AQA

Please write clearly in block capitals.

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

Surname ______________________

Forename(s) ______________________

Candidate signature ______________________
I declare this is my own work.

# GCSE
# PHYSICS

**H**

## Higher Tier Paper 1

Wednesday 22 May 2024 Morning Time allowed: 1 hour 45 minutes

**Materials**
For this paper you must have:
- a ruler
- a scientific calculator
- the Physics Equations Sheet (enclosed).

**Instructions**
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided.
- Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- 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).
- In all calculations, show clearly how you work out your answer.

**Information**
- The maximum mark for this paper is 100.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

| For Examiner's Use | |
|---|---|
| Question | Mark |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |
| **TOTAL** | |

Answer **all** questions in the spaces provided.

**0 1** **Figure 1** shows a wind turbine.

**Figure 1**

Wind turbines may generate electricity when the electricity is not needed.

Two methods that can be used to store the energy from the turbine are:

**Method A**: Heating water to a high temperature.

**Method B**: Pumping water uphill into a reservoir.

**0 1 . 1** Which energy store increases when water is heated?

**[1 mark]**

Thermal (or internal energy)

**0 1 . 2** Which energy store increases when water is pumped uphill into a reservoir?

**[1 mark]**

Gravitational Potential energy

Do not write outside the box

**0 1 . 3** **Table 1** shows information about the two methods of storing energy.

**Table 1**

| Method | Energy stored per 100 kg of water in kJ | Percentage of stored energy wasted | Installation |
|---|---|---|---|
| **A**: Increasing water temperature by 80 °C | 33 600 | 40% | Anywhere |
| **B**: Pumping water uphill to a height of 500 m | 490 | 25% | High mountains |

Compare the advantages and disadvantages of the two methods of storing energy.

Include calculations in your answer.

**[4 marks]**

Method A:
Heated water needs insulating (to maintain high temp)
Energy stored by heating water is much greater per 100 kg
Useful energy from heating 100g water = $(33600 \times \frac{100-40}{100})$ 20160 kJ
Energy wasted per 100 kg = $(33600 \times \frac{40}{100})$ = 13440 kJ
Efficiency = 60%

Method B:
Suitable location needed to pump water uphill
Pumping water efficiency is higher:
Useful energy from pumping 100 kg water = $(490 - \frac{100-25}{100})$ = 367.5 kJ

Question 1 continues on the next page

Energy wasted per 100 kg = $(490 \times \frac{25}{100})$ = 122.5 kJ
Efficiency = 75%

*Do not write outside the box*

**0 1 . 4** Decreasing the amount of carbon dioxide released by different activities will help slow down climate change.

Transport and generating electricity are the two activities that released the largest amounts of carbon dioxide in the UK in 2018.

Explain **one** change that would reduce the amount of carbon dioxide released by **each** activity.

**[4 marks]**

Transport Do not use petrol/diesel cars for transport. Instead use hydrogen fuelled cars

Generating electricity Do not use coal/oil or gas (which contain Carbon) to generate electricity.

Instead use renewable methods, or nucleer power.

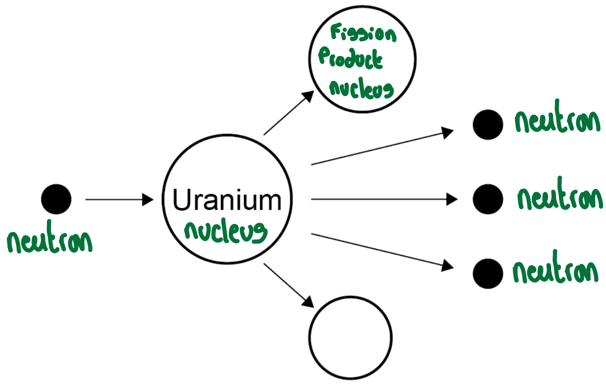
10

Do not write outside the box

**0 2** The process of nuclear fission is used in nuclear power stations.

**Figure 2** shows the process of nuclear fission.

**Figure 2**




**0 2 . 1** Complete the sentences.

Choose answers from the box.

**[3 marks]**

| | | | | |
|---|---|---|---|---|
| **electrons** | **gamma rays** | **neutrons** | **nuclei** | **protons** |

In nuclear power stations, energy is released from

uranium nuclei.

The uranium in **Figure 2** splits into two parts and

releases three neutrons.

The process of nuclear fission releases electromagnetic radiation in the

form of gamma rays.

*Do not write outside the box*

Use the Physics Equations Sheet to answer questions **02.2** and **02.3**.

**0 2 . 2** Write down the equation which links energy ($E$), power ($P$) and time ($t$).

**[1 mark]**

Energy = power × time      $E = P \times t$

| energy transferred = power × time | $E = P\,t$ |
|---|---|

J W s

**0 2 . 3** A nuclear power station has a power output of 500 MW.

Calculate the energy output in 3600 s.

Give your answer in J.

**[3 marks]**

500 MW = $500 \times 10^6$ W

E = P × t

E = $500 \times 10^6$ W × 3600 s

E = $1.8 \times 10^{12}$ J

Energy output = $1.8 \times 10^{12}$ J

**0 2 . 4** Radioactive waste produced by nuclear power stations has a long half-life.

Suggest **one** precaution taken to reduce the hazard caused by radioactive waste from power stations.

**[1 mark]**

Bury the radioactive waste underground.
(shielded from environment while decays)

*Do not write outside the box*

**0 2 . 5** Nuclear power stations do **not** generate electricity every day of the year.

One nuclear power station generated electricity for 92% of a year.

one year = 365 days

Calculate the number of days during the year that the nuclear power station generated electricity.

**[2 marks]**

1 year = 365 days

92% of 1 year = $365 \times \frac{92}{100}$

= 335·8

Number of days = 336 days

10

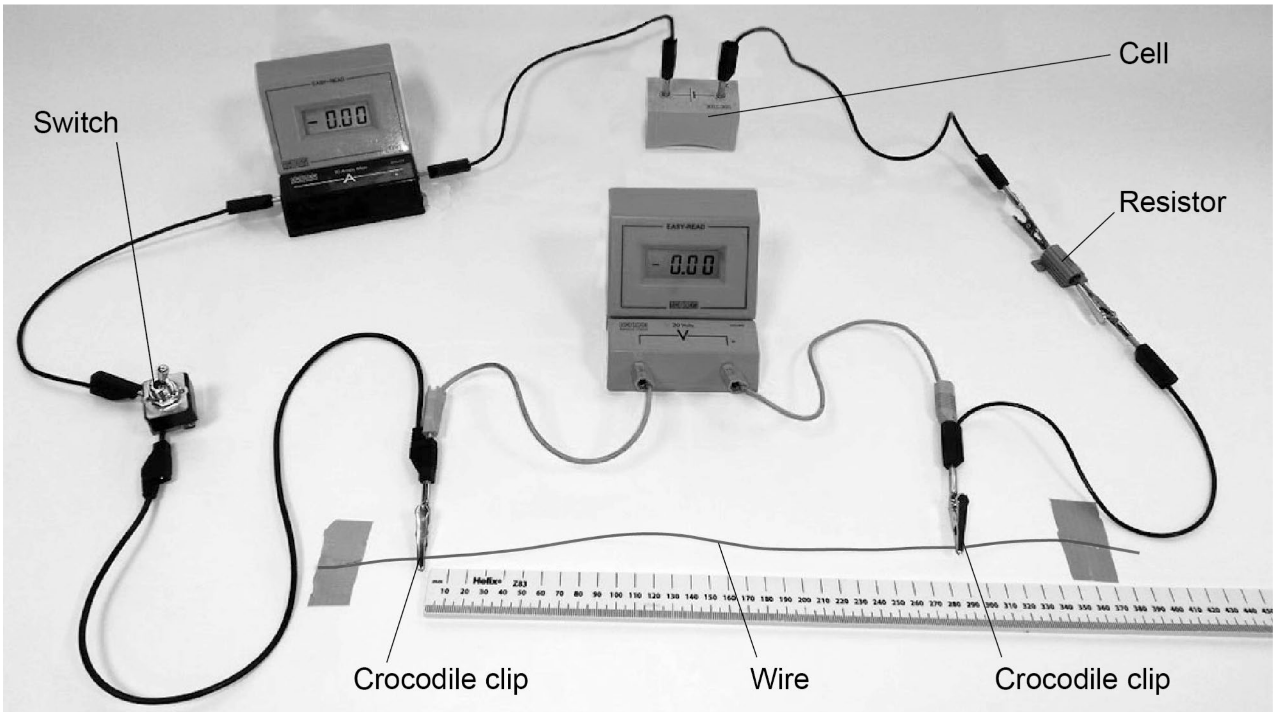
**Turn over for the next question**

*Do not write outside the box*

**0 3** A student investigated how the length of a wire affects the resistance of the wire at constant temperature.

**Figure 3** shows the circuit used.

**Figure 3**




**0 3 . 1** The student plotted a graph of resistance against the length of wire.

Describe a method the student could have used to collect the data needed to plot the graph.

**[6 marks]**

Measure the length of wire (between the crocodile clips) using the ruler.
Vary the length of the wire by moving crocodile clips
Measure the current (I) with the Ammeter
Measure the potential difference with the Voltmeter
Calculate the resistance for each length -
use V = IR, R = V/I to calculate resistance.
Record Current (I) and Potential Difference (V) for different lengths.

Do not write outside the box

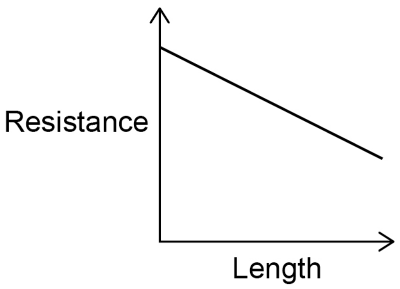
Repeat readings of I and V for each length and calculate mean values.
Remove any anomalous readings
Ensure values of Current are low to minimise heating of the wire.
Ensure the circuit is disconnected between readings

**0 3 . 2** Which graph shows the relationship between the resistance of a wire at constant temperature and its length?

**[1 mark]**

Tick (✓) **one** box.

Resistance ∝ length of wire

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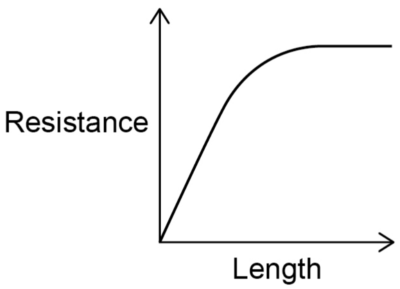


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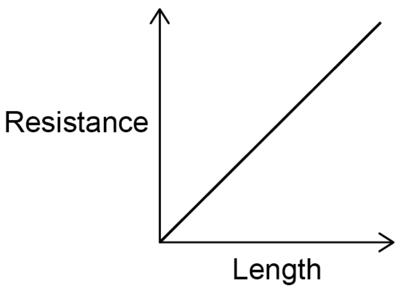


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**Question 3 continues on the next page**

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**0 3 . 3** The student used a cell that had a potential difference of 1.50 V.

Explain why the cell was **not** an electrical hazard to the student in the investigation.

**[2 marks]**

P.D. of cell, 1.50 V, is very low,
so no risk of electrical shock.

9

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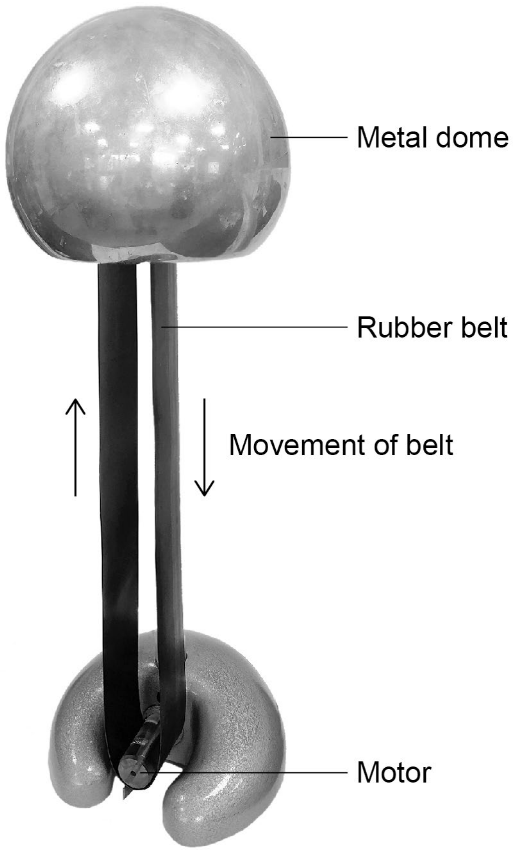
**0 4** **Figure 4** shows a static electricity generator.

**Figure 4**




The rubber belt is turned by a motor.

As the rubber belt moves, charge is transferred from the rubber belt to the metal dome.

**Question 4 continues on the next page**

Do not write outside the box

**0 4 . 1** **Figure 5** shows a student touching the metal dome of the static electricity generator.

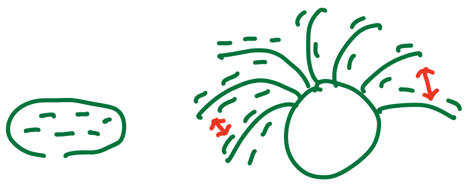
The dome is negatively charged.

**Figure 5**

Explain why the student's hair stands up on end.

**[3 marks]**

Electrons are transfered from the dome to the student.
So her hair is negatively charged.
Like charges repel, so hair strands repel each other.



*Do not write outside the box*

The charged metal dome creates an electric field.

**0 4 . 2** What is an electric field?

**[1 mark]**

The region around a charged object where another charged object experiences a force.

**0 4 . 3** How does the electric field strength vary as the distance from the charged metal dome increases?

**[1 mark]**

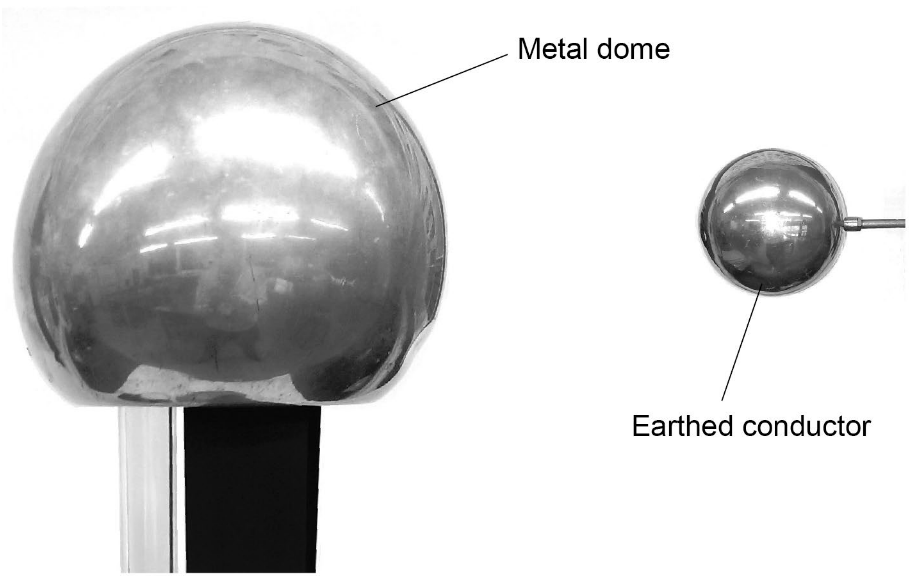
The electric field strength decreases with distance

**Question 4 continues on the next page**

Do not write outside the box

**Figure 6** shows the negatively charged metal dome and an earthed conductor.

**Figure 6**




When the earthed conductor is moved towards the metal dome, there is a spark between the dome and the earthed conductor.

**0 4 . 4** The spark transfers 0.60 J of energy, and 2.0 μC of charge is transferred from the dome to the earthed conductor.

Calculate the potential difference between the metal dome and the earthed conductor.

Use the Physics Equations Sheet.

**[4 marks]**

| energy transferred = charge flow × potential difference | $E = Q\,V$ |
|---|---|

$E = QV$
$E = 0.60\text{ J}$
$Q = 2.0\,\mu C = 2.0 \times 10^{-6}\text{ C}$
$V = ?$

$E = QV$
$V = \frac{E}{Q}$
$V = \frac{0.6\text{J}}{2.0 \times 10^{-6}\text{C}}$
$V = 300\,000\text{ V}$

Potential difference = 300 000 V

*Do not write outside the box*

**0 4 . 5** Which of the following changes would increase the distance a spark can jump between the dome and the earthed conductor?

**[1 mark]**

Tick (✓) **one** box.

| | |
|---|---|
| Decreased charge on the metal dome ↓ | ☐ |
| Decreased electric field strength ↓ | ☐ |
| Decreased electrical resistance of air ↑ | ☑ - Allows electricity to flow more easily |
| Decreased potential difference ↓ | ☐ |

___ 10

**Turn over for the next question**

*Do not write outside the box*

**0 5** **Figure 7** shows a student putting a coin into a vending machine that sells food.

**Figure 7**


**0 5 . 1** The vending machine is connected to the mains electricity supply.

What is the frequency and the potential difference of the mains electricity supply in the UK?

**[2 marks]**

Frequency = 50 Hz

Potential difference = 230 V

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The vending machine identifies the value of the coin by measuring the resistance of the coin.

**0 5 . 2** The power dissipated by the coin is 340 mW when the current in the coin is 0.75 A.

Calculate the resistance of the coin.

Use the Physics Equations Sheet.

**[4 marks]**

| | |
|---|---|
| power = (current)$^2$ × resistance | $P = I^2 R$ |

$P = 340 \text{ mW} = 340 \times 10^{-3} \text{ W} = 0.34 \text{ W}$

$P = I^2 R$

$R = \frac{P}{I^2} = \frac{0.34}{(0.75)^2} = 0.60 \ \Omega$

Resistance = 0.60 Ω

**0 5 . 3** Coins that are dirty are **not** recognised by the vending machine.

Suggest **one** reason why.

**[1 mark]**

The dirt changes the measured resistance of the coin.

**Question 5 continues on the next page**

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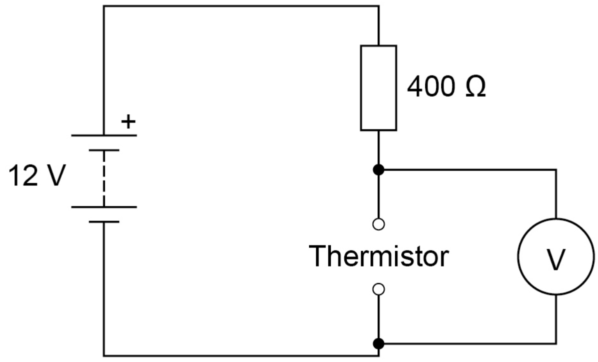
**Figure 8** shows part of a different circuit that is used to monitor the temperature inside the vending machine.

**Figure 8**




Thermistor and resister in 'series'

**0 5 . 4** The circuit symbol for a thermistor has not been included.

Draw the circuit symbol for a thermistor in the box below.

**[1 mark]**

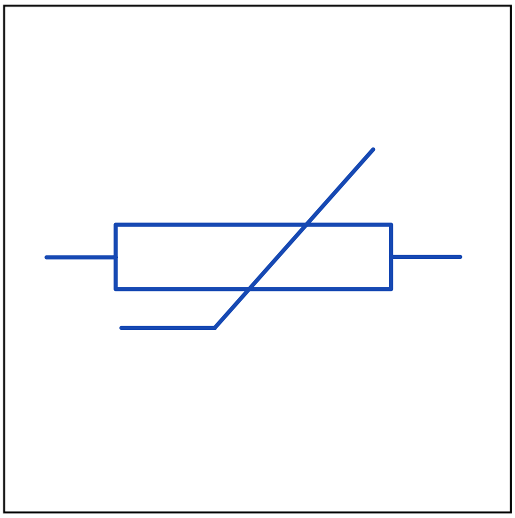


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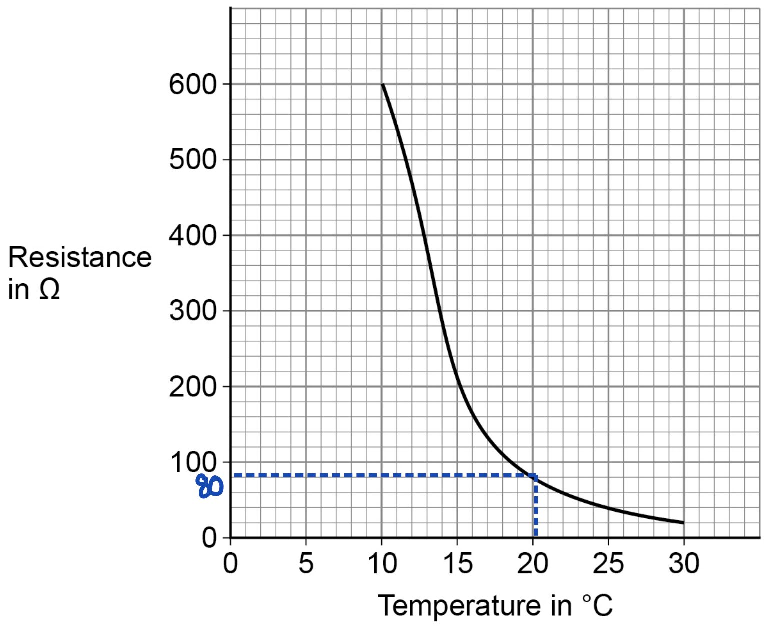
**Figure 9** shows how the resistance of the thermistor varies with temperature.

**Figure 9**




**0 5 . 5** The cooling system inside the vending machine turns on when the temperature of the thermistor is above 20 °C.

Determine the potential difference across the thermistor when the temperature is 20 °C.

Use the Physics Equations Sheet.

**[5 marks]**

From the graph, at T = 20°C, Thermistor R = 80 Ω

For Resistors in series, $R_{TOTAL}$ = 400 + 80
= 480 Ω

1) Use cell P.D. to calculate circuit current:

$V = IR$   $I = \frac{V}{R}$   $I = \frac{12\ V}{480\ \Omega} = 0.025\ A$

2) Series, so now calculate P.D. across thermistor:

Potential difference = 2.0 V

13

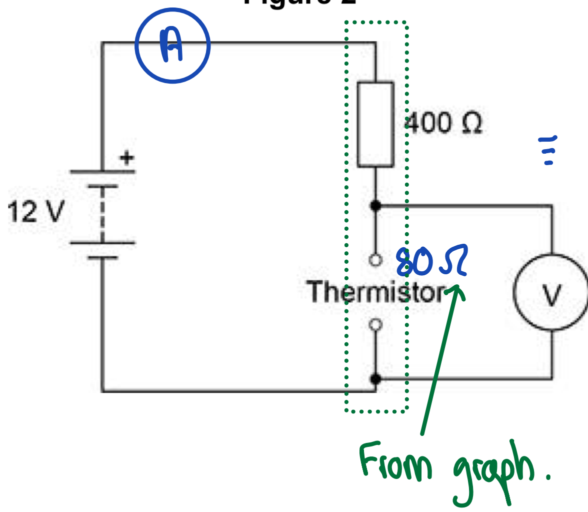
| potential difference = current × resistance | $V = I R$ |
|---|---|

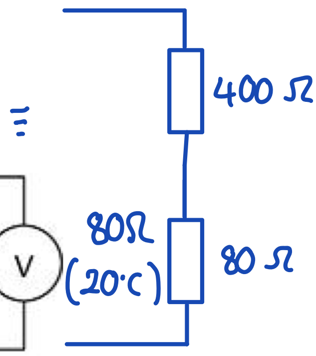
**Turn over ►**

$V = IR$

$V = 0.025\ A \times 80\ \Omega = 2.0\ V$

Figure 2

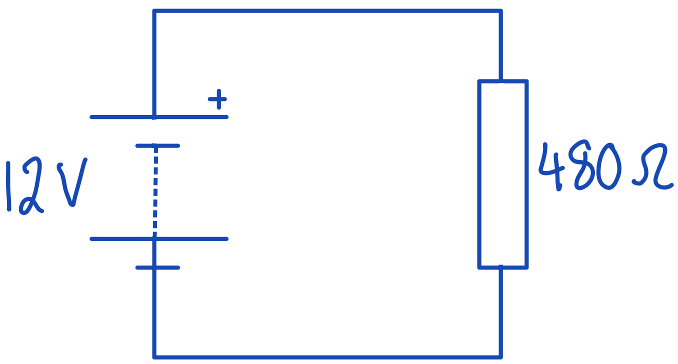



In series, so:

$R_{TOTAL} = 400 + 80 = 480$

Calculate circuit current, I :

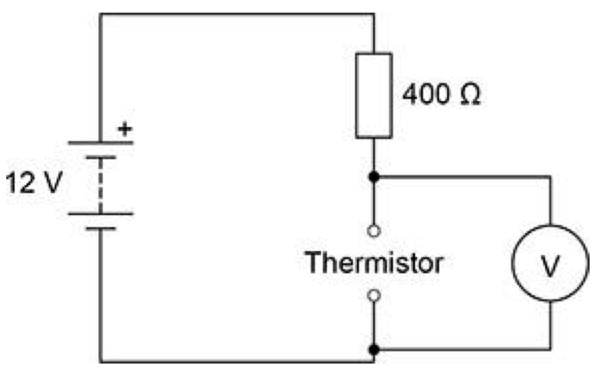


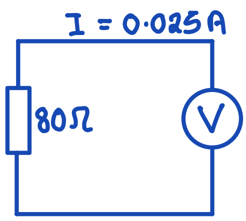

$V = IR$

$I = \frac{V}{R}$

$I = \frac{12\ V}{480\ \Omega} = 0.025\ A$

Figure 2




$V = IR$

$V = 0.025 \times 80$

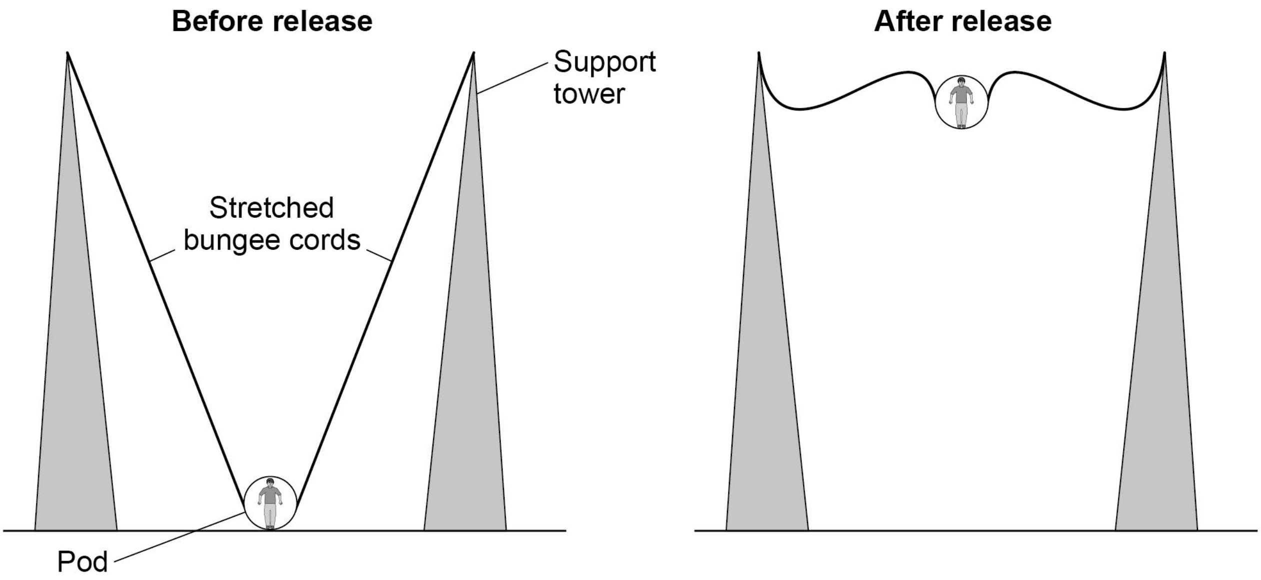
$\underline{V = 2.0 V}$

**0 6** In a ride at a theme park, a person is strapped into a pod that is attached to two stretched bungee cords.

The bungee cords behave like springs.

**Figure 10** shows a person using the ride.

**Figure 10**




**0 6 . 1** Which energy store increases as the bungee cords are stretched?

**[1 mark]**

Elastic potential energy.

*Do not write outside the box*

**0 6 . 2** When the pod is released, the pod accelerates upwards.

Before the pod is released the extension of **each** of the two bungee cords is 8.0 m.

The spring constant of each bungee cord is 735 N/m.

The mass of the pod is 240 kg.

gravitational field strength = 9.8 N/kg

Calculate the maximum height reached by the pod.

Use the Physics Equations Sheet.

**[6 marks]**

| elastic potential energy = 0.5 × spring constant × (extension)$^2$ | $E_e = \frac{1}{2} k e^2$ |
|---|---|

Energy in 1 bungee cord, $E_e = 0.5 \times 735\ N/m \times 8.0^2\ m$

$= 23\,520\ J$

There are 2 cords, so

Total Energy $= 23\,520 \times 2$

Converted to: $= 47\,040\ J$

| gravitational potential energy = mass × gravitational field strength × height | $E_p = m\,g\,h$ |
|---|---|

$47\,040 = 240\ kg \times 9.8\ N/kg \times$ height

Height $= \frac{47\,040}{240 \times 9.8} = 20\ m$

Maximum height = 20 m

**0 6 . 3** The actual maximum height reached by the pod will be lower than the correct answer to Question **06.2**

Explain why.

**[2 marks]**

Air resistance opposes the motion of the pod upwards, so not all of the elastic potential energy will be transferred to gravitational potential energy.

9

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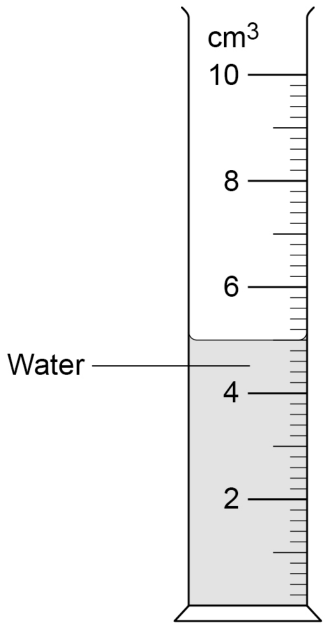
**0 7** **Figure 11** shows a measuring cylinder containing some water, which a student used to measure the volume of a metal ring.

**Figure 11**




**0 7 . 1** When measuring the volume, the student's eye was in line with the level of the water.

Which type of error would have been caused if the student's eye was **not** in line with the level of the water?

**[1 mark]**

Tick (✓) **one** box.

Random error ☑

Systematic error ☐

Zero error ☐

*Do not write outside the box*

**0 7 . 2** The student tied a piece of thick string to the metal ring and lowered the ring into the water.

Suggest **one** reason why the student should have used thin string instead of thick string.

**[1 mark]**

Thin string would affect the volume measurement less than thick string.

**Question 7 continues on the next page**

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**Table 2** shows the results.

**Table 2**

| Volume of water in $cm^3$ | Volume of water and ring in $cm^3$ | Volume of ring in $cm^3$ |
|---|---|---|
| 5.0 | 5.4 | 0.4 |

0·4   1 d.p.

**0 7 . 3** The true volume of the ring was 0.44 $cm^3$.   0·44   2 d.p.

Even without using the string, the measuring cylinder could not give an accurate value for the volume of the ring.

Give **one** reason why.

**[1 mark]**

The measuring cylinder could not be used to measure to 2 d.p.

**0 7 . 4** The student used a balance to measure the mass of the ring.

After the ring was removed from the balance, the reading on the balance was 0.02 g.

How could the student use the readings from the balance to determine the correct mass of the ring?

**[1 mark]**

0·02g is a 'zero error'

To determine the correct mass of the ring, subtract 0·02g from the measured value.

*Do not write outside the box*

**0 7 . 5** The student determined that the density of the ring was 21 500 $kg/m^3$.

The volume of the ring was 0.44 $cm^3$.

$1 m = 100 cm$

$1^2 m^2 = 100^2 cm$

$1^3 m^3 = 100^3 cm$

Calculate the mass of the ring.

Use the Physics Equations Sheet.

Give your answer in kg.

**[4 marks]**

Volume $= 0.44 \text{ cm}^3$ convert → $m^3$

$= \frac{0.44}{100^3} = 4.4 \times 10^{-7} \text{ m}^3$

$\rho = \frac{m}{V}$ $m = \rho \times V$

$m = 21\,500 \text{ kg/m}^3 \times 4.4 \times 10^{-7} \text{ m}^3$

$m = 9.46 \times 10^{-3} \text{ kg}$

Mass = $9.46 \times 10^{-3}$ kg

8

**Turn over for the next question**

| | |
|---|---|
| density = $\frac{\text{mass}}{\text{volume}}$ | $\rho = \frac{m}{V}$ |

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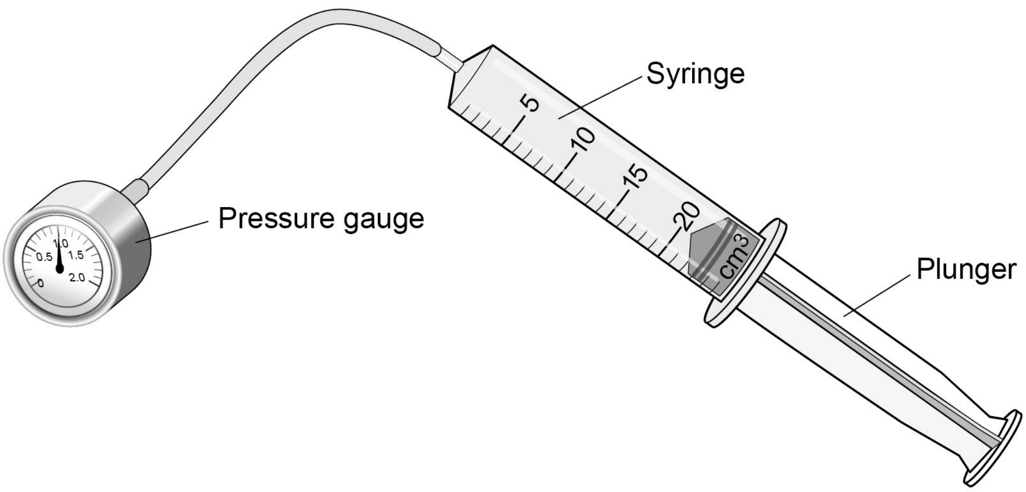
**0 8** A student investigated how the pressure in a fixed mass of air varies with the volume of the air.

**Figure 12** shows the equipment used.

**Figure 12**




**0 8 . 1** When the plunger was pushed slowly into the syringe, the pressure in the syringe increased.

The temperature of the air remained constant.

Explain why the pressure increased.

**[3 marks]**

The air particles are closer together.

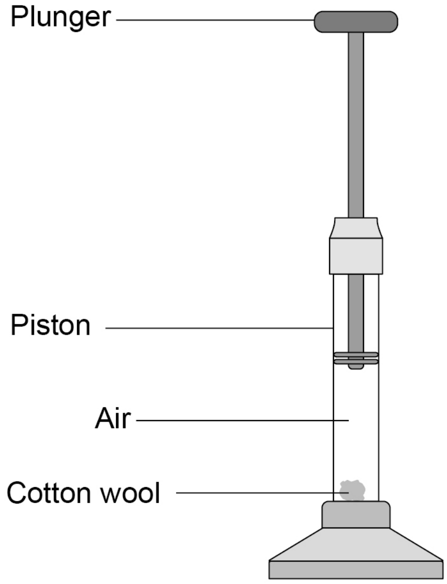
so frequency of collision between air particles and syringe walls increased.

Thus a larger total force on a smaller surface area.

A fire piston is a special type of syringe that can be used to start fires.

**Figure 13** shows a fire piston.

**Figure 13**




The plunger is pushed quickly downwards and compresses the air.

When the air is compressed quickly, the temperature of the air increases.

**0 8 . 2** How does an increase in temperature affect the air particles inside the piston?
**[1 mark]**

Tick (✓) **one** box.

| | |
|---|---|
| The mean kinetic energy of the particles increases. | ✓ |
| The mean potential energy of the particles increases. | |
| The mean separation of the particles increases. | |

decreases!

**Turn over ►**

Do not write outside the box

**0 8 . 3** When the air is hot enough, a small piece of cotton wool in the piston catches fire.

The energy transferred to the air in the piston is 0.0130 J. $\Delta E$

The mass of air in the piston is $2.60 \times 10^{-8}$ kg. $m$

specific heat capacity of air = 1.01 kJ/kg °C $c$

Calculate the temperature change of the air. $\Delta\theta$

Use the Physics Equations Sheet.

**[4 marks]**

change in thermal energy = mass × specific heat capacity × temperature change | $\Delta E = m\,c\,\Delta\theta$

$\Delta E = mc\Delta\theta$ $\quad\quad \Delta\theta = \frac{\Delta E}{mc}$

$\Delta E = 0.0130$ J $\quad = \frac{0.0130 \text{ J}}{2.60\times10^{-8} \text{ kg} \times 1.01\times10^{3} \text{ J/kg °C}}$

$m = 2.60 \times 10^{-8}$ kg

$c = 1.01$ kJ/kg °C $\quad = 495.0$ °C

$= 1.01 \times 10^{3}$ J/kg °C

Temperature change = 495 °C

8

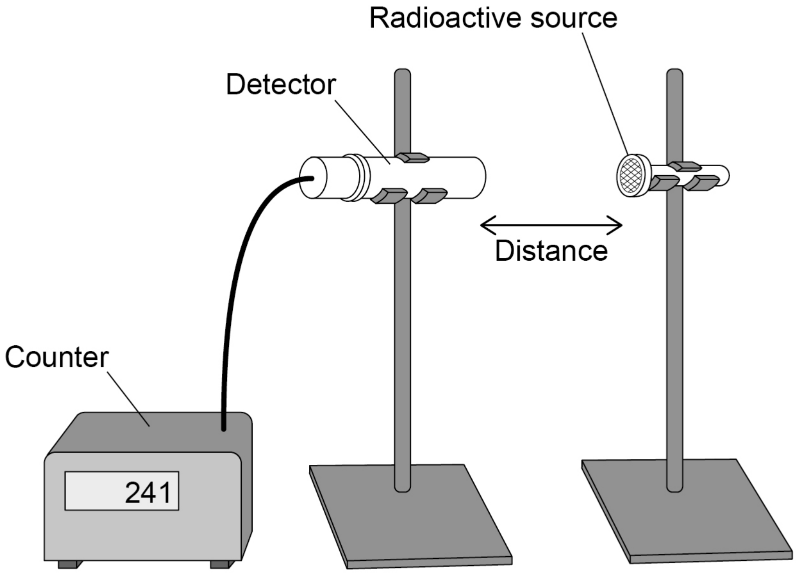
**Turn over for the next question**

**DO NOT WRITE ON THIS PAGE**
**ANSWER IN THE SPACES PROVIDED**

**0 9** A teacher investigated the radiation emitted by two different radioactive sources, **A** and **B**.

**Figure 14** shows a radiation detector positioned near one of the radioactive sources.

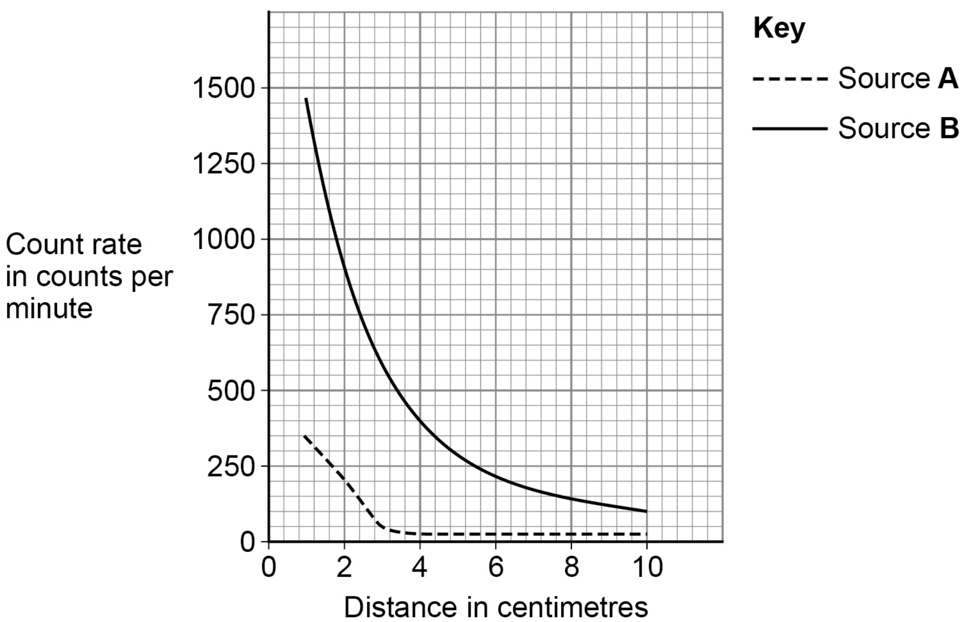
**Figure 14**




The teacher measured the count rate at different distances for each radioactive source.

**Figure 15** shows the results.

**Figure 15**



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**0 9 . 1** Explain how **Figure 15** shows that Source **A** only emits alpha radiation.

**[3 marks]**

Radiation from source A travels ~3 cm in air,

after which, the count rate decreases to background level radiation,

because alpha (α) radiation has a short range in air.

**0 9 . 2** **Figure 15** can **not** be used to determine if Source **B** emits beta radiation or gamma radiation.

Explain how an absorbing material could be used to show which type of radiation is emitted by Source **B**.

**[2 marks]**

Use an aluminium sheet,

which beta (β) radiation will not penetrate but gamma (γ) will.

**Question 9 continues on the next page**

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The teacher took safety precautions during the experiment.

**0 9 . 3** Suggest **one** safety precaution the teacher would have taken to reduce the radiation dose the teacher received.

**[1 mark]**

Increase distance between source and teacher.
(limit exposure time)

**0 9 . 4** Suggest **one** safety precaution that the teacher would have taken to avoid becoming contaminated.

**[1 mark]**

Wear gloves / lab coat.

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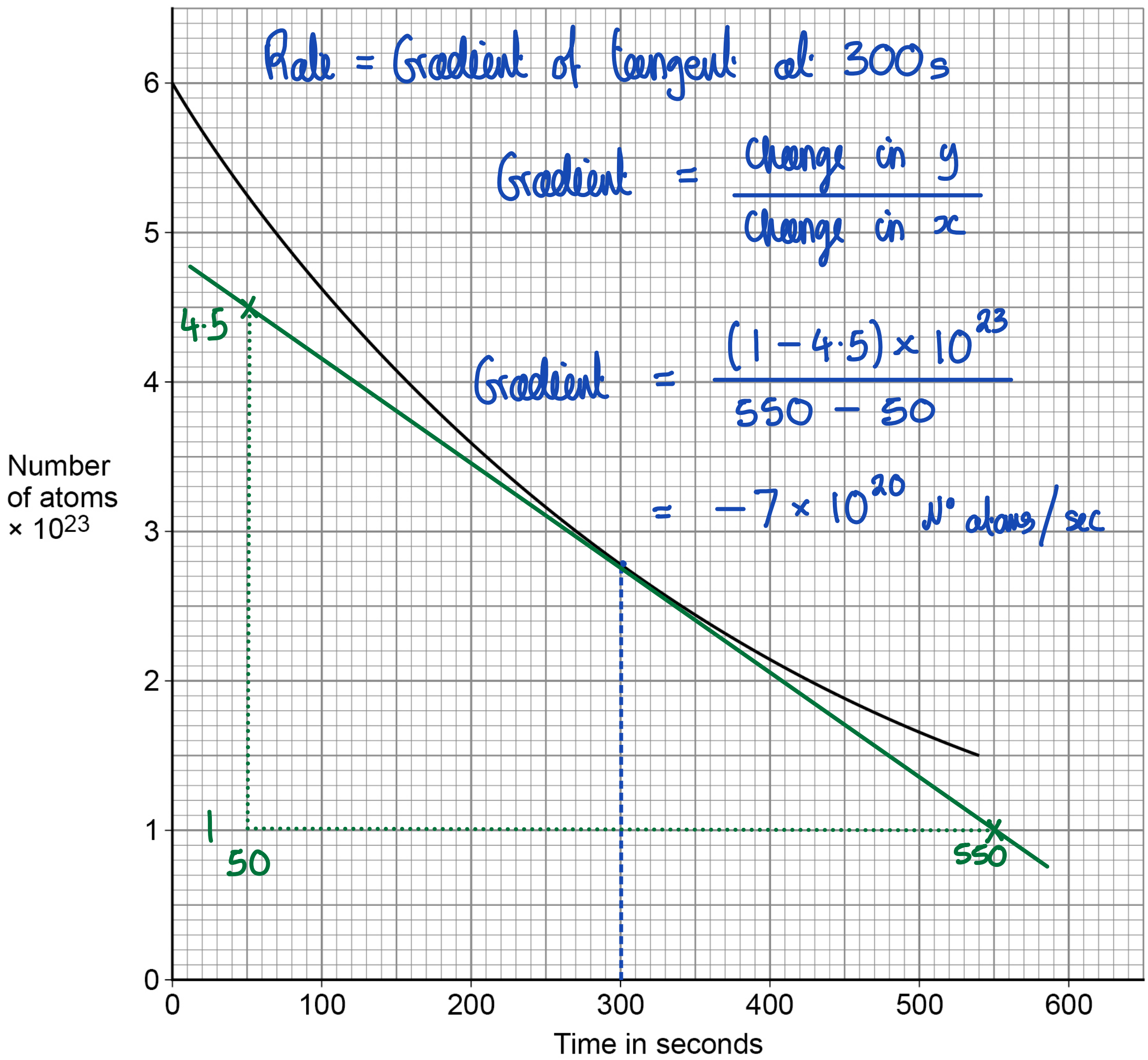
**0 9 . 5** **Figure 16** shows how the number of atoms of a radioactive element in a sample varied with time.

**Figure 16**




Activity is the rate at which a source of unstable nuclei decays.

Determine the activity of the radioactive sample at 300 seconds.

Give the unit.

**[4 marks]**

Rate = Gradient = $-7\times10^{20}$ atoms per second.

Activity = $7\times10^{20}$ Becquerel (Bq)

Activity = $7\times10^{20}$ Unit Bq

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Activity measured in: decays per second or Becquerel (Bq)

N.B. Even though the gradient slopes down and is negative, the rate at which the nuclei are decaying is positive.

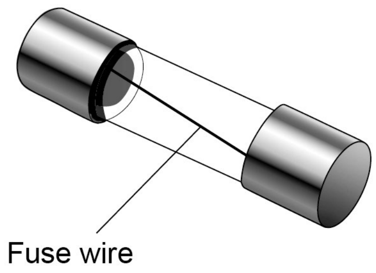
**Turn over ►**

**1 0** The live wire in a three-core cable is connected to a fuse inside a plug.

A fuse contains a wire that is designed to melt when the current gets too great.

**Figure 17** shows a fuse.

**Figure 17**




Live – Brown
Neutral - Blue
Earth · Green / Yellow

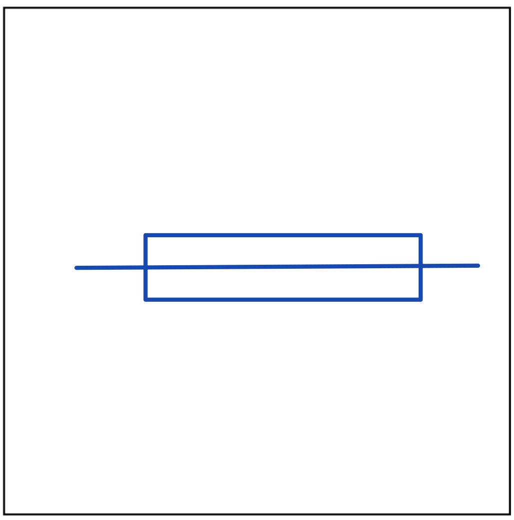
**1 0 . 1** What colour is the insulation covering the live wire in a three-core cable?

**[1 mark]**

Brown

**1 0 . 2** Draw the circuit symbol for a fuse in the box below.

**[1 mark]**



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**1 0 . 3** The fuse wire melts when there is a charge flow of 2.0 C for 400 ms.

Calculate the current in the fuse wire.

Use the Physics Equations Sheet.

**[4 marks]**

| | |
|---|---|
| charge flow = current × time | $Q = I\,t$ |

$Q = 2.0\ C$

$t = 400\ ms = 400 \times 10^{-3}\ s = 0.4 s$

$I = ?$

$Q = It$

$I = \frac{Q}{t}$ $I = \frac{2.0\ C}{0.4\ s} = 5\ A$

Current = 5 A

**1 0 . 4** When the fuse wire is at its melting point, the additional energy needed to melt the wire is 1.02 J. E

specific latent heat of fuse wire = 60 kJ/kg L

Calculate the mass of the fuse wire. m

Use the Physics Equations Sheet.

**[4 marks]**

| | |
|---|---|
| thermal energy for a change of state = mass × specific latent heat | $E = m\,L$ |

$E = 1.02\ J$

$L = 60\ kJ/kg = 60 \times 10^{3}\ J/kg$

$m = ?$

$E = mL$ $m = \frac{E}{L} = \frac{1.02\ J}{60 \times 10^{3}\ J/kg} = 1.7 \times 10^{-5}\ kg$

Mass = $1.7 \times 10^{-5}$ kg

**Question 10 continues on the next page**

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**10.5** The calculation in Question **10.4** assumes there is no energy transferred to the surroundings.

How would the time taken for the wire to melt be affected if some energy was transferred to the surroundings?

Give a reason for your answer.

**[2 marks]**

Tick (✓) **one** box.

| | |
|---|---|
| Time taken would decrease | ☐ |
| Time taken would stay the same | ☐ |
| Time taken would increase | ✓ |

Reason More energy would need to be transferred in total.

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**END OF QUESTIONS**

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**ANSWER IN THE SPACES PROVIDED**

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