

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL A-LEVEL PHYSICS

Unit 4 Energy and energy resources

Friday 5 June 2026

08:00 UK Time

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

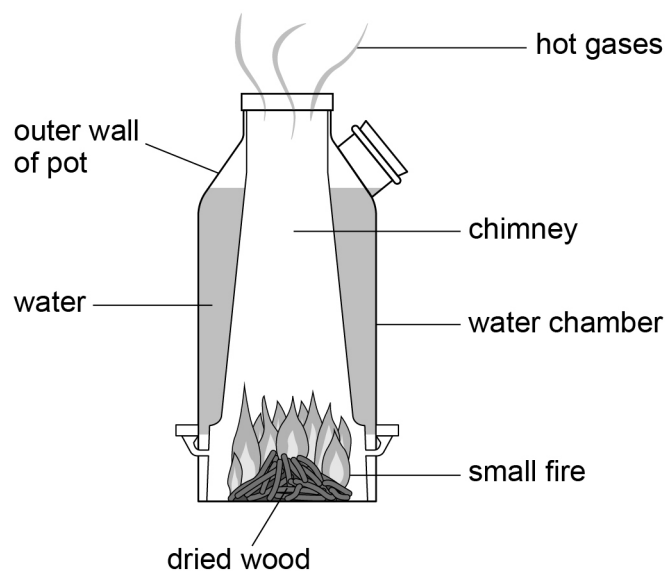
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

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



Section AAnswer **all** questions in this section.**0 1**When 1.0 kg of dried wood is burned, 19.2×10^6 J of thermal energy is released.**0 1 . 1**A mass m of dried wood is burned. This releases 11 kW h of thermal energy.Calculate m .

Give your answer to an appropriate number of significant figures.

[2 marks] $m =$ _____ kg**Figure 1** shows a cross-sectional view of a pot that uses dried wood as a fuel to heat water.**Figure 1**

Water is placed in the water chamber. A small fire is lit and hot gases pass through the chimney. This heats the water.

0	1	.	2
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The pot contains 650 g of water. The water is heated from 15 °C to 95 °C.
The efficiency of the system is 5.7%.

Calculate the minimum mass of dried wood required.

specific heat capacity of water = $4200 \text{ J kg}^{-1} \text{ K}^{-1}$

[4 marks]

minimum mass of dried wood = _____ kg

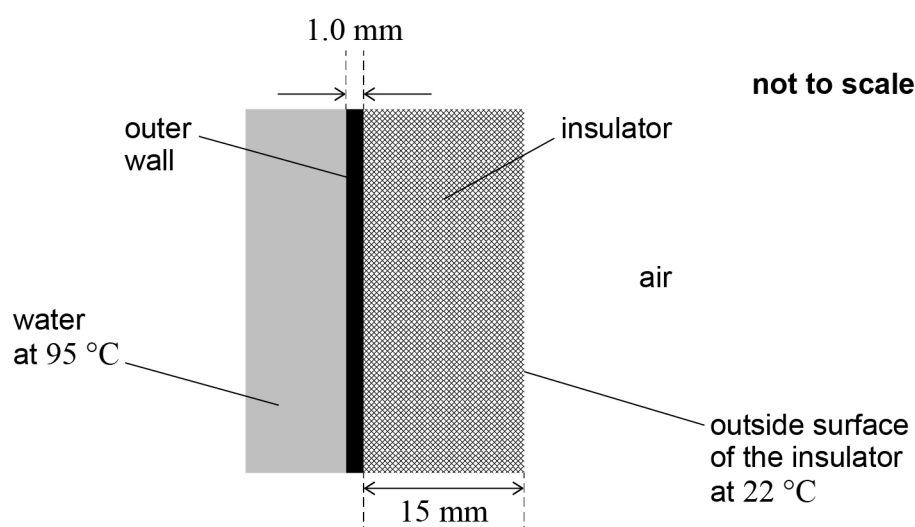
Question 1 continues on the next page

Turn over ►



The efficiency is improved by covering the pot's outer wall with a thermal insulator. **Figure 2** shows a section of the outer wall when the insulator has been added.

Figure 2



The area of the outer wall covered by the insulator is 0.13 m^2 .
The rate of conduction of heat through this area is the same for the outer wall and the insulator.

Table 1 contains data about the insulator and the outer wall.

Table 1

	Thermal conductivity / $\text{W m}^{-1} \text{K}^{-1}$	Thickness / mm
insulator	0.040	15
outer wall	18	1.0

The temperature of the water is 95°C and the temperature of the outside of the insulator is 22°C as shown in **Figure 2**.

0 1 . 3

Show that the temperature difference across the outer wall is negligible.
Support your answer with calculations.

[3 marks]

0 1 . 4

The area of the outer wall covered by the insulator is 0.13 m^2 .

Calculate the rate of energy transfer by conduction through this area.

[2 marks]

rate of energy transfer = _____ W

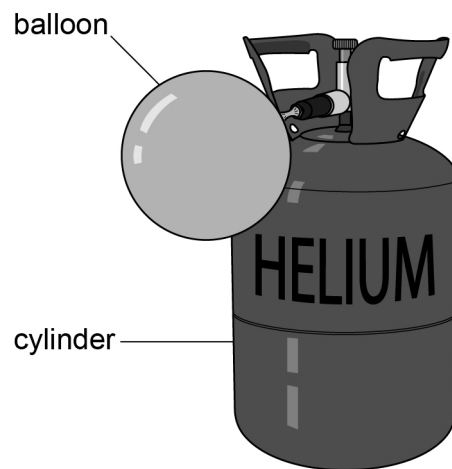
11

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0 2

Figure 3 shows a balloon being filled from a cylinder.

Figure 3



The cylinder is full of helium in the form of a gas. Helium gas is made of single atoms.

mass of one mole of helium atoms = 4.0 g

0 2 . 1

The cylinder has a fixed internal volume of 0.014 m^3 .

The helium in the cylinder is at a constant temperature of 18°C .

The initial pressure in the cylinder is $3.3 \times 10^6 \text{ Pa}$.

Helium is released from the cylinder. This causes the pressure inside the cylinder to decrease to $1.7 \times 10^6 \text{ Pa}$.

Calculate the mass of helium released.

[4 marks]

mass = _____ kg



0 2 . 2

A balloon is initially empty and has negligible volume.
The cylinder is used to fill the balloon with helium.
The balloon is spherical and has a diameter of 23 cm when it is full.
The helium does work on the atmosphere as it fills the balloon.

Calculate the work done on the atmosphere as the balloon is filled.

$$\text{atmospheric pressure} = 1.0 \times 10^5 \text{ Pa}$$

[3 marks]

work done = _____ J

0 2 . 3

The filled balloon is now placed in a hot room and the temperature of the helium in the balloon increases to 305 K.

Calculate the rms speed for the helium atoms in the balloon.

[3 marks]

rms speed = _____ m s^{-1}

10

Turn over ►

03

An alpha particle initially has a kinetic energy of 4.8 MeV.
A student determines the distance of closest approach of the alpha particle to a lead-204 ($^{204}_{82}\text{Pb}$) nucleus.

The student then uses this distance as an estimate of the nuclear radius R .
The student then uses this estimate of R to obtain a value for R_0 using the relationship:

$$R = R_0 A^{\frac{1}{3}}$$

03.1

Determine the value of R_0 that the student obtains.

[4 marks]

$R_0 =$ _____ m

03.2

Suggest why this estimate of R does **not** produce an accurate value for R_0 .

[2 marks]



Turn over for the next question

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0 9

Explain the operation of a moderator in a thermal nuclear reactor.

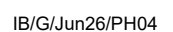
- explain why the moderator is required
- describe the process of moderation in the thermal nuclear reactor
- name **one** material used as a moderator
- state the properties that make this material suitable as a moderator.

[6 marks]

[illegible]

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Turn over ►



A reaction that occurs in a nuclear reactor is

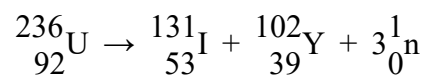


Table 2 gives data for this reaction.

Table 2

Nuclide	Binding energy per nucleon / pJ
${}_{92}^{236}\text{U}$	1.214
${}_{39}^{102}\text{Y}$	1.341

0 4 . 2 The energy released in this reaction is 26.9 pJ.

Calculate the mass defect of a nucleus of ${}_{53}^{131}\text{I}$.

[3 marks]

mass defect = _____ kg



0	4	.	3
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A nucleus of $^{131}_{53}\text{I}$ is unstable and undergoes beta decay to form a stable nucleus of xenon.

State and explain how the binding energy per nucleon of the xenon nucleus compares with the binding energy per nucleon of the $^{131}_{53}\text{I}$ nucleus.

[3 marks]

12

Turn over for the next question

Turn over ►



0 5 . 1

An important relationship in translational dynamics is

$$F\Delta t = \Delta(mv)$$

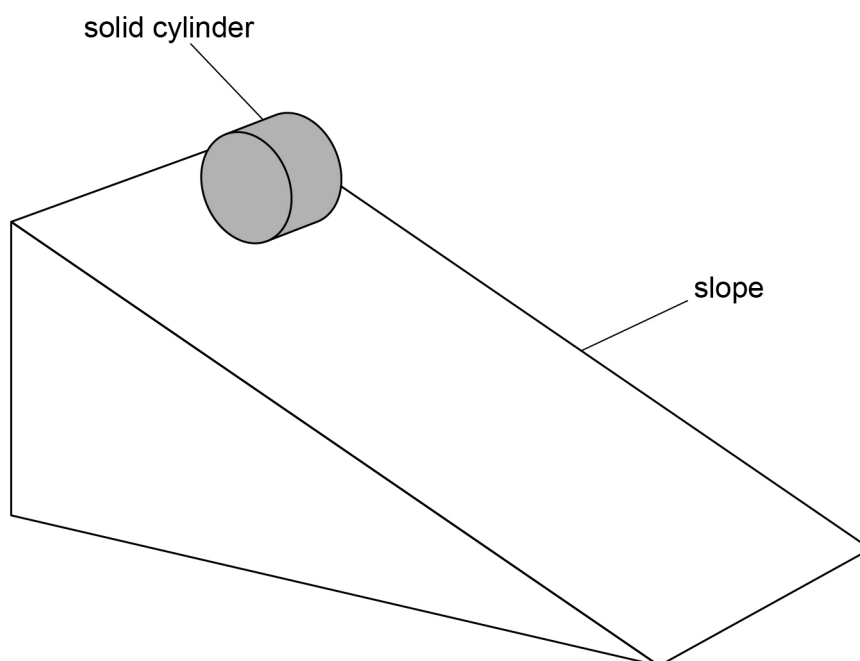
Write, in symbols, the equivalent relationship in rotational dynamics.

[1 mark]

A student investigates the moment of inertia of a solid cylinder.

The student places the cylinder near the top of a slope, as shown in **Figure 4**.
The length of the slope is about 50 cm.

Figure 4



The student plans to release the cylinder from rest and measure the time t for the cylinder to roll a distance of 38.0 cm down the slope.



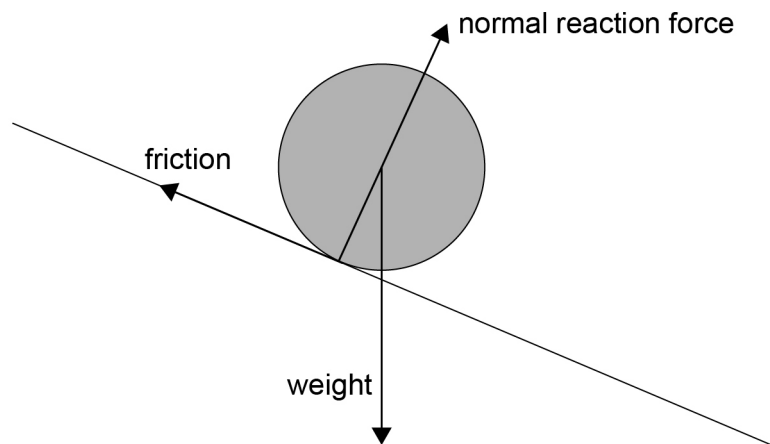
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Figure 5 shows the three forces acting on the cylinder as it rolls down the slope without slipping.

Figure 5



0 5 . 3

Explain what would happen to the cylinder if there was no friction.

[2 marks]



The mass of the cylinder is 2.1 kg and its radius is 3.4 cm.

The cylinder is released from rest and rolls 38.0 cm down the slope without slipping.

0 5 . 4

Calculate, in rad, the angular displacement, with respect to the centre of the cylinder, of a point on the edge of the cylinder.

[2 marks]

angular displacement = _____ rad

After rolling 38.0 cm down the slope, the change in gravitational potential energy ΔE_p of the cylinder is 3.2 J.

0 5 . 5

Calculate the angle that the slope makes to the horizontal.

[2 marks]

angle = _____ °

Question 5 continues on the next page

Turn over ►



0 5 . 6 After rolling 38.0 cm down the slope, the cylinder reaches a linear speed of 1.42 m s^{-1} .

Determine, using conservation of energy, the moment of inertia of the cylinder.

[4 marks]

moment of inertia = _____ kg m^2



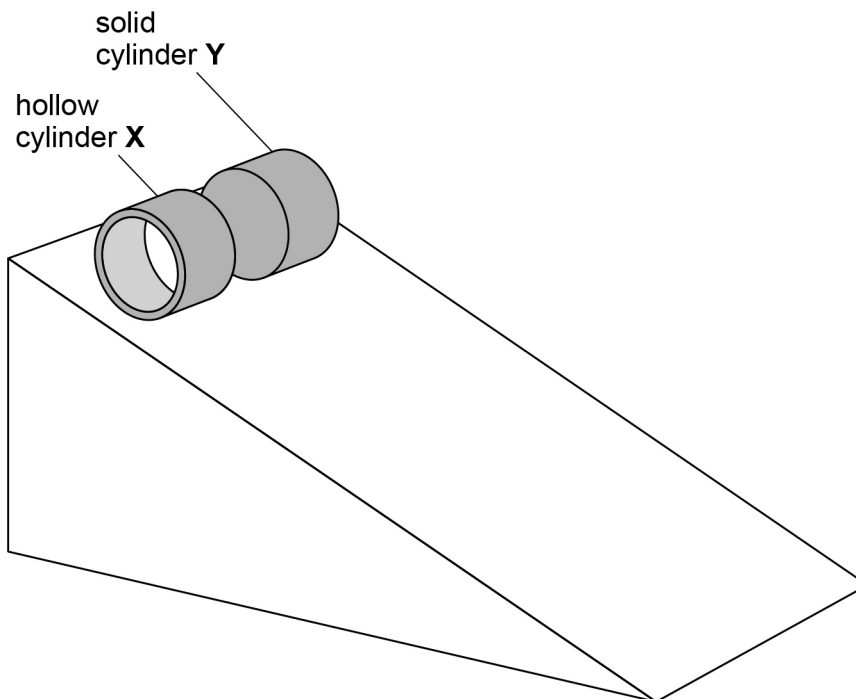
0 5 . 7

The student compares the motion of a hollow cylinder **X** and a solid cylinder **Y** on the slope.

X and **Y** have the same mass.

X and **Y** are placed at the same height as shown in **Figure 6**. They are then released at the same time and roll down the slope without slipping.

Figure 6



Deduce which cylinder, **X** or **Y**, reaches the bottom of the slope first.
Do **not** include any calculations in your answer.

[3 marks]

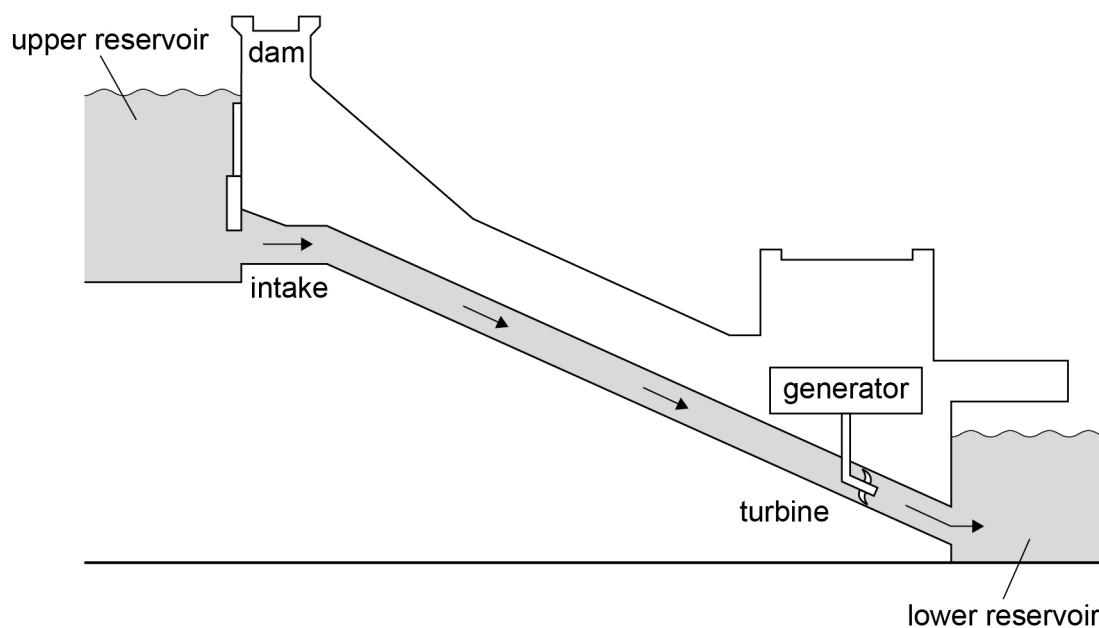


0 6

Figure 7 shows a hydroelectric power station that produces electrical energy.

Figure 7

not to scale



0 6 . 1

Water enters the turbine with a speed v .
The density of the water is ρ .
The diameter of the rotor in the turbine is d .

Show that the mass m of water flowing through the turbine per second is given by

$$m = \frac{\pi d^2 \rho v}{4}$$

[2 marks]



0 6 . 2 The maximum power available from the flow of water through the turbine is 55 MW.

Calculate m .

$$\rho = 1.0 \times 10^3 \text{ kg m}^{-3}$$

$$d = 8.5 \text{ m}$$

[3 marks]

$$m = \text{_____ kg s}^{-1}$$

Question 6 continues on the next page

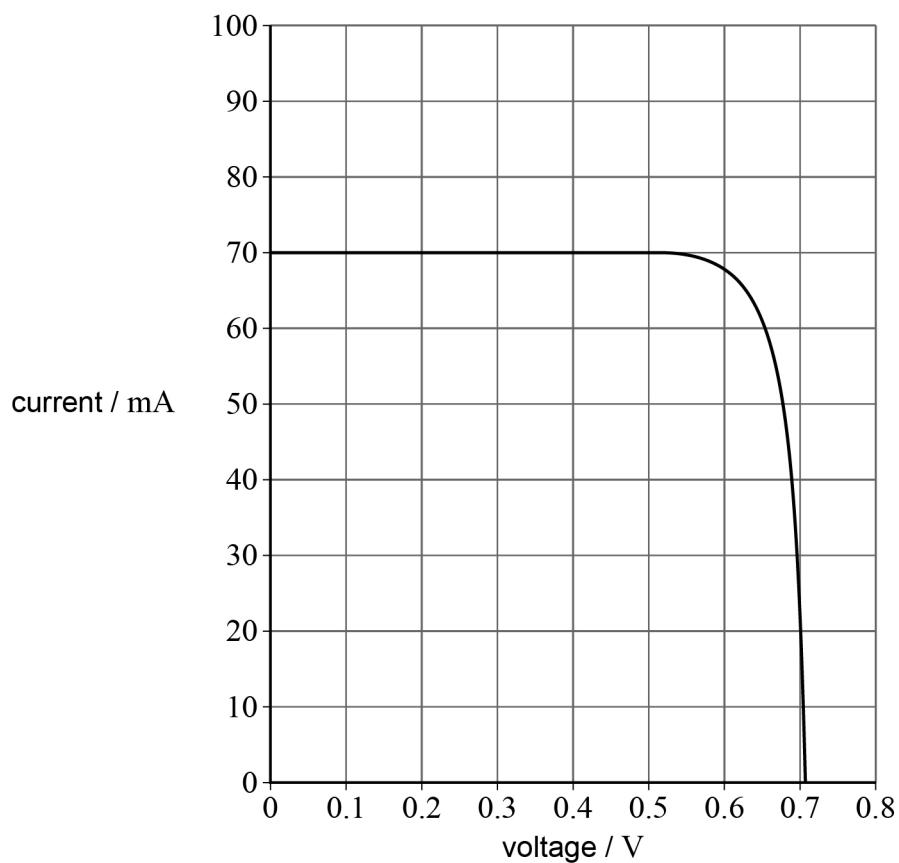
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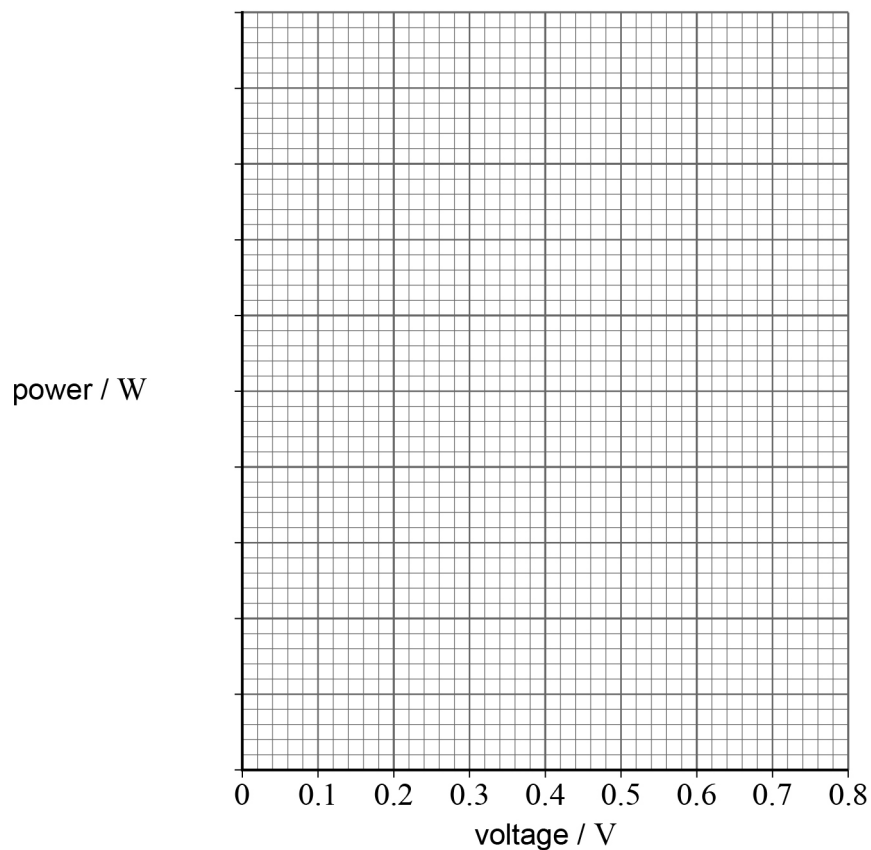
0 6 . 3 Electrical energy can also be produced by a solar cell.

Figure 8 shows the current–voltage characteristic for a solar cell.

Figure 8



Draw a graph on **Figure 9** to show how the power from the solar cell varies with voltage.
Include a scale on the power axis.

[3 marks]**Figure 9**

8

END OF SECTION A**Turn over ►**

Section B

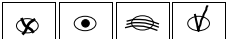
Each of the questions in this section is followed by four responses, **A**, **B**, **C** and **D**.

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** Initially, a sample of an ideal gas has an internal energy of $4E$ and an absolute temperature of T .

Two changes are made:

- energy of $3E$ is transferred to the gas by heating
- work of $2E$ is done by the gas.

What is the absolute temperature of the gas after these changes?

[1 mark]

A $0.80T$ ☐

B $1.25T$ ☐

C $1.50T$ ☐

D $2.25T$ ☐



0 8

At atmospheric pressure:

- nitrogen boils at a temperature of $-196\text{ }^{\circ}\text{C}$
- 500 J of energy is required to boil 25 g of nitrogen at its boiling point.

What can be deduced from this information?

[1 mark]**A** The specific heat capacity of liquid nitrogen is $20\,000\text{ J kg}^{-1}\text{ K}^{-1}$.☐**B** The specific latent heat of liquid nitrogen is 2000 J kg^{-1} .☐**C** Nitrogen is a gas at a temperature of 73 K at atmospheric pressure.☐**D** The potential energy of nitrogen increases by 500 J when 25 g of it boils.☐**0 9**

The length of one side of a square window is 0.65 m.

The temperature of the inside of the window is $19.0\text{ }^{\circ}\text{C}$ and the temperature of the outside is $-5.0\text{ }^{\circ}\text{C}$.The U-value of the window is $5.2\text{ W m}^{-2}\text{ K}^{-1}$.

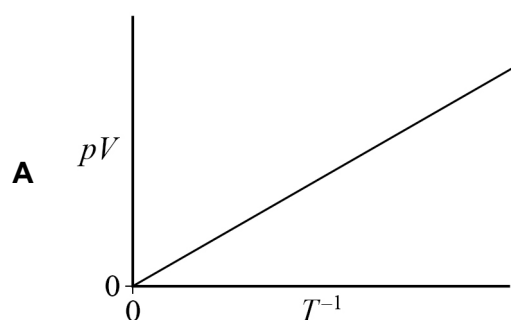
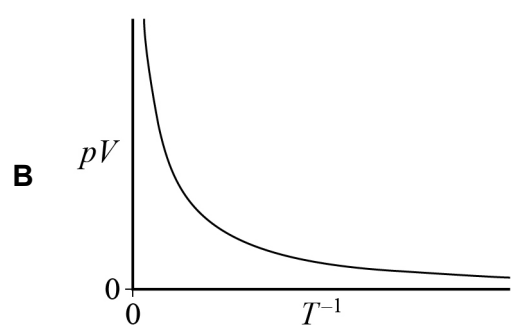
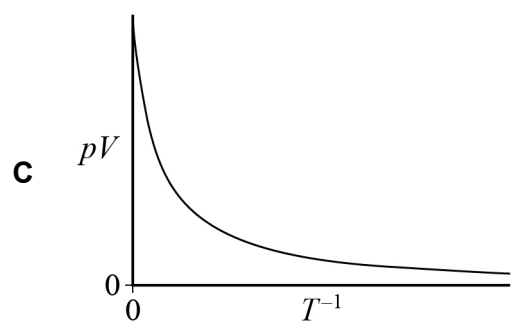
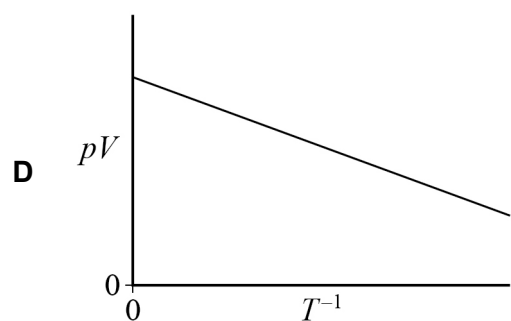
What is the rate of energy transfer through the window?

[1 mark]**A** 31 W☐**B** 41 W☐**C** 53 W☐**D** 650 W☐**Turn over for the next question****Turn over ►**

1 0

A fixed mass of an ideal gas has pressure p , volume V and absolute temperature T .

Which graph shows the variation of pV with T^{-1} for the fixed mass of the ideal gas?

[1 mark]

1 1

Which is an assumption about the particles in an ideal gas when deriving the equation

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

[1 mark]**A** The total mass of the particles is negligible.☐**B** The speed of a particle does not change when it collides with the container wall.☐**C** No forces act on the particles when they collide with the container wall.☐**D** At any particular temperature, all the particles in the container have the same speed.☐**1 2**

A sample of an ideal gas is trapped inside an insulated sealed syringe.

Initially the gas has absolute temperature T and pressure p .

An external force increases the volume of the gas inside the syringe.

Which row gives two effects of this change?

[1 mark]

A	T decreases	The time between particle collisions with the walls decreases.	☐
B	T increases	The internal energy of the gas decreases.	☐
C	p decreases	The time between particle collisions with the walls increases.	☐
D	p increases	The root mean square speed of the particles increases.	☐

Turn over for the next question**Turn over ►**

1 3What is the definition of the atomic mass unit u ?**[1 mark]****A** the mass of a proton☐**B** the average mass of a proton and a neutron☐**C** the mass of a carbon-12 ($^{12}_6\text{C}$) nucleus in its ground state divided by 12☐**D** the mass of a carbon-12 ($^{12}_6\text{C}$) atom in its ground state divided by 12☐**1 4**

The hydrogen cycle describes how helium nuclei are formed in the Sun.

Which row gives the number of protons required and the number of protons emitted in one cycle?

[1 mark]

	Number of protons required	Number of protons emitted	
A	4	0	☐
B	4	2	☐
C	6	0	☐
D	6	2	☐

1 5

In a thermal nuclear reactor, an emergency shutdown is achieved by

[1 mark]**A** fully removing fuel rods.☐**B** inserting more coolant.☐**C** fully removing control rods.☐**D** fully inserting control rods.☐

1 6

A wheel is rotating about its axis with an initial angular speed of 12 rad s^{-1} clockwise. A constant torque is applied to the wheel for 20 s. When the torque is removed, the wheel has an angular speed of 4 rad s^{-1} anticlockwise.

What is the angular acceleration of the wheel?

[1 mark]

A 0.80 rad s^{-2} clockwise ☐

B 0.80 rad s^{-2} anticlockwise ☐

C 0.40 rad s^{-2} clockwise ☐

D 0.40 rad s^{-2} anticlockwise ☐

1 7

The power output of the Sun is $3.8 \times 10^{26} \text{ W}$.

A space probe is a distance of $2.50 \times 10^{11} \text{ m}$ from the Sun.

To decrease the intensity of the sunlight on the probe by 10%, the probe moves away from the Sun.

What is the minimum distance the probe must move?

[1 mark]

A $1.4 \times 10^{10} \text{ m}$ ☐

B $2.8 \times 10^{10} \text{ m}$ ☐

C $2.6 \times 10^{11} \text{ m}$ ☐

D $5.5 \times 10^{11} \text{ m}$ ☐

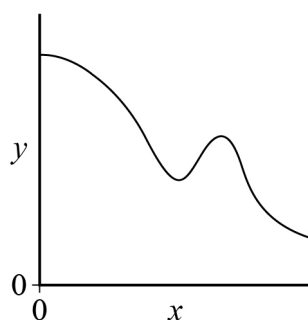
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1 8

The diagram shows a graph of quantity x against quantity y .



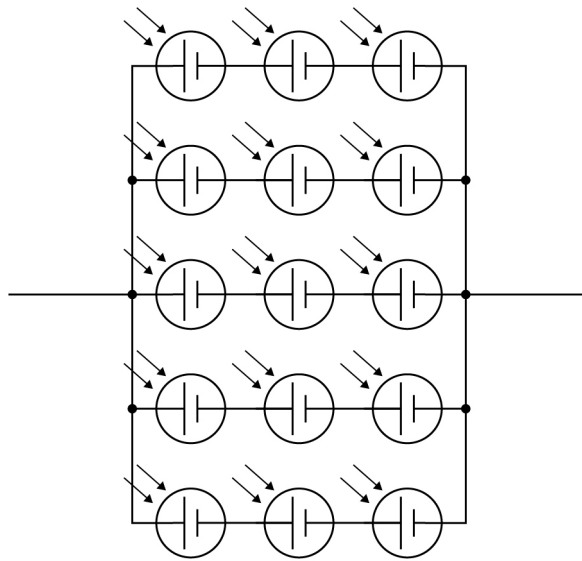
Which row gives x and y ?

[1 mark]

	x	y	
A	nucleon number	binding energy per nucleon	☐
B	diffraction angle	intensity of electrons diffracted by a nucleus	☐
C	nucleon number	radius of a nucleus	☐
D	proton number	mass defect	☐

1 9

The array shown below consists of 15 solar cells.



The output of each solar cell is 4.5 V and 1.2 A.

Which row gives the potential difference and current output of the array?

[1 mark]

	Potential difference / V	Current / A	
A	22.5	3.6	☐
B	22.5	6.0	☐
C	13.5	3.6	☐
D	13.5	6.0	☐

Turn over for the next question

Turn over ►



2 0

Fusion reactions in a reactor maintain a power output of 14 MW for 5.0 s.

What is the mass equivalence of the output energy during this time?

[1 mark]

A $2.3 \times 10^{-9} \text{ kg}$ ☐

B $7.8 \times 10^{-10} \text{ kg}$ ☐

C $3.1 \times 10^{-11} \text{ kg}$ ☐

D $4.0 \times 10^{-12} \text{ kg}$ ☐

2 1

A wind turbine **X** has a blade length r .

The maximum power available to **X** is P when the wind speed is v .

A different wind turbine **Y** has a blade length $2r$.

What is the maximum power available to **Y** when the wind speed is $\frac{v}{2}$?

[1 mark]

A $\frac{P}{2}$ ☐

B $\frac{2P}{3}$ ☐

C P ☐

D $2P$ ☐

15

END OF QUESTIONS

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