OXFORD
INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname ______________________

Forename(s) ______________________

Candidate signature ______________________

INTERNATIONAL A-LEVEL
PHYSICS

Unit 4 Energy and Energy resources

Wednesday 20 June 2018   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.

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 page or on blank pages.
- All working must be shown.
- 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	
6–35	
TOTAL	

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Section A

Answer **all** questions in this section.

0 1 . 1 A farmer uses a wind turbine to provide power. The blades of the turbine sweep out a circle of diameter $3.70\ \text{m}$. At a given instant, the maximum power available from the wind is $7.7\ \text{kW}$.

Calculate the wind speed at this instant.

The density of air is $1.2\ \text{kg m}^{-3}$

[2 marks]

wind speed = ______________________ m s^{-1}

0 1 . 2 Explain why the electrical power output from the turbine is significantly less than $7.7\ \text{kW}$.

[2 marks]

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0 1 . 3 The farmer plans to install several more wind turbines to make a wind farm.

Discuss the factors he should consider when positioning the turbines to optimise their power output.

[2 marks]

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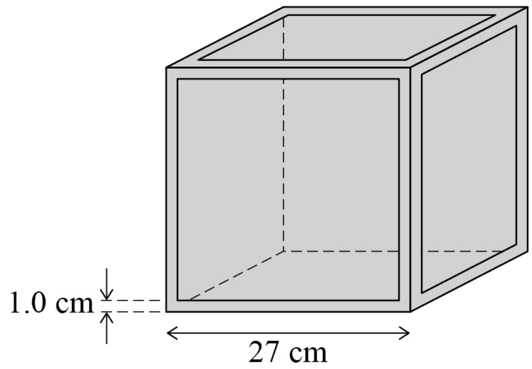
6

Turn over for the next question

0 2 **Figure 1** shows a hollow cube of external dimension 27 cm.

The walls and lid of the cube are made from an insulating material which is 1.0 cm thick.

Figure 1



The cube is filled with 14.3 kg of ice at 0 °C.

The outer surface of the cube is maintained at 25 °C.

It takes 2 days for all the ice to melt.

The specific latent heat of fusion of ice is $334\ \text{kJ kg}^{-1}$

0 2 . 1 Show that the energy needed to melt the ice is about 5×10^6 J.

[1 mark]

energy = ______________________ J

Do not write outside the box

0 2 . 2 Calculate the thermal conductivity of the insulating material used to make the cube.

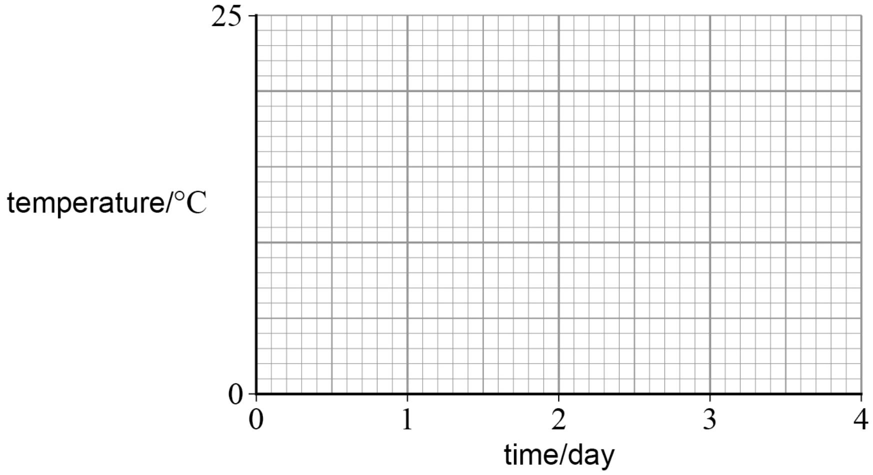
[4 marks]

thermal conductivity = ______________________ $W\ m^{-1}\ K^{-1}$

0 2 . 3 After the ice has melted, the cube is left in the same conditions for 2 more days.

Sketch a graph to show the variation with time of the temperature of the contents of the cube over the 4-day period.

[2 marks]



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0 3 . 1 An alpha particle, with an initial kinetic energy of $8.0\ \mathrm{MeV}$, approaches the centre of a nucleus of gold–197 ($^{197}_{79}\mathrm{Au}$).

Calculate the distance of closest approach between the alpha particle and the nucleus.

[3 marks]

distance = ____________________ m

0 3 . 2 **Table 1** shows the nuclear radii R of three stable nuclides measured using electron diffraction.

Table 1

Nuclide	R / fm
$^{9}_{4}\mathrm{Be}$	2.52
$^{12}_{6}\mathrm{C}$	2.79
$^{16}_{8}\mathrm{O}$	3.02

A model of the nucleus predicts that the nuclear radius is proportional to the cube root of the nucleon number.

Comment on the degree to which the data in **Table 1** are consistent with this prediction.

[3 marks]

0 3 . 3 Discuss why electron diffraction gives a more accurate value of nuclear radius than using the distance of closest approach of alpha particles.

[3 marks]

9

Turn over for the next question

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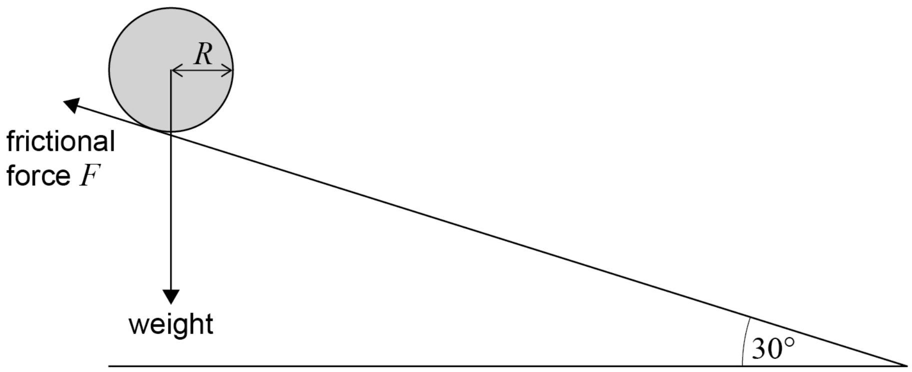
0 4 **Figure 2** shows a solid sphere of uniform density with a radius R of 0.14 m. The sphere is at the top of a ramp inclined at $30°$ to the horizontal. The sphere, initially at rest, is released and rolls down the ramp without slipping. The frictional torque produces an angular acceleration on the sphere of $25\ \text{rad s}^{-2}$

Figure 2



The mass M of the sphere is 1.8 kg.

The moment of inertia of a solid sphere is $\frac{2}{5}MR^2$

0 4 . 1 Calculate the frictional force F.

[3 marks]

frictional force = ____________________ N

0 4 . 2 Calculate the angular speed of the sphere 1.5 s after its release.

[1 mark]

angular speed = ____________________ rad s^{-1}

Do not write outside the box

0 4 . 3 Show that the sphere travels approximately 3.9 m along the ramp in the first 1.5 s of its motion.

[4 marks]

0 4 . 4 Calculate the reduction in gravitational potential energy of the sphere during the first 1.5 s.

[2 marks]

reduction in gravitational potential energy = ____________________ J

0 4 . 5 Calculate the increase in the rotational kinetic energy of the sphere during the first 1.5 s.

[2 marks]

increase in rotational kinetic energy = ____________________ J

0 4 . 6 The sphere is now placed on a similar frictionless ramp.

State and explain how the lack of friction will affect the change in rotational kinetic energy.

[2 marks]

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14

Turn over ►

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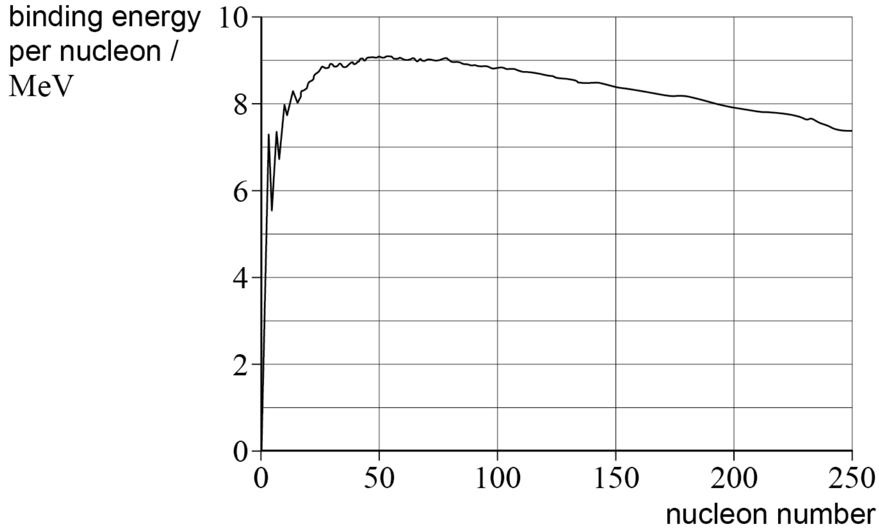
0 5 **Figure 3** is a plot showing the variation with nucleon number of the binding energy per nucleon.

Figure 3



0 5 . 1 Explain with reference to **Figure 3** why nuclear fusion can lead to the release of energy.

[3 marks]

Do not write outside the box

0 5 . 2 A uranium–235 nucleus undergoes induced fission to form two nuclei of equal mass.

Calculate, using **Figure 3**, the energy in J released by this fission event.

[5 marks]

energy released = ____________________ J

0 5 . 3 Describe, with reference to their energy, the role of neutrons in a thermal nuclear reactor.

[3 marks]

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Question 5 continues on the next page

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0 5 . 4 Describe the function of the control rods in a thermal nuclear reactor.

Your answer should include **one** example of a suitable material for a control rod and its properties.

[3 marks]

14

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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 sheets for this working.

0 6 The molecular mass of carbon dioxide is 44

How many molecules are in 2.4 kg of carbon dioxide?

[1 mark]

A 1.1×10^{21}

B 3.3×10^{22}

C 1.1×10^{25}

D 3.3×10^{25}

Turn over for the next question

Do not write outside the box

0 7 A fixed mass of an ideal gas is at pressure p. The volume of the gas is increased by 50% and its absolute temperature is halved.

What is the new pressure of the gas?

[1 mark]

A $\frac{p}{3}$ ⬭

B $\frac{3p}{4}$ ⬭

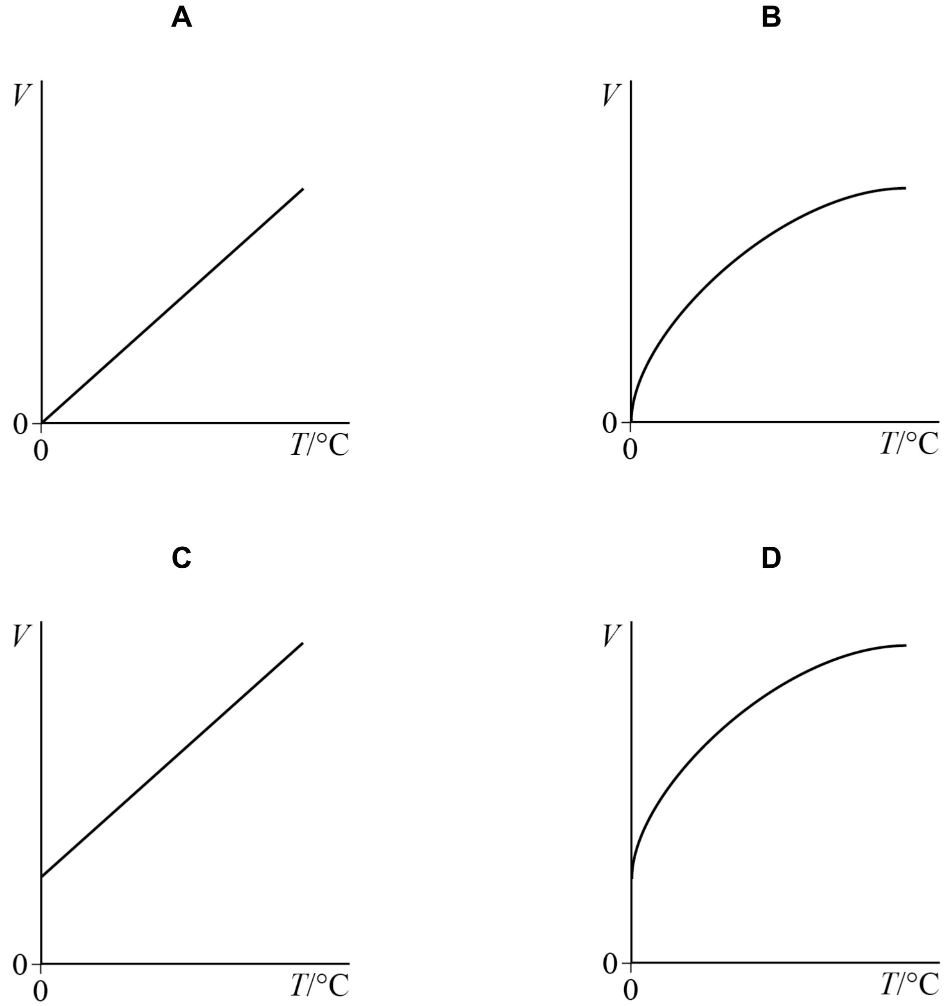
C p ⬭

D $3p$ ⬭

0 8 A fixed mass of an ideal gas is at a constant pressure.

Which graph shows the variation of volume with temperature in °C?

[1 mark]



A ⬭

B ⬭

C ⬭

D ⬭

Do not write outside the box

0 9 Which assumption is made about the particles when using the kinetic theory model of a gas?

[1 mark]

A They have negligible mass. ⬭

B They have negligible volume. ⬭

C They have the same speed. ⬭

D They travel in the same direction. ⬭

1 0 A sample of oxygen gas is at a temperature of 30.0 °C.
Oxygen has a molecular mass of 32

What is the root mean square speed of molecules in the sample?

[1 mark]

A $0.153\ \text{km s}^{-1}$ ⬭

B $0.486\ \text{km s}^{-1}$ ⬭

C $23.4\ \text{km s}^{-1}$ ⬭

D $236\ \text{km s}^{-1}$ ⬭

1 1 Four gas molecules have velocities of $200\ \text{m s}^{-1}$, $-200\ \text{m s}^{-1}$, $300\ \text{m s}^{-1}$ and $-300\ \text{m s}^{-1}$ respectively.

What is the root mean square speed of the molecules?

[1 mark]

A $0\ \text{m s}^{-1}$ ⬭

B $106\ \text{m s}^{-1}$ ⬭

C $250\ \text{m s}^{-1}$ ⬭

D $255\ \text{m s}^{-1}$ ⬭

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1 2 The nucleus ${}^{A}_{Z}X$ has a mass defect Δm.

mass of a proton = m_p

mass of a neutron = m_n

mass of nucleus ${}^{A}_{Z}X$ = m_x

Which expression is correct?

[1 mark]

A $\Delta m = m_x - (Zm_n + (A-Z)m_p)$ ⬭

B $\Delta m = ((A-Z)m_n + Zm_p) - m_x$ ⬭

C $\Delta m = (Am_n + (A-Z)m_p) - m_x$ ⬭

D $\Delta m = m_x - (Am_n + (A-Z)m_p)$ ⬭

1 3 The mass defect of a nucleus exists because

[1 mark]

A protons in the nucleus repel each other. ⬭

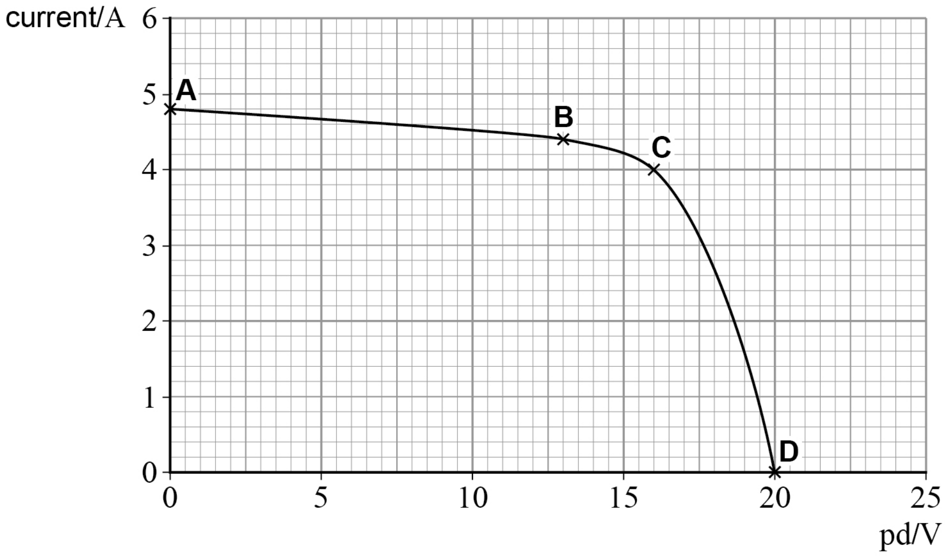
B neutrons have a greater mass than protons. ⬭

C work must be done to separate a nucleus into its constituent nucleons. ⬭

D large nuclei are always more stable than small nuclei. ⬭

Turn over for the next question

1 4 The graph shows the variation of the current in a solar cell with the pd across the cell.



At which point does the solar cell have maximum power output?

[1 mark]

A ⬭

B ⬭

C ⬭

D ⬭

Do not write outside the box

1 5 The table shows data for ideal gases **P** and **Q**.

Gas	Molecular mass	Temperature / K
P	m	T
Q	$\frac{m}{2}$	$4T$

The root mean square speed of molecules in **P** is c_{rms}

What is the root mean square speed of molecules in **Q**?

[1 mark]

A $\frac{c_{\mathrm{rms}}}{\sqrt{2}}$ ○

B $\sqrt{2}c_{\mathrm{rms}}$ ○

C $2\sqrt{2}c_{\mathrm{rms}}$ ○

D $8c_{\mathrm{rms}}$ ○

1 6 A pumped storage station contains six turbines a vertical distance h below its upper reservoir. The rate of flow of water through each turbine is 2.3×10^4 kg s^{-1} when the station is generating an output of 75 MW. The pumped storage system converts the water's gravitational potential energy to electrical energy with an efficiency of 0.92

What is h?

[1 mark]

A 51 m ○

B 60 m ○

C 310 m ○

D 361 m ○

Turn over ►

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1 7 The table shows data measured for the Sun.

Power output / W	3.83×10^{26}
Maximum distance from Mars / km	2.49×10^{8}
Minimum distance from Mars / km	2.06×10^{8}

What is the maximum intensity of the Sun's radiation at the orbit of Mars?

[1 mark]

A $492\ \text{W m}^{-2}$

B $718\ \text{W m}^{-2}$

C $6180\ \text{W m}^{-2}$

D $9030\ \text{W m}^{-2}$

1 8 Which is **not** a difficulty in a nuclear fusion reactor?

[1 mark]

A Confining the plasma.

B Dealing with highly radioactive waste.

C Heating the plasma.

D Sustaining fusion over a period of time.

1 9 Which process would cause the internal energy of a gas to change by –40 J?

[1 mark]

A The gas is cooled losing 120 J of energy and expands doing 80 J of work.

B The gas is cooled losing 120 J of energy and 80 J of work is done on the gas by compressing it.

C The gas is heated gaining 120 J of energy and expands doing 80 J of work.

D The gas is heated gaining 120 J of energy and 80 J of work is done on the gas by compressing it.

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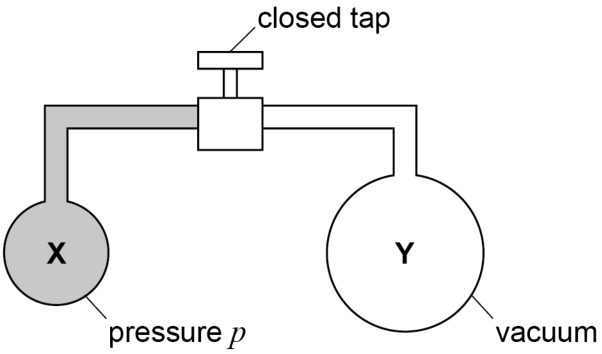
2 0 Flask **X** has a volume V.

Flask **Y** has a volume 2V.

The flasks are connected by a tube of volume $\frac{V}{8}$ with a uniform cross-section.

There is a closed tap in the middle of the tube.

A gas at pressure p occupies the left hand side of the system as shown in the diagram.



The tap is then opened.

What is the new pressure of the gas?

Assume that the temperature remains constant.

[1 mark]

A $\frac{1}{5}p$ ⬭

B $\frac{8}{25}p$ ⬭

C $\frac{17}{50}p$ ⬭

D $\frac{33}{50}p$ ⬭

Do not write outside the box

2 1 The mass of an alpha particle is 6.644×10^{-27} kg.

What is the binding energy of an alpha particle?

[1 mark]

A 3.2×10^{-12} J

B 4.3×10^{-12} J

C 4.7×10^{-12} J

D 5.0×10^{-12} J

2 2 What are the fundamental units of U-value?

[1 mark]

A kg m s^{-2} K^{-1}

B kg m s^{-3} K^{-1}

C kg s^{-2} K^{-1}

D kg s^{-3} K^{-1}

2 3 An insulated tube of negligible heat capacity contains 100 identical lead pellets. The tube is turned upside down so that the pellets fall from the top to the bottom through the same vertical distance. It is found that after 220 turns of the tube the temperature of the pellets has increased by 5 °C.

The experiment is repeated with 400 of these lead pellets in the tube.

How many turns of the tube are needed to increase the temperature of 400 pellets by 5 °C?

[1 mark]

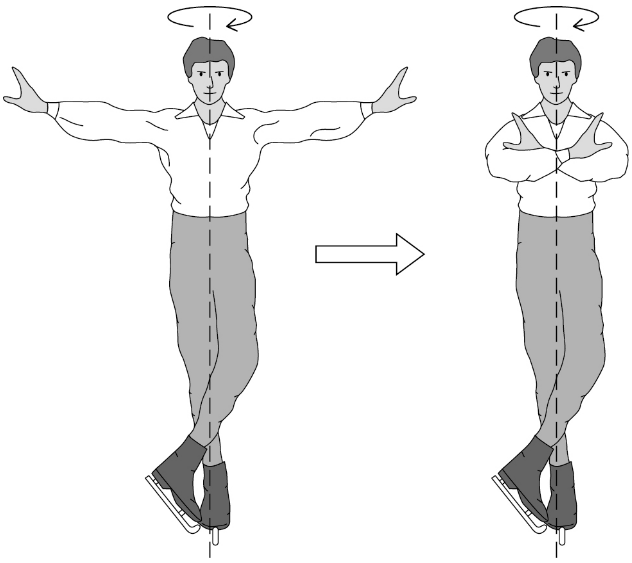
A 55

B 220

C 440

D 880

2 4 The diagrams show an ice skater spinning freely about a fixed vertical axis.



The skater brings his arms in towards his chest.

What happens to his angular velocity and angular momentum?

[1 mark]

	Angular velocity	Angular momentum	
A	Decreases	Decreases	⬭
B	Increases	Decreases	⬭
C	Decreases	Unchanged	⬭
D	Increases	Unchanged	⬭

Turn over for the next question

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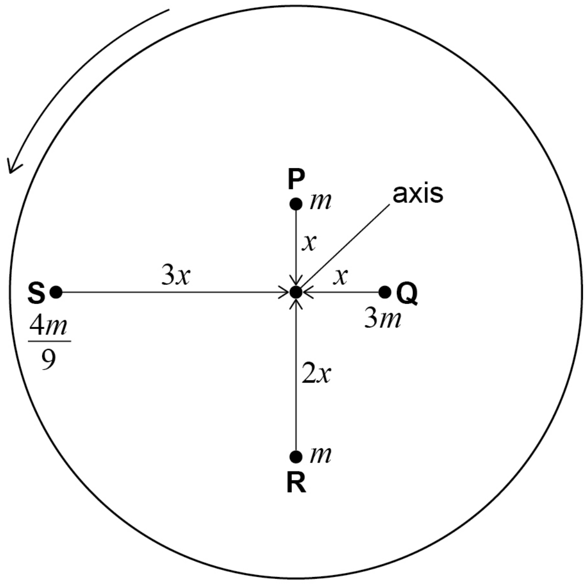
Questions **25** and **26** relate to the diagram below.
The diagram shows a light disc with four point masses attached. The disc rotates about a vertical axis.

The masses of **P**, **Q**, **R** and **S** are m, $3m$, m and $\frac{4m}{9}$ respectively.



2 5 What is the moment of inertia of the system about the axis shown?

[1 mark]

A $\frac{8}{3}mx^2$

B $4mx^2$

C $\frac{22}{3}mx^2$

D $12mx^2$

2 6 Which two masses have the same angular momentum about the axis?

[1 mark]

A **P** and **Q**

B **P** and **R**

C **Q** and **S**

D **R** and **S**

Do not write outside the box

2 7 The Moon orbits the Earth with a period of 27 days.

What is the average angular velocity of the Moon about the Earth?

[1 mark]

A 4.3×10^{-7} rad s^{-1}

B 2.7×10^{-6} rad s^{-1}

C 6.5×10^{-5} rad s^{-1}

D 2.3×10^{-1} rad s^{-1}

2 8 A point mass of moment of inertia 8.64×10^{-3} kg m^2 rotates about a fixed axis. The initial angular velocity is 2.51 rad s^{-1} and the constant angular acceleration is 0.10 rad s^{-2}
The mass makes 2 complete rotations about the axis.

What is the change in angular momentum of the mass?

[1 mark]

A 0

B 4.0×10^{-3} kg m^2 s^{-1}

C 2.2×10^{-2} kg m^2 s^{-1}

D 2.6×10^{-2} kg m^2 s^{-1}

Turn over for the next question

2 9 In a particular design of pumped storage station, water is pumped from a lower reservoir to an upper reservoir, both of fixed volume. The table shows data for two such stations, **X** and **Y**.

	Station X	**Station Y**
Volume of lower reservoir	$2V$	$5V$
Volume of upper reservoir	$3V$	$4V$
Vertical distance between upper and lower reservoir	$2h$	h
Maximum energy that can be stored by pumping water from the lower reservoir to the upper	E_X	E_Y

What is the ratio $\frac{E_X}{E_Y}$?

[1 mark]

A $\frac{2}{5}$

B $\frac{3}{4}$

C 1

D 2

Do not write outside the box

3 0 An electrical shower has a power of $10.5\ \text{kW}$. Water of specific heat capacity $4200\ \text{J kg}^{-1}\ \text{K}^{-1}$ passes through the shower at a rate of $9.3 \times 10^{-2}\ \text{kg s}^{-1}$. The water enters the shower at $20\ ^\circ\text{C}$ and leaves at $45\ ^\circ\text{C}$.

Some energy is wasted in heating the components of the shower.

How much energy is wasted in one second?

[1 mark]

A 0.74 kJ ⬭

B 3.5 kJ ⬭

C 2.7 kJ ⬭

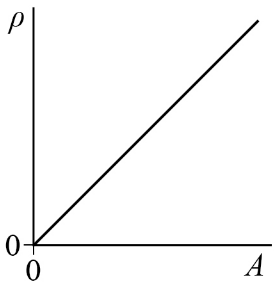
D 9.8 kJ ⬭

Turn over for the next question

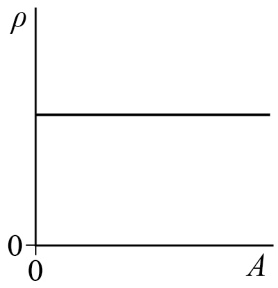
3 1 Which graph shows the variation of nuclear density ρ with nucleon number A?

[1 mark]

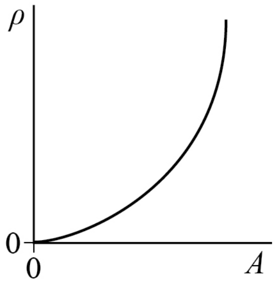
A



B



C



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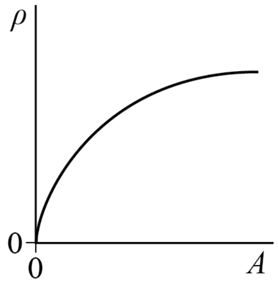

A ⬭

B ⬭

C ⬭

D ⬭

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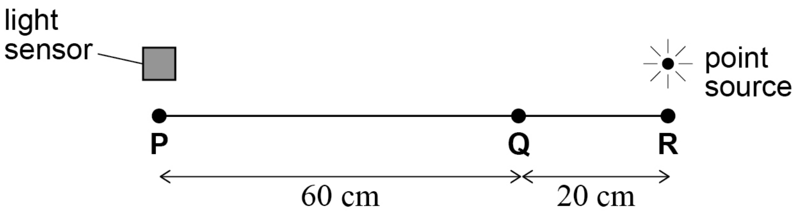
3 2 The diagram shows an experiment in which a light sensor can be moved along the line **PQR** from a fixed light source. The intensity of light at **Q** is I.

What is the intensity at **P**?

[1 mark]



A $\frac{I}{16}$

B $\frac{I}{9}$

C $\frac{I}{4}$

D $\frac{I}{3}$

3 3 Two thermal insulation boards **X** and **Y** have the same dimensions.

Board **X** has U-value U.
Board **Y** has a rate of heat transfer that is 50% more than that of board **X** for the same temperature difference.

What is the U-value of board **Y**?

[1 mark]

A $\frac{U}{4}$

B $\frac{3U}{2}$

C $2U$

D $3U$

Turn over for the next question

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3 4 A thermal nuclear reactor maintains a steady chain reaction.
The average number of neutrons emitted per fission is 3.

Which row shows possible average numbers of neutrons absorbed by control rods and lost from the reactor without causing fission?

[1 mark]

	Average number of neutrons absorbed by control rods	Average number of neutrons lost from the reactor without causing fission	
A	2	1	⬭
B	1	0	⬭
C	1	1	⬭
D	0	1	⬭

3 5 The atomic mass unit is:

[1 mark]

A the mass of a hydrogen atom. ⬭

B the average of the mass of a free proton and the mass of a free neutron. ⬭

C one-twelfth of the mass of a carbon–12 atom. ⬭

D one-quarter of the mass of an alpha particle. ⬭

30

END OF QUESTIONS

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