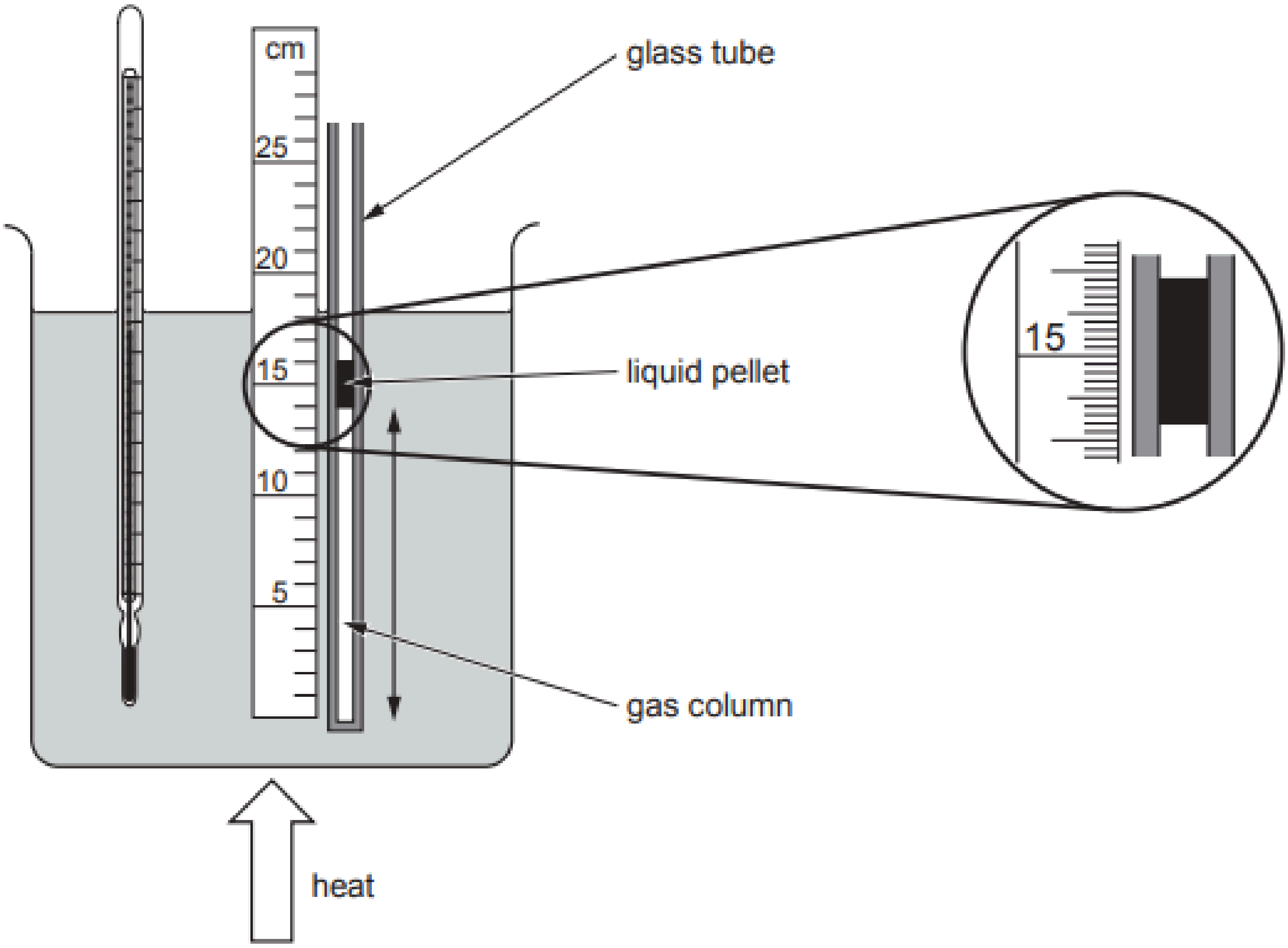
– an increase in pressure at constant volume.

A student says that approximately 60 J of heat flows into the gas during the overall cycle (the expansion and return of the gas to its original state). Justify this. Include a sketch of the paths on a p–V diagram with values on both axes. [4]



#7

1. A student performs an experiment to estimate the Celsius temperature of absolute zero.



The length, l, of the gas column and its temperature, θ, are measured at atmospheric pressure, 1.01×10^5 Pa. The temperature of the water is initially 0.0 °C. It is then increased to 80.0 °C. Readings are taken at 20.0 °C intervals. The scale used to measure the length gives an uncertainty of ± 0.1 cm at the top of the column and an uncertainty of ± 0.1 cm at the bottom.

Values of θ and l are recorded in the table below.

θ / °C	l / cm
0.0	11.5
20.0	12.5
40.0	13.2
60.0	14.2
80.0	15.0

(a) Justify the number of significant figures used to record the length, l. [2]

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(b) The glass tube in which the gas is trapped has an internal diameter of (1.5 ± 0.1) mm.

(i) Calculate the volume of the gas at 0.0 °C. [2]

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(ii) Show that the percentage uncertainty in this volume, V, is approximately 15%. [3]

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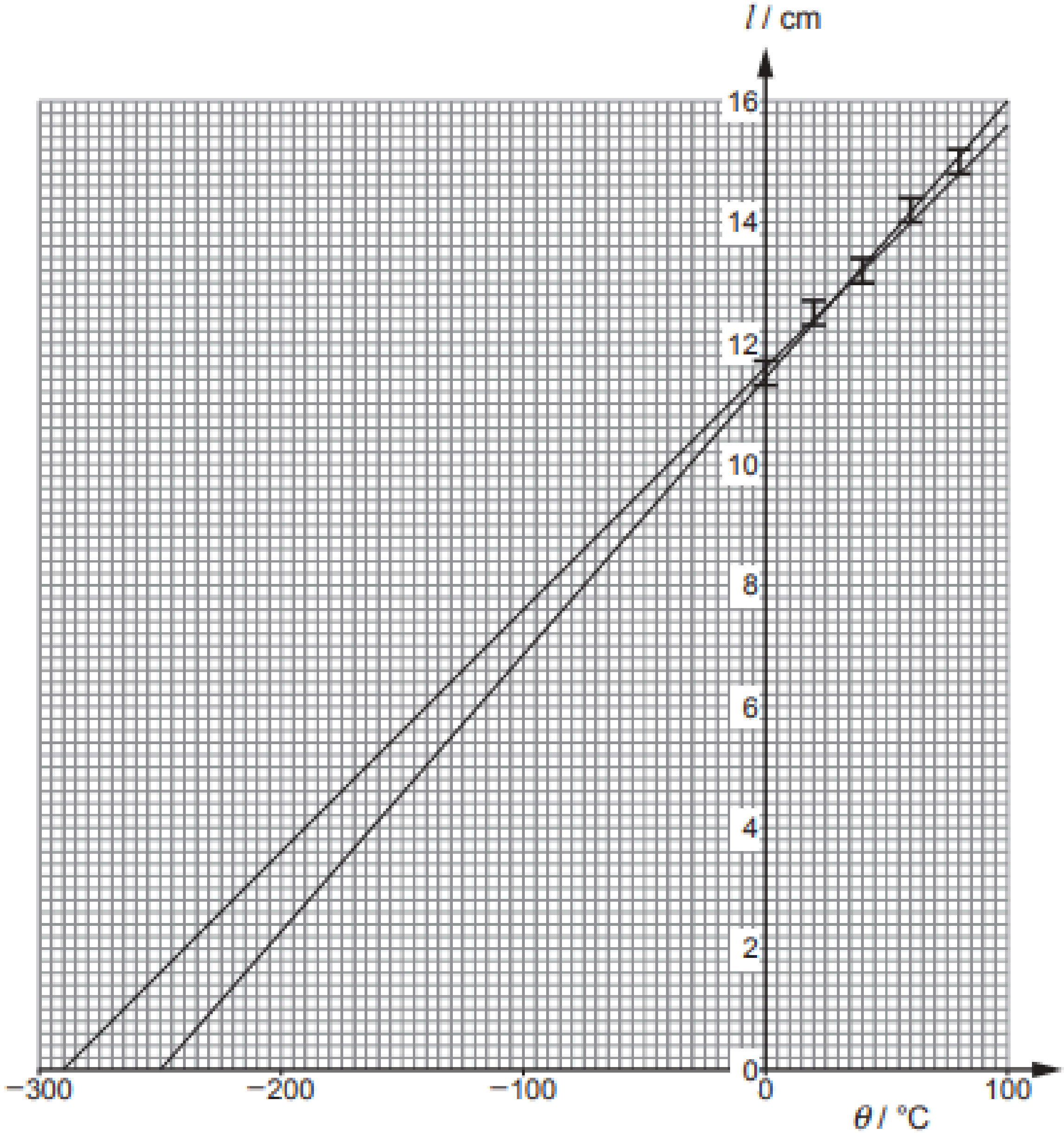
(c) The length, *l*, is plotted against the temperature, *θ*. Lines of maximum and minimum gradient consistent with the error bars have been drawn.



(i) Use the graph to estimate the temperature of absolute zero in °C, together with its **absolute** uncertainty. [2]

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(ii) Justify the statement that *the results are consistent with the ideal gas equation*. [4]

(d) State what happens to the behaviour of the gas molecules as the temperature approaches absolute zero. [1]

(e) The scale resolution of the ruler affects the final uncertainty in the value of absolute zero. Identify **two** other factors that could affect the accuracy. [2]

#8

2. *(a)* The escape velocity, v, of a mass, m, from a spherical mass, M, and radius, R, can be calculated using:

$$\tfrac{1}{2}mv^2 - \frac{GMm}{R} = 0$$

(i) Explain how this equation is an application of conservation of energy. [3]

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(ii) Calculate the escape velocity from the Sun ($M_{Sun} = 1.99 \times 10^{30}$ kg, $R_{Sun} = 6.96 \times 10^{8}$ m). [3]

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(b) (i) The temperature of the surface of the Sun is 5 780 K. Use a kinetic theory equation to show that the rms speed of a free electron on the surface of the Sun is approximately 500 km s^{-1}. [4]

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(ii) By considering your answers to *(a)*(ii) and *(b)*(i), explain why the Sun has a slight positive charge. [2]

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(iii) A student claims that a positive charge of approximately 0.08 C on the Sun is enough to produce an electrostatic force equal to the gravitational force on an escaping electron. Determine whether or not she is correct. [3]

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(iv) Estimate the percentage of lost electrons compared with the total number of electrons on the Sun. Assume that the Sun is mainly hydrogen and that it has lost 0.08 C of charge in the form of electrons. [3]

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