

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname StemUp Model Solution

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL A-LEVEL PHYSICS

Unit 4 Energy and Energy resources

Tuesday 10 June 2025

07:00 GMT

Time allowed: 2 hours

Materials

For this paper you must have:

- a Data and Formulae Booklet as a loose insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate
- a protractor.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each question or on blank pages.
- All working must be shown.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7–21	
TOTAL	



J U N 2 5 P H 0 4 0 1

Section A

Answer **all** questions in this section.

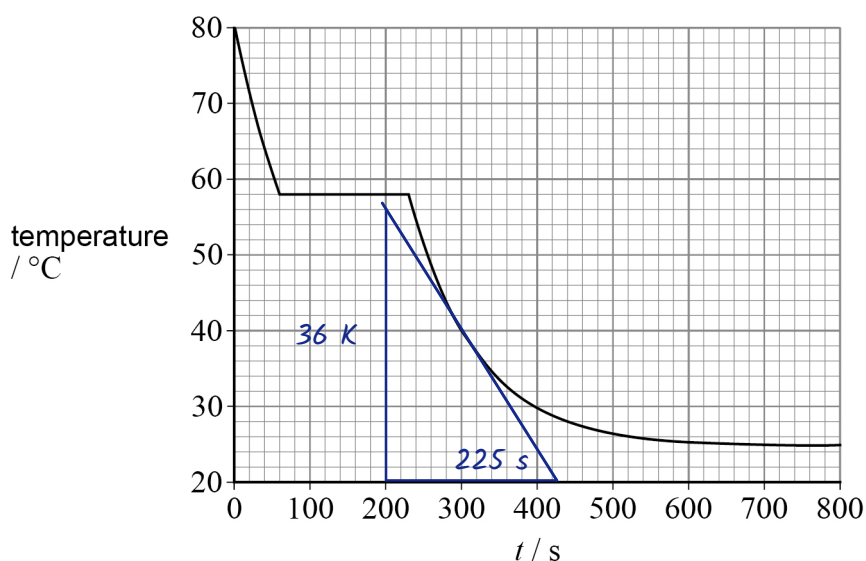
0 1

A test tube contains a sample **S** of a liquid at $80.0\text{ }^{\circ}\text{C}$.

A student records the temperature of **S** using a temperature sensor and data logger. At time $t = 0$, **S** starts to cool down. It turns into a solid before cooling to room temperature.

Figure 1 shows the variation of the temperature of **S** with t .

Figure 1



0 1 . 1

Suggest why the student uses a temperature sensor and data logger rather than a thermometer and stopclock when recording the temperature in this experiment.

[1 mark]

It allows many readings to be recorded automatically, close together, over the long duration (800 s) of the experiment.

0 1 . 2

Explain, in terms of energy transfer, why the temperature of **S** does not change between $t = 60\text{ s}$ and $t = 230\text{ s}$.

[2 marks]

S is freezing (liquid to solid): latent heat is transferred to the surroundings as bonds form.

Energy released by S in the phase change equals energy lost to the surroundings, so the particles' kinetic energy stays constant.



Table 1 shows some of the properties of **S**.

Table 1

mass / kg	6.60×10^{-2}
specific heat capacity of liquid / $\text{J kg}^{-1} \text{K}^{-1}$	2.80×10^3
specific latent heat of fusion / J kg^{-1}	2.64×10^5
specific heat capacity of solid / $\text{J kg}^{-1} \text{K}^{-1}$	2.10×10^3

0 1 . 3 Calculate the total energy transferred from **S** during the time shown in **Figure 1**.

[4 marks]

liquid cooling: $\Delta\theta = 80 - 58 = 22 \text{ K}$

$Q_1 = mc\Delta\theta = 6.60 \times 10^{-2} \times 2.80 \times 10^3 \times 22 = 4066 \text{ J}$

freezing: $Q_2 = mL = 6.60 \times 10^{-2} \times 2.64 \times 10^5 = 17\,424 \text{ J}$

solid cooling: $\Delta\theta = 58 - 25 = 33 \text{ K}$

$Q_3 = 6.60 \times 10^{-2} \times 2.10 \times 10^3 \times 33 = 4574 \text{ J}$

total = $4066 + 17\,424 + 4574 = 26\,064 \text{ J}$

energy transferred = 2.61×10^4 J

0 1 . 4 Determine, using **Figure 1**, the rate of temperature decrease of **S** when $t = 300 \text{ s}$.

[2 marks]

tangent drawn on Figure 1 at $t = 300 \text{ s}$

gradient = $\Delta\theta / \Delta t = (56 - 20) / (425 - 200)$

= $36 / 225 = 0.16 \text{ K s}^{-1}$

rate = 0.16 K s^{-1}

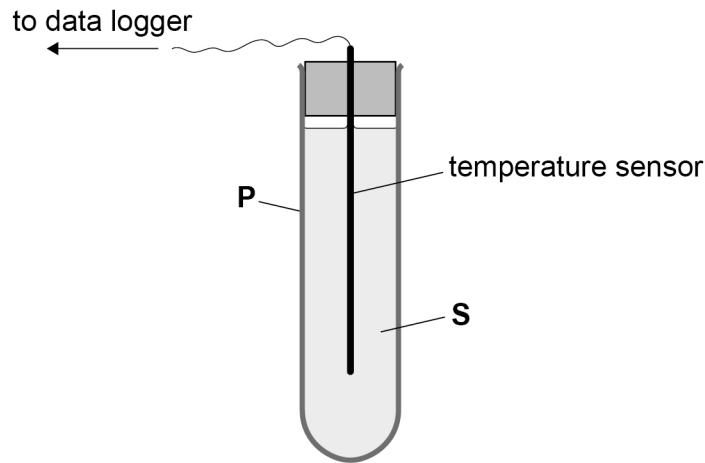
Question 1 continues on the next page

Turn over ►



0 1 . 5 Figure 2 shows **S** in the test tube.

Figure 2



P is a point on the **outside** of the test tube as shown in **Figure 2**.

The test tube is made from glass of thickness 1.2 mm.
The thermal conductivity of the glass is $1.14 \text{ W m}^{-1} \text{ K}^{-1}$.

Energy is transferred by conduction from **S** through an area of $8.0 \times 10^{-3} \text{ m}^2$ of the glass. Assume that all the energy transferred from **S** is by conduction through this area.

When $t = 400 \text{ s}$ the rate of temperature decrease of **S** is 0.055 K s^{-1} .

Determine the temperature of **P** when $t = 400 \text{ s}$.

[3 marks]

At 400 s S is solid, reading from Figure 1: $\theta_S = 30^\circ \text{C}$

rate of energy transfer = $mc \times (\text{rate of temperature fall})$

$$= 6.60 \times 10^{-2} \times 2.10 \times 10^3 \times 0.055 = 7.62 \text{ W}$$

$$P = kA\Delta\theta / L \text{ so } \Delta\theta = PL / kA$$

$$\Delta\theta = 7.62 \times 1.2 \times 10^{-3} / (1.14 \times 8.0 \times 10^{-3}) = 1.0 \text{ K}$$

$$\text{temperature of P} = 30 - 1.0 = 29^\circ \text{C}$$

temperature of **P** = 29 $^\circ \text{C}$

12



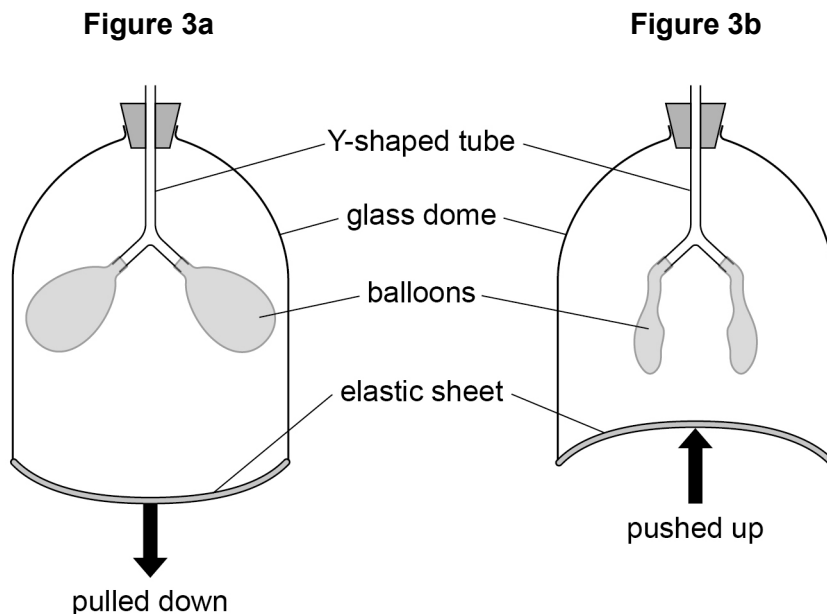
0 2

Figures 3a and 3b show a simple model of the human breathing system.

The model consists of a glass dome that contains two balloons.

The balloons are connected by a Y-shaped tube that is open to the atmosphere at one end.

Air can be made to enter or leave the balloons by moving an elastic sheet that covers the bottom of the dome.



The air is heated as it travels through the Y-shaped tube. The heater is not shown. The air that enters the balloons is at a temperature of 32 °C.

0 2 . 1

The temperature of the air before it enters the Y-shaped tube is 15 °C.

Calculate the change in the average molecular kinetic energy of air when its temperature is increased from 15 °C to 32 °C.

[2 marks]

$$\text{average molecular KE} = \frac{3}{2} kT$$

$$\Delta E = \frac{3}{2} k\Delta T, \quad \Delta T = 32 - 15 = 17 \text{ K}$$

$$\Delta E = 1.5 \times 1.38 \times 10^{-23} \times 17 = 3.52 \times 10^{-22} \text{ J}$$

change in average molecular kinetic energy = 3.5×10^{-22} J

Question 2 continues on the next page

Turn over ►



The elastic sheet is pulled down as shown in **Figure 3a** and then pushed up as shown in **Figure 3b**.

Air moves in and out of the balloons so that the air inside the balloons is always at atmospheric pressure.

Table 2 shows data for the air in one balloon.

Table 2

	Figure 3a	Figure 3b
volume / 10^2 cm^3	3.1	0.35
temperature / $^{\circ}\text{C}$	32	32

Atmospheric pressure is $1.10 \times 10^5 \text{ Pa}$.
Assume that the air behaves as an ideal gas.

0 2 . 2

Calculate the work done on the air as it leaves **one** balloon.

[2 marks]

$$\Delta V = (3.1 - 0.35) \times 10^2 \text{ cm}^3 = 2.75 \times 10^{-4} \text{ m}^3$$

$$W = p\Delta V = 1.10 \times 10^5 \times 2.75 \times 10^{-4}$$

$$W = 30.25 \text{ J}$$

work done = 30 J



0 2 . 3

Calculate the number of particles of air that leave **one** balloon when the elastic sheet is pushed up.

[3 marks]

$$T = 32 + 273 = 305 \text{ K}$$

$$p\Delta V = \Delta N kT \quad \text{so} \quad \Delta N = p\Delta V / kT$$

$$\Delta N = 1.10 \times 10^5 \times 2.75 \times 10^{-4} / (1.38 \times 10^{-23} \times 305)$$

$$\Delta N = 30.25 / 4.21 \times 10^{-21} = 7.19 \times 10^{21}$$

$$\text{number of particles} = \underline{7.2 \times 10^{21}}$$

0 2 . 4

The model is taken to the top of a mountain.
The air in the balloons is now at a much smaller atmospheric pressure.
The air entering the Y-shaped tube is also at a much lower temperature.

The air is now heated to a temperature of 32 °C as it travels through the tube, as in Question 02.1.

Discuss, without calculation, how taking the model to the top of the mountain affects the energy required to:

- move the same volume of air as in Question 02.2
- heat the same number of air particles to the same temperature as in Question 02.3
- move the same number of particles out of **one** balloon as calculated in Question 02.3.

[3 marks]

Moving the same volume: the external (atmospheric) pressure is lower, so less work ($p\Delta V$) is done and less energy is needed to move the air out of the balloons.

Heating: more energy is needed, because the air starts colder, so the temperature rise to 32 °C is greater and each particle gains more kinetic energy.

Same number of particles: the work done = $p\Delta V = \Delta N kT$, and ΔN and T (32 °C) are the same, so the energy (work done) is the same.



0 3

Experiments are done to determine the nuclear radius of an iron isotope **X** and of an iron isotope **Y**.

A nucleus of **X** contains 26 protons and 28 neutrons.

0 3 . 1

The radius of a nucleus of **X** is measured as 4.30×10^{-15} m using electron diffraction.

Determine the density of this nucleus.

[3 marks]

$$V = \frac{4}{3} \pi R^3 = \frac{4}{3} \times \pi \times (4.30 \times 10^{-15})^3 = 3.33 \times 10^{-43} \text{ m}^3$$

$$\text{mass} = 54 u = 54 \times 1.66 \times 10^{-27} = 8.96 \times 10^{-26} \text{ kg}$$

$$\rho = m / V = 8.96 \times 10^{-26} / 3.33 \times 10^{-43}$$

$$\rho = 2.69 \times 10^{17} \text{ kg m}^{-3}$$

$$\text{density} = \underline{2.7 \times 10^{17}} \text{ kg m}^{-3}$$

0 3 . 2

The radius of a nucleus of **Y** is measured as 4.40×10^{-15} m using electron diffraction.

Determine the number of neutrons in the nucleus of **Y**.

[3 marks]

$$R = R_0 A^{1/3}, \text{ so } R_0 = 4.30 \times 10^{-15} / 54^{1/3} = 1.13 \times 10^{-15} \text{ m}$$

$$A_Y = (R_Y / R_0)^3 = 54 \times (4.40 / 4.30)^3$$

$$A_Y = 54 \times 1.071 = 57.9 \approx 58$$

$$\text{neutrons} = A - Z = 58 - 26 = 32$$

$$\text{number of neutrons} = \underline{32}$$



The nuclear radius of **X** and the nuclear radius of **Y** are estimated using the closest approach of an alpha particle.

03.3 The upper limit for the radius of a nucleus of **X** is estimated to be 5.0×10^{-14} m.

Calculate the initial speed of an alpha particle that gives this estimate.
Assume that the nucleus remains at rest during the interaction.

[4 marks]

$$\text{charges: } Q (\text{iron}) = 26e, \quad q (\text{alpha}) = 2e$$

$$E_p = Qq / 4\pi\epsilon_0 r$$

$$E_p = (26 \times 2 \times (1.60 \times 10^{-19})^2) / (4\pi \times 8.85 \times 10^{-12} \times 5.0 \times 10^{-14})$$

$$E_p = 2.39 \times 10^{-13} \text{ J} = \text{initial kinetic energy } 1/2 mv^2$$

$$\text{mass of alpha } m = 6.64 \times 10^{-27} \text{ kg}$$

$$v = \sqrt{(2 \times 2.39 \times 10^{-13} / 6.64 \times 10^{-27})} = \sqrt{(7.21 \times 10^{13})}$$

$$v = 8.49 \times 10^6 \text{ m s}^{-1}$$

$$\text{initial speed} = \underline{8.5 \times 10^6} \text{ m s}^{-1}$$

03.4 The upper limit for the radius of a nucleus of **Y** is estimated using an alpha particle with the same initial speed as in Question **03.3**.

Suggest a value for this estimate.
Explain your answer.

[1 mark]

$$\text{estimate of upper limit for radius} = \underline{5.0 \times 10^{-14}} \text{ m}$$

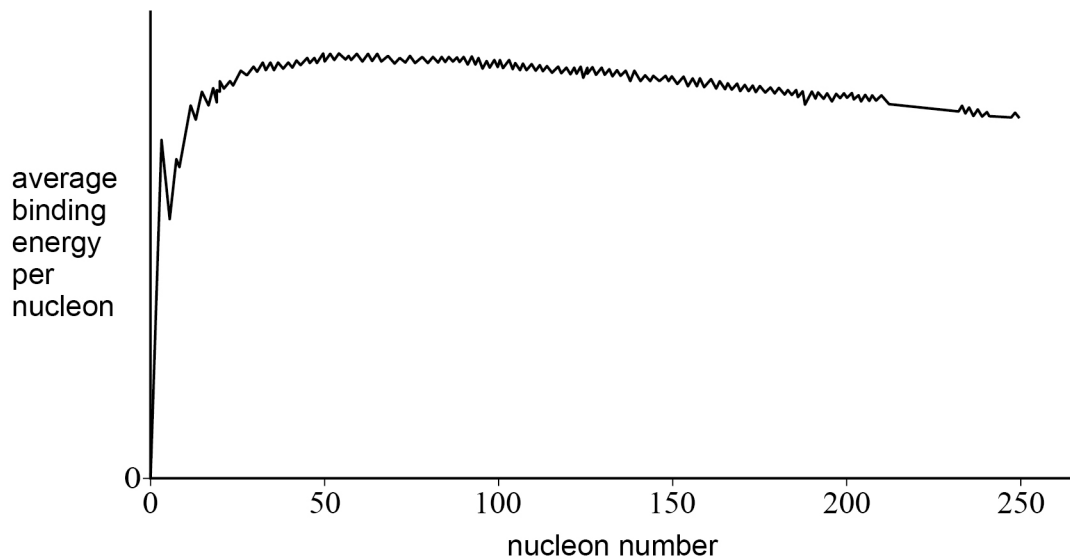
The closest approach depends on the charge on the target nucleus, not its mass: X and Y have the same number of protons (26), so the same charge.



0 4

Figure 4 is a plot of average binding energy per nucleon against nucleon number for common nuclides.

Figure 4



0 4 . 1

Explain how:

- the fission of a nucleus and the fusion of nuclei can release energy
- the fission of a nucleus can release a greater amount of energy than the fusion of two nuclei.

Refer to relevant regions of **Figure 4** in your answer.

[4 marks]

Fusion: light nuclei on the left of Figure 4 (below the peak at iron-56) combine to form a larger nucleus. Fission: a heavy nucleus on the right (e.g. uranium) splits into two smaller nuclei.

In both, the products are nearer the peak, so binding energy per nucleon increases; the products have a greater mass defect, and this mass difference is released as energy.

The curve is much steeper on the left, so the increase in binding energy per nucleon is greater for fusion.

But fission involves very many more nucleons (about 236) than fusing two light nuclei, so the total energy released is greater for fission.



0 4 . 2 The reaction below occurs in a nuclear reactor.

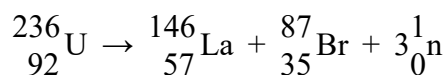


Table 3 gives data for the nuclides in this reaction.

Table 3

Nuclide	Binding energy per nucleon / MeV
${}_{92}^{236}\text{U}$	7.5865
${}_{57}^{146}\text{La}$	8.2400
${}_{35}^{87}\text{Br}$	8.6059

Calculate, in J, the energy released in the reaction.

[3 marks]

$$BE(\text{U}) = 236 \times 7.5865 = 1790.414 \text{ MeV}$$

$$BE(\text{La}) = 146 \times 8.2400 = 1203.040 \text{ MeV}$$

$$BE(\text{Br}) = 87 \times 8.6059 = 748.713 \text{ MeV} \quad (\text{neutrons have no BE})$$

$$\text{energy released} = 1203.040 + 748.713 - 1790.414 = 161.34 \text{ MeV}$$

$$= 161.34 \times 1.60 \times 10^{-13} = 2.58 \times 10^{-11} \text{ J}$$

$$\text{energy} = \underline{2.6 \times 10^{-11}} \text{ J}$$

Question 4 continues on the next page

Turn over ►



0 4 . 3 An iron ($^{56}_{26}\text{Fe}$) nucleus has a mass of 55.935 u.

Calculate, in MeV, the binding energy of this nucleus.

[3 marks]

$$\text{mass of 26 protons} = 26 \times 1.673 \times 10^{-27} = 4.350 \times 10^{-26} \text{ kg}$$

$$\text{mass of 30 neutrons} = 30 \times 1.675 \times 10^{-27} = 5.025 \times 10^{-26} \text{ kg}$$

$$\text{total} = 9.375 \times 10^{-26} \text{ kg}$$

$$\text{mass of nucleus} = 55.935 \times 1.661 \times 10^{-27} = 9.291 \times 10^{-26} \text{ kg}$$

$$\text{mass defect} = 9.375 \times 10^{-26} - 9.291 \times 10^{-26} = 8.40 \times 10^{-28} \text{ kg}$$

$$E = mc^2 = 8.40 \times 10^{-28} \times (3.00 \times 10^8)^2 = 7.56 \times 10^{-11} \text{ J}$$

$$E = 7.56 \times 10^{-11} / 1.60 \times 10^{-13} = 473 \text{ MeV}$$

binding energy = 473 MeV

10

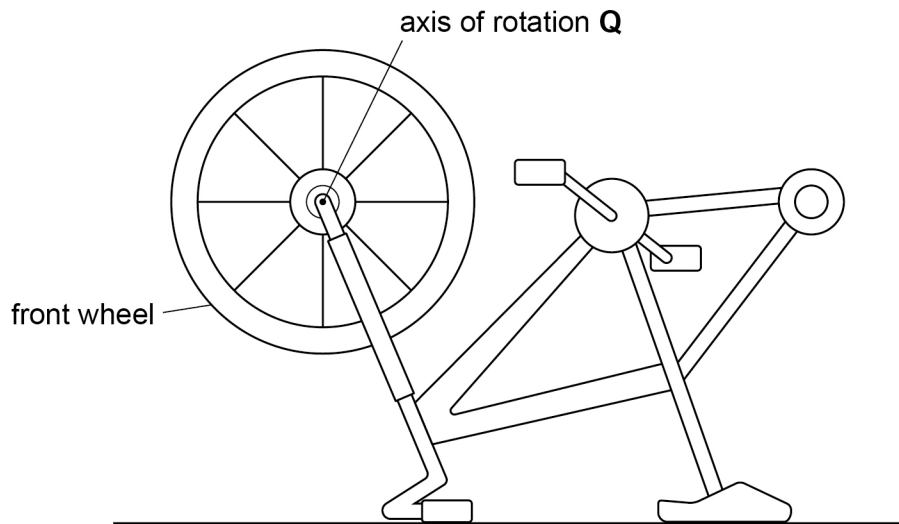


0 5

A student investigates the frictional torque on the wheel of a bicycle.

Figure 5 shows a bicycle that has been turned upside down and placed on level ground. The back wheel is removed. The front wheel is not connected to the pedals. The axis of rotation **Q** of the front wheel is horizontal.

Figure 5



0 5. 1

The wheel has an initial angular speed of 21 rad s^{-1} .

A frictional torque of $3.6 \times 10^{-3} \text{ N m}$ acts on the wheel.
The wheel takes 481 revolutions to come to rest.

Calculate the moment of inertia of the wheel.

[3 marks]

$$\theta = 481 \times 2\pi = 3022 \text{ rad}$$

$$\text{work done by friction} = T\theta = 3.6 \times 10^{-3} \times 3022 = 10.9 \text{ J}$$

$$\text{work done} = \text{loss of kinetic energy} = \frac{1}{2} I\omega^2$$

$$I = 2 \times 10.9 / 21^2 = 21.8 / 441$$

$$I = 0.0493 \text{ kg m}^2$$

moment of inertia = 0.049 kg m²

Question 5 continues on the next page

Turn over ►



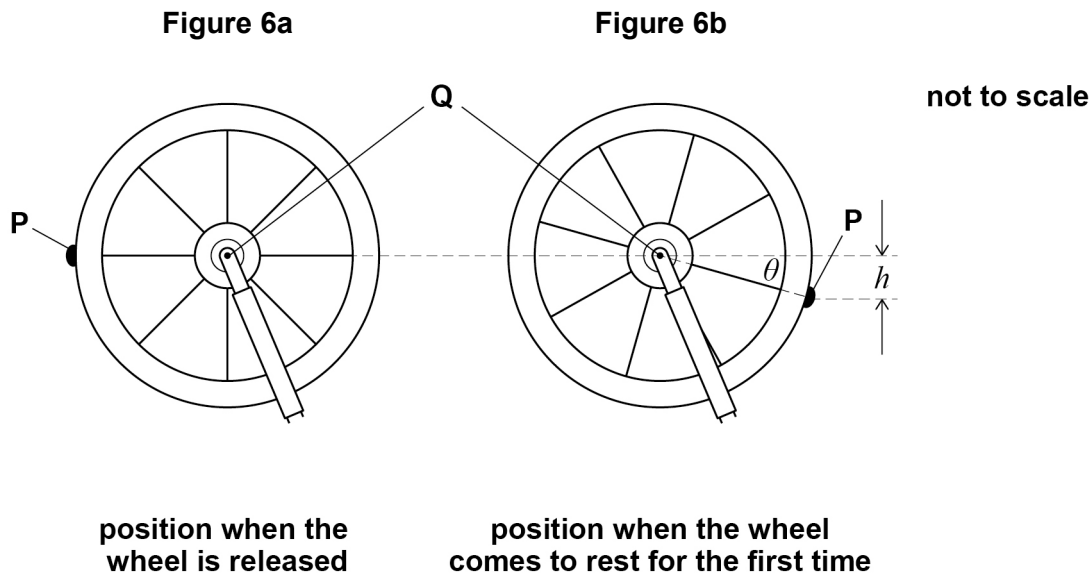
The student then reduces the frictional torque on the wheel and attaches a mass **P** to the outside of the wheel.

The mass of **P** is 0.017 kg.

The edge of the wheel is held with **P** at the same height above the ground as **Q**, as shown in **Figure 6a**. The edge is then released and the wheel begins to rotate.

Figure 6b shows the wheel when it comes to rest for the first time. The angle θ between the horizontal and the line from **Q** through the centre of mass of **P** is measured.

The vertical distance h from the centre of mass of **P** to its starting position is also measured.



The work done by the frictional torque is equal to the change in the gravitational potential energy of **P**.

0 5 . 2

The student obtains the following readings:

$$\theta = 5^\circ$$

$$h = 4.8 \text{ cm}$$

Calculate the new frictional torque.

[4 marks]

$$\text{weight of } P = mg = 0.017 \times 9.81 = 0.167 \text{ N}$$

$$\Delta E_p = mg\Delta h = 0.167 \times 0.048 = 8.01 \times 10^{-3} \text{ J}$$

$$\text{angle turned} = 180^\circ - 5^\circ = 175^\circ = 175 \times \pi / 180 = 3.05 \text{ rad}$$

$$T\theta = mg\Delta h$$



$$T = 8.01 \times 10^{-3} / 3.05$$

$$T = 2.62 \times 10^{-3} \text{ N m}$$

new frictional torque = 2.6×10^{-3} N m

0 5 . 3 The student now repeats the investigation.

Describe how repeated measurements can be used to determine the absolute uncertainty in the value of the frictional torque.

Assume that the uncertainty in the mass of **P** is negligible.

[4 marks]

Repeat the release several times (at least 5), measuring θ and h each time, and reject any anomalous results.

Calculate the mean of h and the mean of θ , and find the absolute uncertainty in each as half the range of the repeated readings.

Find the percentage uncertainty in each: % uncertainty = (absolute uncertainty / mean value) $\times$ 100.

Since $T = mgh / \theta$ (with θ in radians) and the uncertainty in m is negligible, add the percentage uncertainties in h and θ to give the percentage uncertainty in T .

Calculate T from the mean values, then absolute uncertainty in $T =$ (percentage uncertainty in $T / 100) $\times$ T .$



0 6

A wind farm is being designed to provide power to a small town.

0 6 . 1

Explain the factors that affect the design of the wind farm and its location.

In your answer you should consider:

- the factors that affect the maximum power that is available from a wind turbine
- the factors that determine the number and arrangement of the turbines
- the environmental factors involved in the use of wind turbines.

[6 marks]

Maximum power available: the kinetic energy per second of the wind passing through the blades is $P = \frac{1}{2} \rho A v^3$, so the power depends on the wind speed ($P \propto v^3$), the area swept by the blades ($A = \pi r^2$, so $P \propto r^2$ for blade radius r) and the density of the air. The location must therefore have reliable, strong winds, for example on hills or offshore.

Not all of this power can be extracted: the wind speed cannot be reduced to zero behind the turbine, and energy is lost to friction in the bearings and gearbox, and in the generator.

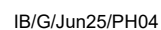
Number and arrangement: the number of turbines depends on the power needed by the town and on the power output of each turbine, which depends on its size. Larger turbines give more power but must be spaced further apart. Turbines remove energy from the wind, creating a wind shadow (slower, turbulent air) behind them, so they must be spaced several blade diameters apart and arranged so that they do not shelter each other in the direction of the prevailing wind. The available space limits how many turbines can be fitted in.

Environmental factors: turbines are noisy, so they should be built away from houses. Moving blades can kill birds and bats, and construction (roads, foundations) damages habitats. Large turbines have a visual (aesthetic) impact on the landscape. Rotating blades cause shadow flicker (strobing) when the Sun is behind them. The land between turbines may not be usable for other purposes.



[illegible]

Turn over ►



A solar farm is suggested as an alternative to the wind farm.

The solar farm consists of an array of solar panels. Each panel is angled so that the average intensity of the sunlight on the panels is at a maximum. Each panel has an area of 1.0 m^2 .

The power per square metre from the Sun at a distance equal to the orbital radius of the Earth is 1.34 kW m^{-2} .

0 6 . 2 Calculate the power output of the Sun.

radius of Earth's orbit = 150 Gm

[2 marks]

$$\text{area of sphere} = 4\pi r^2 = 4\pi \times (150 \times 10^9)^2 = 2.83 \times 10^{23} \text{ m}^2$$

$$\text{power} = 1.34 \times 10^3 \times 2.83 \times 10^{23} = 3.79 \times 10^{26} \text{ W}$$

power output = 3.8×10^{26} W

0 6 . 3 The maximum output of a 1.0 m^2 solar panel is typically about 250 W in bright conditions.

Discuss why this is significantly smaller than 1.34 kW .

[3 marks]

1.34 kW m^{-2} is the intensity above the atmosphere: some sunlight is absorbed, reflected and scattered by clouds and the atmosphere before it reaches the panel.

The angle of the Sun changes during the day and through the year, so the light is not always at right angles to the panel.

Not all of the incident power can be converted by a solar panel: it has a maximum efficiency of only about 20%.

END OF SECTION A



Section B

Each of the questions in this section is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.

For each question, completely fill in the circle alongside the appropriate answer.

CORRECT METHOD 

WRONG METHODS    

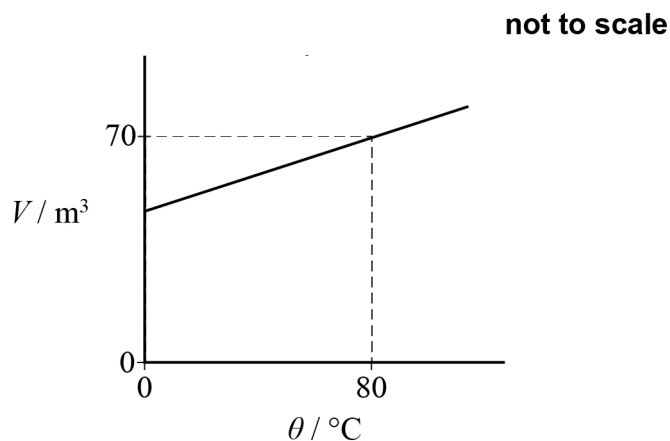
If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

You may do your working in the blank space around each question but this will not be marked.
Do **not** use additional pages for this working.

0 7

The graph shows the variation of volume V with temperature θ for a fixed mass of an ideal gas at constant pressure.



What is the gradient of the line?

[1 mark]

A 0.20 

B 0.26 

C 0.58 

D 0.88 

Turn over ►



0 8

An efficient moderator in a thermal nuclear reactor must

[1 mark]**A** contain atoms that are good at absorbing neutrons.☐**B** be a good thermal conductor.☐**C** be a liquid at its operating temperature.☐**D** contain atoms with a small nucleon number.☒**0 9**

What is the main purpose of lowering control rods into the core of a thermal nuclear reactor?

[1 mark]**A** to decrease the number of thermal neutrons☒**B** to increase the number of thermal neutrons☐**C** to decrease the average kinetic energy of the thermal neutrons☐**D** to increase the average kinetic energy of the thermal neutrons☐**1 0**

A nuclear fission power station is designed to provide 45 MW of electrical power.

The energy output of the power station is 11% of the energy obtained by converting mass into energy.

What is the rate of conversion of mass into energy in the power station?

[1 mark]**A** $4.5 \times 10^{-15} \text{ kg s}^{-1}$ ☐**B** $5.5 \times 10^{-11} \text{ kg s}^{-1}$ ☐**C** $5.0 \times 10^{-10} \text{ kg s}^{-1}$ ☐**D** $4.5 \times 10^{-9} \text{ kg s}^{-1}$ ☒

- 1 1** An equation that arises from the kinetic theory model is

$$pV = \frac{1}{3}Nm(c_{\text{rms}})^2$$

Which assumption is required in the derivation of this equation?

[1 mark]

A The particles all move with the same speed.

☐

B The mass of an individual particle is negligible.

☐

C The sides of the container all have the same area.

☐

D The volume of an individual particle is negligible.

☒

- 1 2** An isolated system initially has an internal energy U_0 .

An amount of energy Q is removed from the system by cooling.
The internal energy increases to U_1 .

What is the work done on the system?

[1 mark]

A $U_0 + U_1 - Q$

☐

B $U_1 + Q - U_0$

☒

C $U_0 + Q - U_1$

☐

D $U_0 - U_1 - Q$

☐

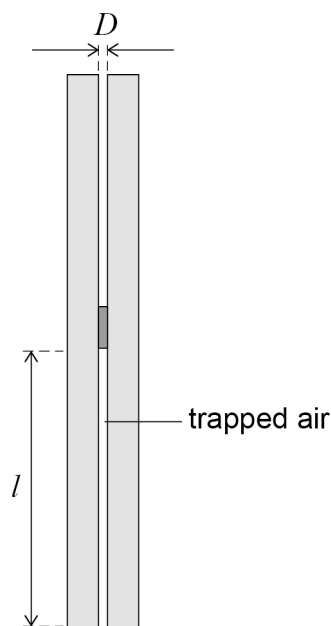
Turn over for the next question

Turn over ►



1 3

A student does a Charles's law experiment. The student uses measurements of the length of air trapped in a tube to estimate a value for absolute zero.



The initial length of the trapped air is l and the diameter of the tube is D .

The behaviour of the liquid trapping the air does not depend on the diameter of the tube.

Which row shows the changes to l and D that could lead to an improvement in the accuracy of the student's value?

[1 mark]

	l	D	
A	decrease	increase	☐
B	increase	decrease	☒
C	decrease	decrease	☐
D	increase	increase	☐



1 4 What are the fundamental (base) units of U-value?

[1 mark]

A $\text{kg m}^2 \text{s}^{-3} \text{K}^{-1}$ ☐

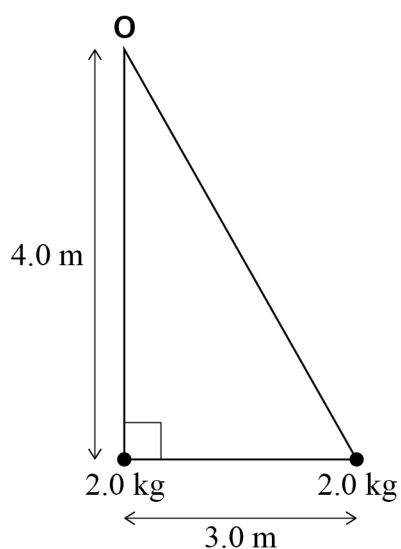
B $\text{kg s}^{-2} \text{K}^{-1}$ ☐

C $\text{kg s}^{-3} \text{K}^{-1}$ ☒

D $\text{kg m}^{-1} \text{s}^{-3} \text{K}^{-1}$ ☐

1 5 The diagram shows a light triangular card with point masses of 2.0 kg attached at two corners.

not to scale



The system is completed by adding a third point mass of 2.0 kg at a distance of 1.0 m from O.

What is the moment of inertia of the system about O?

[1 mark]

A 16 kg m^2 ☐

B 20 kg m^2 ☐

C 82 kg m^2 ☐

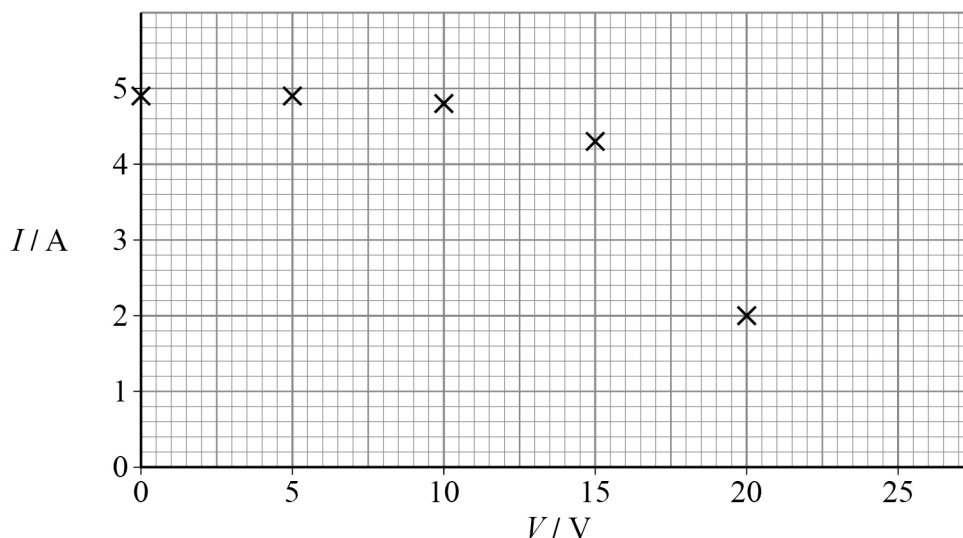
D 84 kg m^2 ☒

Turn over ►



1 6

A student takes measurements to obtain an I - V characteristic for an array of solar panels. The diagram shows the student's results.



The student decides to take more readings to obtain an accurate value for the maximum power output.

What range of voltages should the student investigate?

[1 mark]

A 0 to 6 V ☐

B 6 V to 12 V ☐

C 12 V to 18 V ☒

D 18 V to 24 V ☐

1 7

The energy storage capacity of a pumped storage station is 9.1×10^6 kW h. At peak output, the rate of flow of water through the generators is $390 \text{ m}^3 \text{ s}^{-1}$. The generators are 110 m below the upper reservoir. The density of water is 1000 kg m^{-3} .

What is the maximum possible length of time for which the station can provide peak output?

[1 mark]

A 1.3×10^3 s ☐

B 2.2×10^4 s ☐

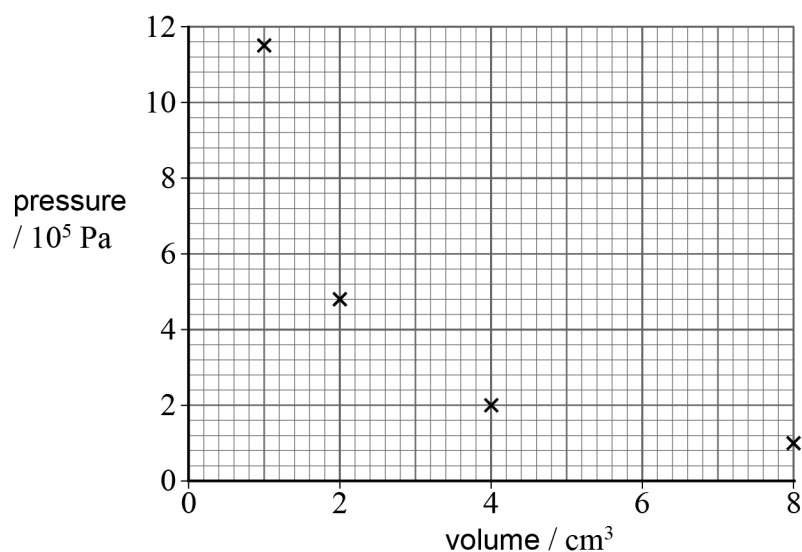
C 7.8×10^4 s ☒

D 7.6×10^5 s ☐



Questions **18** and **19** relate to the data shown below.

The pressure on a fixed mass of ideal gas is increased.
The graph shows the values of pressure and volume for the gas.



The temperature of the gas is 35 °C when its volume is 8 cm³.

1 8

What is the number of moles of molecules in the gas?

[1 mark]

A 3.1×10^{-4} ☒

B 2.8×10^{-3} ☐

C 3.1×10^{-3} ☐

D 2.8×10^{-2} ☐

1 9

Which volume is the smallest at which the temperature of the gas remains at 35 °C?

[1 mark]

A 8 cm³ ☐

B 4 cm³ ☒

C 2 cm³ ☐

D 1 cm³ ☐

Turn over for the next question

Turn over ►



2 0

Which statement about power stations is always correct?

[1 mark]**A** Back-up power stations are more efficient than base-power stations.☐**B** Back-up power stations do not release carbon dioxide.☐**C** The power output of base-power stations can be changed quickly.☐**D** Back-up power stations can be started up quickly.☒**2 1**

A disc is rotating.

At time $t = 0$ the disc has an angular displacement of zero and an angular velocity of 8.0 rad s^{-1} anticlockwise.

The disc accelerates uniformly to an angular velocity of 12.0 rad s^{-1} clockwise. As a result of the acceleration, the final angular displacement of the disc is 80 rad clockwise.

What is the angular acceleration?

[1 mark]**A** 0.50 rad s^{-2} clockwise☒**B** 0.50 rad s^{-2} anticlockwise☐**C** 0.90 rad s^{-2} clockwise☐**D** 0.90 rad s^{-2} anticlockwise☐**15****END OF QUESTIONS**

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