OCR
Oxford Cambridge and RSA

Friday 16 June 2023 – Morning

GCSE (9–1) Physics B (Twenty First Century Science)

J259/04 Depth in physics (Higher Tier)

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (cm/mm)
- the Equation Sheet for GCSE (9–1) Physics B (inside this document)

You can use:
- a scientific or graphical calculator
- an HB pencil

H

Please write clearly in black ink. **Do not write in the barcodes.**

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

First name(s) _____

Last name _____

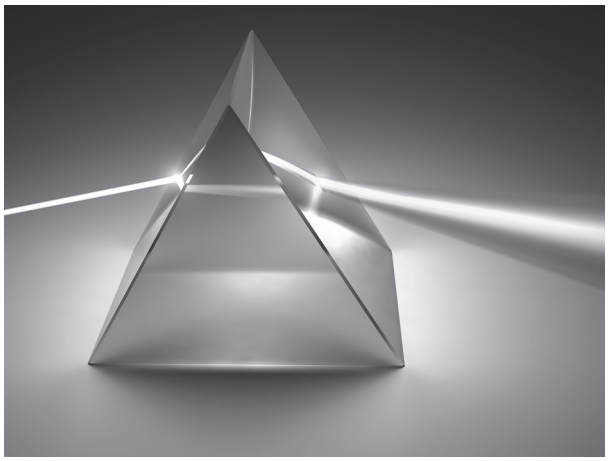
INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **20** pages.

ADVICE
- Read each question carefully before you start your answer.

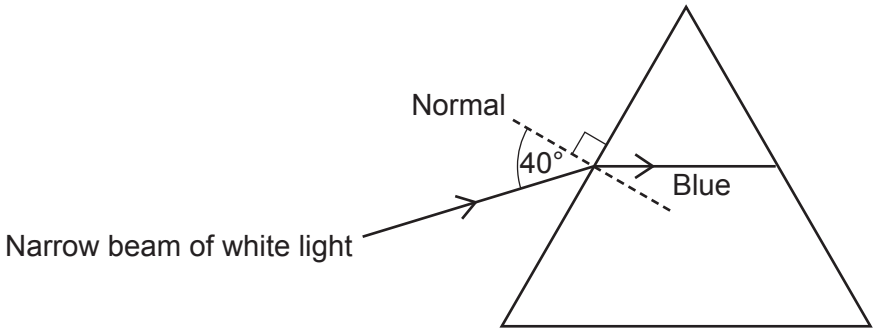
1 A student investigates the path of light passing through a triangular glass prism.

A narrow beam of white light is directed at the prism with an angle of incidence equal to 40°. The student observes a spectrum of different coloured light.



The two-dimensional diagram shows a narrow beam of white light directed at the side of a prism.

A line showing the path of a ray of blue light passing through the prism is partially drawn.



(a) Complete the line to show the path of blue light as it passes out the other side. **[1]**

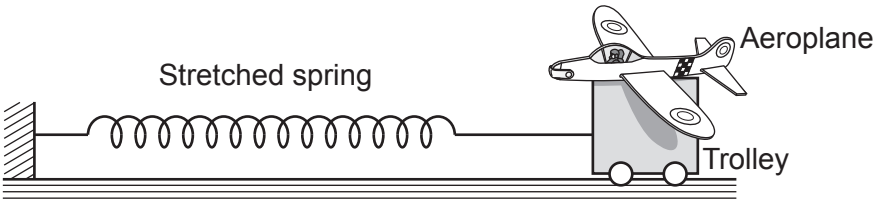
(b) Estimate the size of the angle of refraction of the ray of blue light as it enters the prism.

Angle of refraction = ...° **[1]**

(c) Add another line to the diagram to show the path of a ray of red light as it passes through the prism and out the other side. **[2]**

2 Jamal is making a model aeroplane that can be launched from a moving trolley.

One end of a spring is connected to the trolley. The other end of the spring is held stationary.



The aeroplane is placed on the trolley. Jamal pulls the trolley and the aeroplane to the right so that the spring stretches. When Jamal lets go, the trolley and the aeroplane accelerate to the left.

(a) Explain how Jamal can make the trolley and aeroplane accelerate more quickly using the same apparatus.

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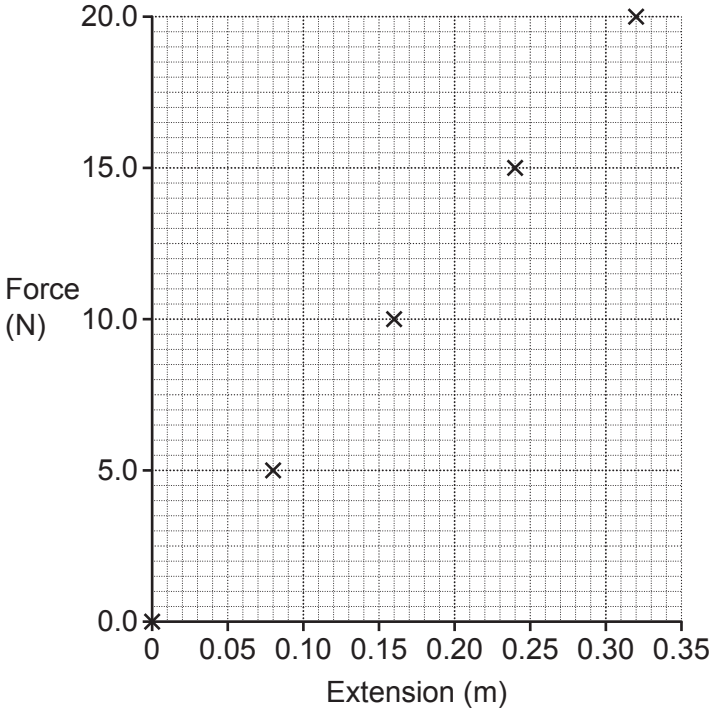
..... **[3]**

(b) Jamal investigates the relationship between force and extension for the spring. The results of the investigation are shown in the table and the graph.

Force (N)	Extension (m)
0.0	0
5.0	0.08
10.0	0.16
15.0	0.24
20.0	0.32



(i)* Describe how Jamal gets these results safely **and** how he uses the results to calculate the work done in stretching the spring.

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..... **[6]**

(ii) The kinetic energy of the trolley must be at least 1 J for the aeroplane to launch from the trolley.

Jamal concludes that the aeroplane can launch from the trolley when the spring has an extension of 0.16 m.

Use the graph to explain why Jamal's conclusion is **wrong**.

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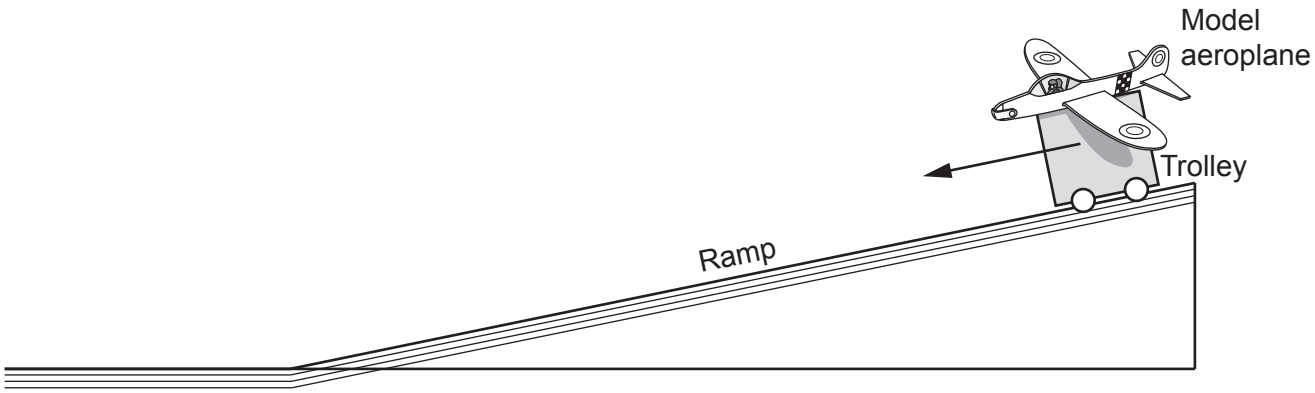
(c) Jamal investigates using a ramp instead of a spring to launch the aeroplane.



Jamal releases the trolley and the trolley accelerates down the ramp. The aeroplane is launched when the trolley reaches the bottom of the ramp.

Describe how Jamal can accurately measure the speed of the trolley at the bottom of the ramp.

You should include the equipment Jamal uses.

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..... **[3]**

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3 A ball is placed in a dark room. White light from a lamp is shone on the ball. The ball appears yellow.

(a) A green filter is placed between the lamp and the ball.

Explain why the ball appears green.

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..... **[2]**

(b) Which **two** statements are correct about green light?

Tick (✓) **two** boxes.

It has a shorter wavelength than red light	☐
It travels faster than yellow light in a vacuum	☐
It is a longitudinal wave	☐
It has a higher frequency than blue light	☐
It has a lower energy than violet light.	☐

[2]

(c) The ball is placed inside a bell jar and the air is removed.

Explain why the ball can still be seen when there is no air in the jar.

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..... **[2]**

4 Two radioactive isotopes of actinium are actinium-225 ($^{225}_{89}Ac$) and actinium-227 ($^{227}_{89}Ac$).

(a) Compare the structures of the nuclei of actinium-225 and actinium-227.

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..... **[2]**

(b) Actinium-225 ($^{225}_{89}Ac$) decays to francium-221
Actinium-227 ($^{227}_{89}Ac$) decays to thorium-227

(i) State why a nucleus might decay.

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..... **[1]**

(ii) Name the electromagnetic radiation that is emitted in both cases.

..... **[1]**

(iii) Name one **other** ionising radiation emitted in each case.

Actinium-225: .....

Actinium-227: .....

[2]

5 The table shows some data for the thinking distance, braking distance and stopping distance of a car travelling at different speeds.

Speed (miles per hour)	Thinking distance (m)	Braking distance (m)	Stopping distance (m)
30		14	
40	12	24	36
50	15	38	53
60	18		
70	21	75	96

(a) When the speed doubles, the thinking distance doubles, and the braking distance quadruples.

Use this information to complete the table. **[2]**

(b) A student concludes that the stopping distance must be at least triple when the speed doubles.

Use data from the table to explain why the student is correct.

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..... **[1]**

(c) Convert 40 miles per hour to m/s.

1 mile = 1609 m.

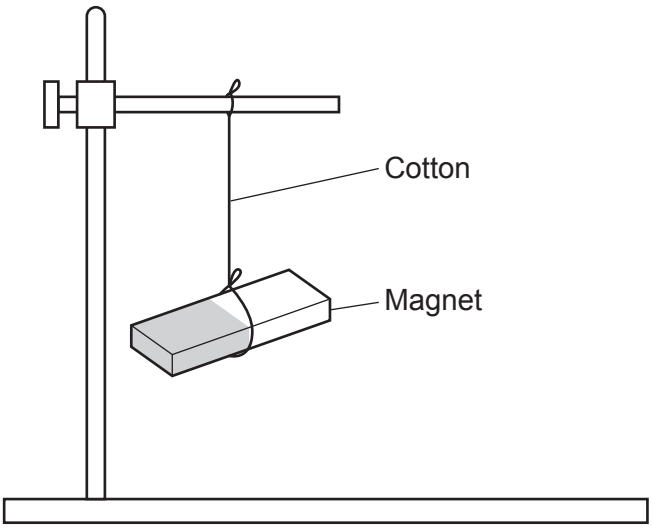
40 miles per hour = ... m/s **[2]**

(d) Estimate the typical speed of a cyclist in m/s.

..... m/s **[1]**

6 Sara is investigating magnetism. She suspends a small bar magnet from a length of cotton as shown in **Fig. 6.1**.

Fig. 6.1



(a) The magnet hangs horizontally and can rotate freely.

Explain why the magnet will always come to rest lying in the same direction.

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(b) Sara has a second magnet with the north and south poles labelled. She brings it up close to the suspended magnet in **Fig. 6.1**.

Explain how she can identify the poles of the suspended magnet.

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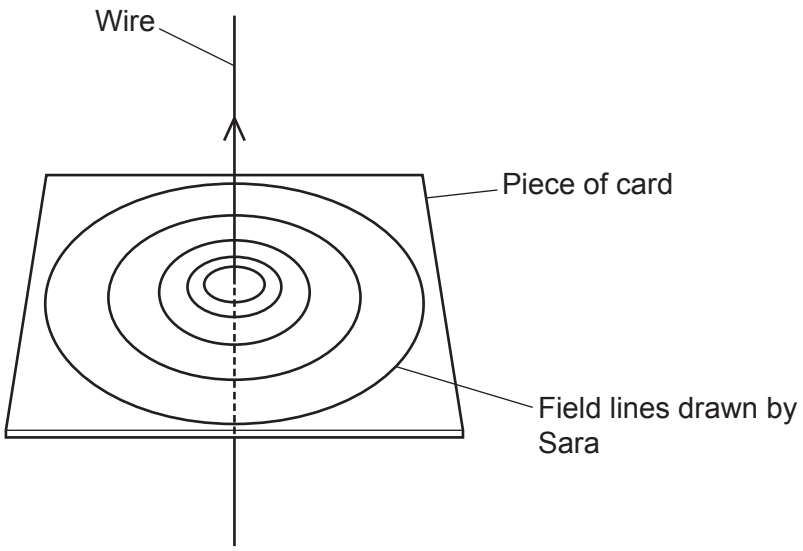
..... **[2]**

(c) Sara investigates the magnetic field around a wire which has a current passing through it.

She puts the wire through a horizontal piece of card. From her investigation she draws field lines to show the pattern of the magnetic field around the wire as shown in **Fig. 6.2**.

Fig. 6.2



(i) Suggest a method Sara uses to observe the pattern of the magnetic field.

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(ii) Draw an arrow on **Fig. 6.2** to show the direction of the magnetic field. **[1]**

(iii) Describe how the field lines in **Fig. 6.2** show that the strength of the magnetic field decreases as the distance from the wire increases.

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(iv) Sara increases the size of the current in the wire.

Explain how the pattern of the field lines changes.

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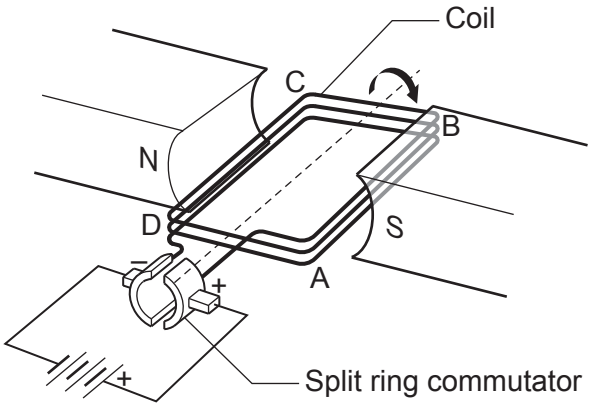
..... **[2]**

(d) Sara makes an electric motor using a length of wire and a magnet with a magnetic flux density of 20 mT.

She winds the wire into a coil and connects the ends of the wire to a split ring commutator. She places the coil between the poles of the magnet.



The current in the wire is 1.5 A.

When the coil is horizontal, a magnetic force of 0.3 N acts on each side of the coil labelled AB and CD.

Calculate the total length of wire that needs to be on side CD of the coil.

Use the Equation Sheet.

Length = ... m **[4]**

(e) **(i)** Describe how Sara can use the motor as a generator.

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..... **[1]**

(ii) Sara replaces the split ring commutator with slip rings.

Describe how the output of the generator changes.

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..... **[1]**

7* Uranium (U) and hydrogen (H) can be used to release energy in a nuclear reaction.

Typical nuclear equations for each are:

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{89}_{36}Kr + {}^{144}_{56}Ba + 3\,{}^{1}_{0}n$$

$$^{3}_{1}H + {}^{2}_{1}H \longrightarrow {}^{4}_{2}He + {}^{1}_{0}n$$

Compare and contrast these **two** processes, explaining how energy is released in both cases.

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..... **[6]**

8 A metal disc has a weight of 4.0 N. The disc is suspended from a spring and the extension of the spring is measured. The measurement is made three times.

The results are shown in the table.

Reading	Extension (m)
1	0.050
2	0.050
3	0.040

(a) Calculate the spring constant of the spring.

Give your answer to **2** significant figures.

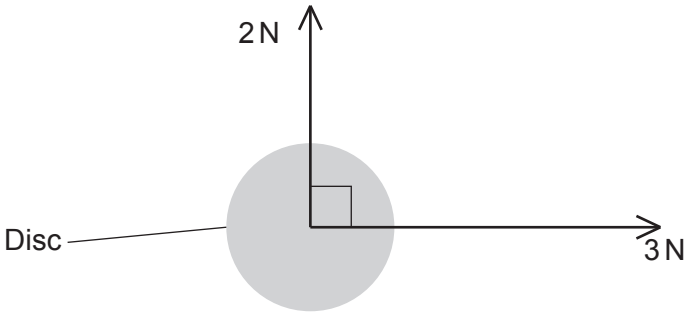
Use the Equation Sheet.

Spring constant = ... N / m **[5]**

(b) The disc is placed flat on a smooth surface. Two perpendicular forces, 2 N and 3 N, are applied to the disc parallel to the surface, as shown in **Fig. 8.1** when viewed from above.

Fig. 8.1 is **not** to scale.

Fig. 8.1



Draw a scale diagram to find the size of the resultant force on the disc.

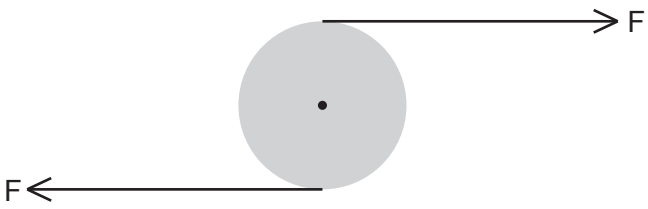
Use the scale 1 N = 2 cm

Resultant force = ... N **[3]**

(c) The centre of the disc is pinned to the surface. The disc can rotate but its position on the surface cannot change.

Two forces are applied to the disc as shown in **Fig. 8.2**.

Fig. 8.2



Explain how these two forces cause the disc to rotate about its centre.

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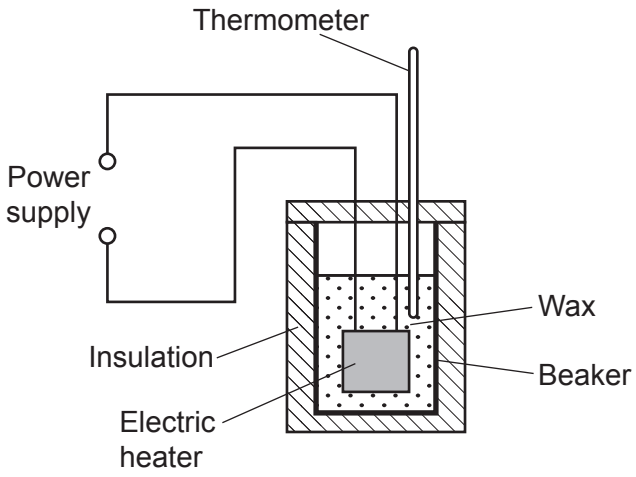
..... **[2]**

9 Li makes wax candles.

(a) Li needs to calculate the specific heat capacity of the wax.

This is the apparatus used:



(i) Name **two** other pieces of equipment that are needed so Li can calculate the specific heat capacity, **and** describe what each piece of equipment is used for.

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2. .....

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[4]

(ii) Explain how the calculated value for the specific heat capacity would be different if the beaker was **not** insulated.

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(iii) Explain why it is important that Li does **not** exceed the melting point of the wax.

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..... **[2]**

(iv) In a different investigation Li connects a 12 V d.c. power supply to a heater. 0.02 kg of wax is heated.

The temperature of the wax increases by 18 °C in 120 s.

Calculate the current in the heater.

The specific heat capacity of the wax is 2890 J / kg °C.

Use these equations:

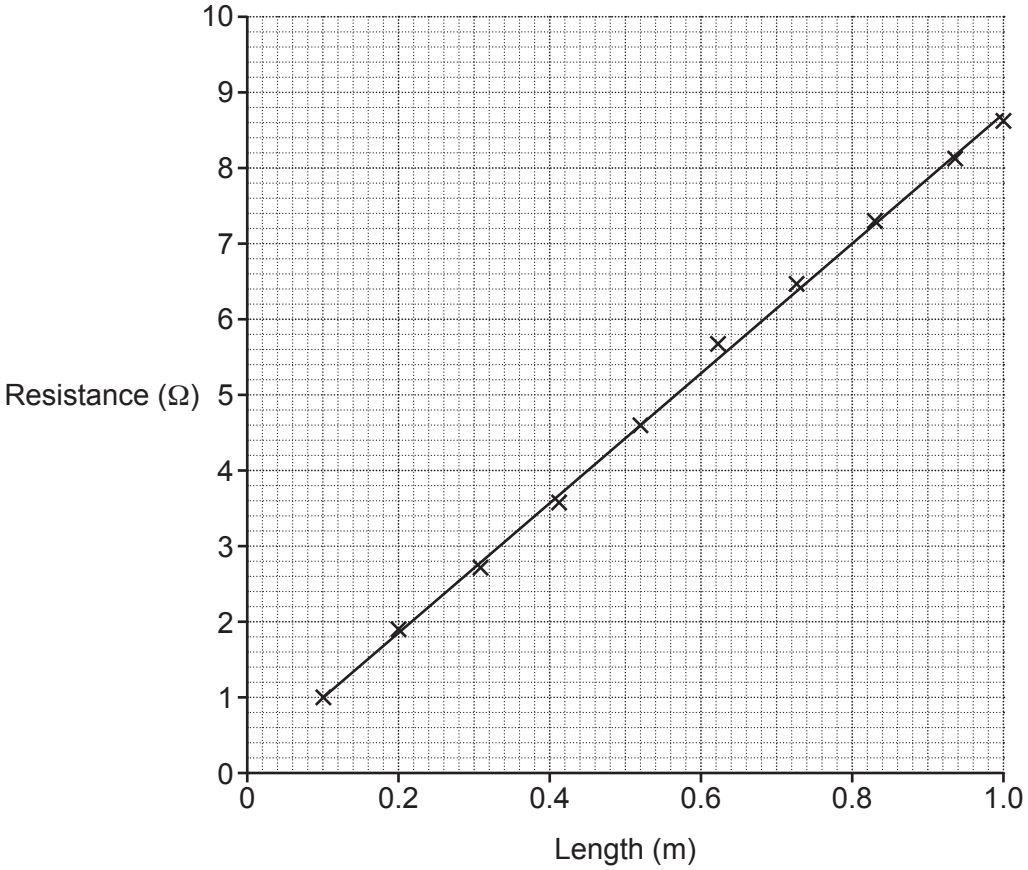
- change in internal energy = mass × specific heat capacity × change in temperature
- power = energy ÷ time
- power = potential difference × current

Current = ... A **[4]**

(b) Li designs an electric heater using nichrome wire.

Li connects the wire in a circuit with a power supply, an ammeter and a voltmeter. He makes measurements and calculates the resistance of different lengths of the wire.

He produces a graph as shown.



(i) Describe how Li calculates the resistance of different lengths of the wire.

Your answer should include a circuit diagram.

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..... **[3]**

(ii) Suggest why Li switches off the power supply between each measurement.

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..... **[2]**

(iii) Li uses a length of the nichrome wire as a heater connected to a different power supply.

This heater supplies a power of 20 W when the current is 2.5 A.

Calculate the length of the wire.

Use the Equation Sheet and the graph.

Length = ... m **[4]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).