Please write clearly in block capitals.

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

Surname ________________________________

Forename(s) ________________________________

Candidate signature ________________________________
I declare this is my own work.

AS
PHYSICS

Paper 1

Time allowed: 1 hour 30 minutes

Materials
For this paper you must have:
- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet
- 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 page or on blank pages.
- 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.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	

Do not write outside the box

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

0 1 A sigma-plus (Σ^+) particle and an unidentified particle **Y** are produced by the strong interaction between a positive pion (π^+) and a proton (p).

This interaction is represented by the equation:

$$\pi^+ + p \rightarrow \Sigma^+ + \mathbf{Y}$$

0 1 . 1 Complete **Table 1** to show the baryon number B, charge Q and strangeness S for the particles in this interaction.

[2 marks]

Table 1

	π^+	p	Σ^+	Y
B				0
Q	+1	+1	+1	
S				+1

0 1 . 2 Which particle in **Table 1** has the quark structure uus?

Tick (✓) **one** box.

[1 mark]

π^+ ☐

p ☐

Σ^+ ☐

Y ☐

Do not write outside the box

0 1 . 3 Deduce which particle, π^+ or **Y**, has the greater charge-to-mass ratio.
Justify your conclusion.

[3 marks]

6

Turn over for the next question

0 2 A sample of bromine gas contains a mixture of two isotopes. An experiment is done to find the percentage of each isotope in this sample.

0 2 . 1 In the experiment, the gas is ionised by a beam of electrons.

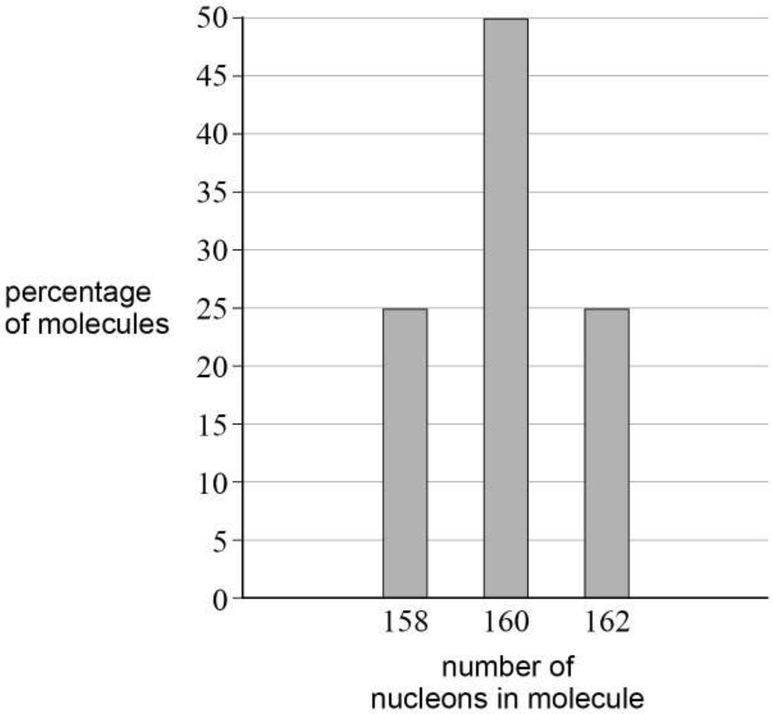
Explain how the beam of electrons causes a particle of the gas to have a charge of $+1e$.

[2 marks]

The gas consists of bromine molecules. Each molecule has two bromine atoms. The experiment finds that the bromine molecules contain 158, 160 or 162 nucleons.

Figure 1 shows the percentage of these different molecules in the sample.

Figure 1



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0 2 . 2 Bromine has a proton number of 35
The two isotopes in the sample have different nucleon numbers.

Calculate the number of neutrons for the isotope that has the greater nucleon number.
[2 marks]

number of neutrons = ____________________

0 2 . 3 Deduce the percentage of each isotope in the gas.
Justify your conclusion.
[2 marks]

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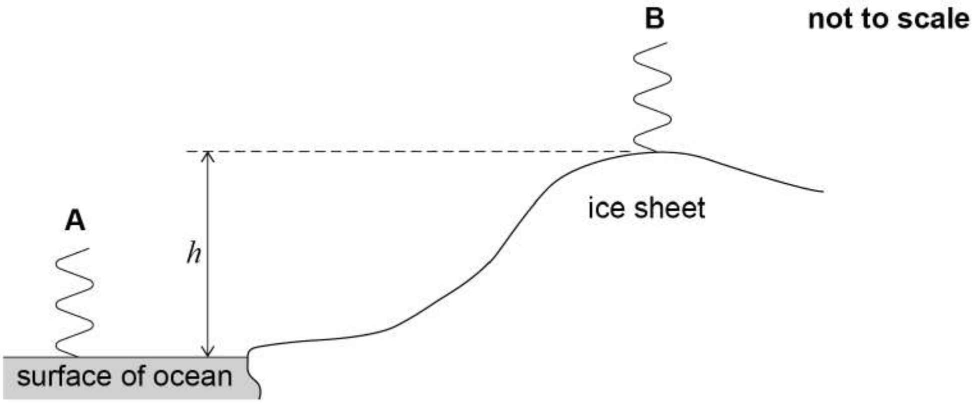
____

6

Turn over for the next question

0 3 A satellite system is used to measure the height h of the top of an ice sheet above the surface of the ocean.
The satellite emits two pulses **A** and **B** of infrared radiation. **A** is incident on the surface of the ocean and **B** is incident on the top of the ice sheet as shown in **Figure 2**.

Figure 2



0 3 . 1 The frequency of the infrared radiation is 3.8×10^{14} Hz.
Each pulse has a duration of 6.0 ns.

Calculate the number of cycles in each pulse.

[2 marks]

number of cycles = ____________________

0 3 . 2 **A** and **B** reflect and return to the satellite. The travel time is the time between the emission of a pulse and its return to the satellite.

The difference in the travel times of **A** and **B** is 10.7 μs.

Calculate h.

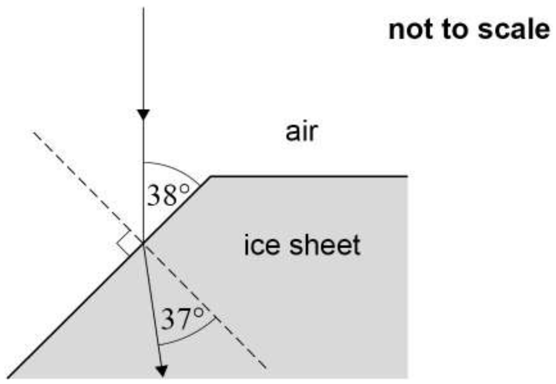
[2 marks]

h = ____________________ m

Some of the infrared radiation enters the ice sheet.

Figure 3 shows the path of infrared radiation that refracts at a sloping part of the ice sheet.

Figure 3



0 3 . 3 Calculate the refractive index of the ice.

[2 marks]

refractive index = ____________________

0 3 . 4 Calculate the wavelength of the infrared radiation when it is inside the ice sheet.

[2 marks]

wavelength = ____________________ m

8

Turn over ►

Do not write outside the box

0 4 An isolated metal plate is given a negative charge. Electromagnetic radiation is incident on the plate. The plate loses its charge due to the photoelectric effect.

0 4 . 1 Discuss how the rate of loss of charge from the plate depends on the frequency and intensity of the incident radiation.

In your answer you should explain why:

- the plate loses its charge
- the photoelectric effect occurs only for frequencies greater than a particular value
- the rate of loss of charge increases with intensity for radiation above that particular value of frequency.

[6 marks]

Do not write outside the box

0 4 . 2 Charged particles are emitted from the metal plate with a maximum kinetic energy of $1.1\ \mathrm{eV}$ when radiation of frequency $1.2 \times 10^{15}\ \mathrm{Hz}$ is incident on the plate.

Calculate, in eV, the work function of the metal.

[3 marks]

work function = ____________________ eV

9

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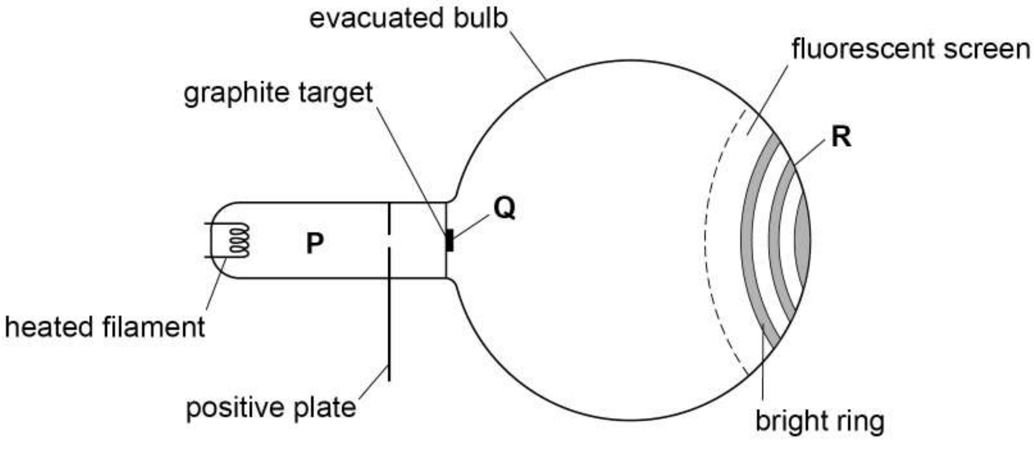
0 5 **Figure 4** shows apparatus used to demonstrate the wave–particle duality of electrons.

Figure 4



The heated filament emits slow-moving electrons.

In region **P**, the electrons are accelerated to a high speed.
At **Q**, the fast-moving electrons are incident on the graphite target.
R is a point on one of the bright rings that are formed where the electrons strike the fluorescent screen.

0 5 . 1 The electrons demonstrate wave-like and particle-like behaviour as they travel from the filament to the screen.

State and explain at which of **P**, **Q** or **R** the electrons are demonstrating wave-like behaviour.

[2 marks]

____

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Do not write outside the box

0 5 . 2 The apparatus is adjusted so that the electrons are incident on the graphite target with a greater speed.

Explain why the bright rings formed on the screen now have a smaller diameter.

[3 marks]

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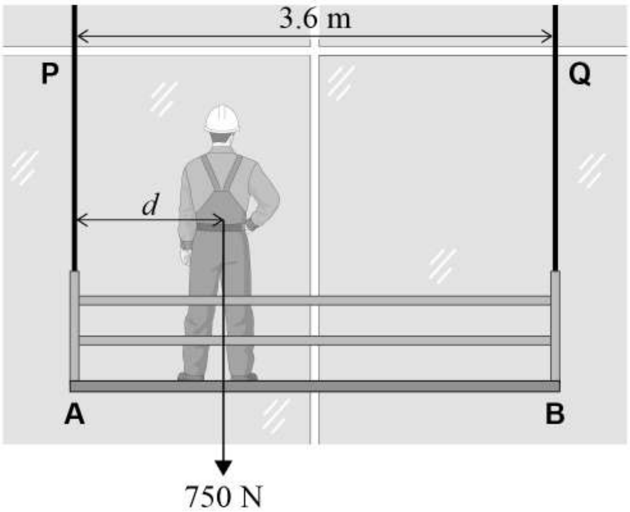
5

Turn over for the next question

0 6 **Figure 5** shows a worker of weight $750\ \mathrm{N}$ on a uniform platform. The weight of the worker is acting at a horizontal distance d from end **A**.

Throughout this question, assume that the platform is horizontal and that all cables obey Hooke's law.

Figure 5



The platform weighs $1800\ \mathrm{N}$ and is suspended by vertical cables **P** and **Q**.
Each cable has an unstretched length of $3.0\ \mathrm{m}$.
The horizontal distance between **P** and **Q** is $3.6\ \mathrm{m}$.

0 6 . 1 The worker moves to a position where the tension in the left-hand cable **P** is $1150\ \mathrm{N}$.

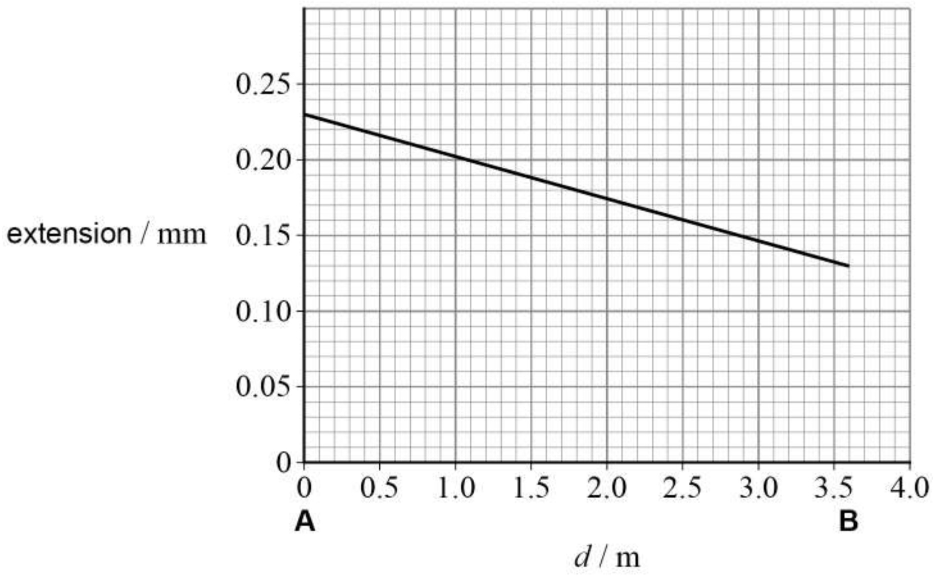
Calculate d for this position.

[3 marks]

$d =$ ____________________ m

Figure 6 shows how the extension of **P** varies with d as the worker walks slowly along the platform from **A** to **B**.

Figure 6



The worker moves to a position **X** where the strain in **P** is 6.0×10^{-5}.

0 6 . 2 Determine d for position **X**.

[2 marks]

d = ____________________ m

0 6 . 3 The cable material has a Young modulus of 1.9×10^{11} N m^{-2}.

Calculate the tensile stress in **P** when the worker is at **X**.

[1 mark]

tensile stress = ____________________ N m^{-2}

Question 6 continues on the next page

Turn over ►

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0 6 . 4 The original cables **P** and **Q** are replaced.

Table 2 shows how the properties of the original cables compare with the replacement cables.

Table 2

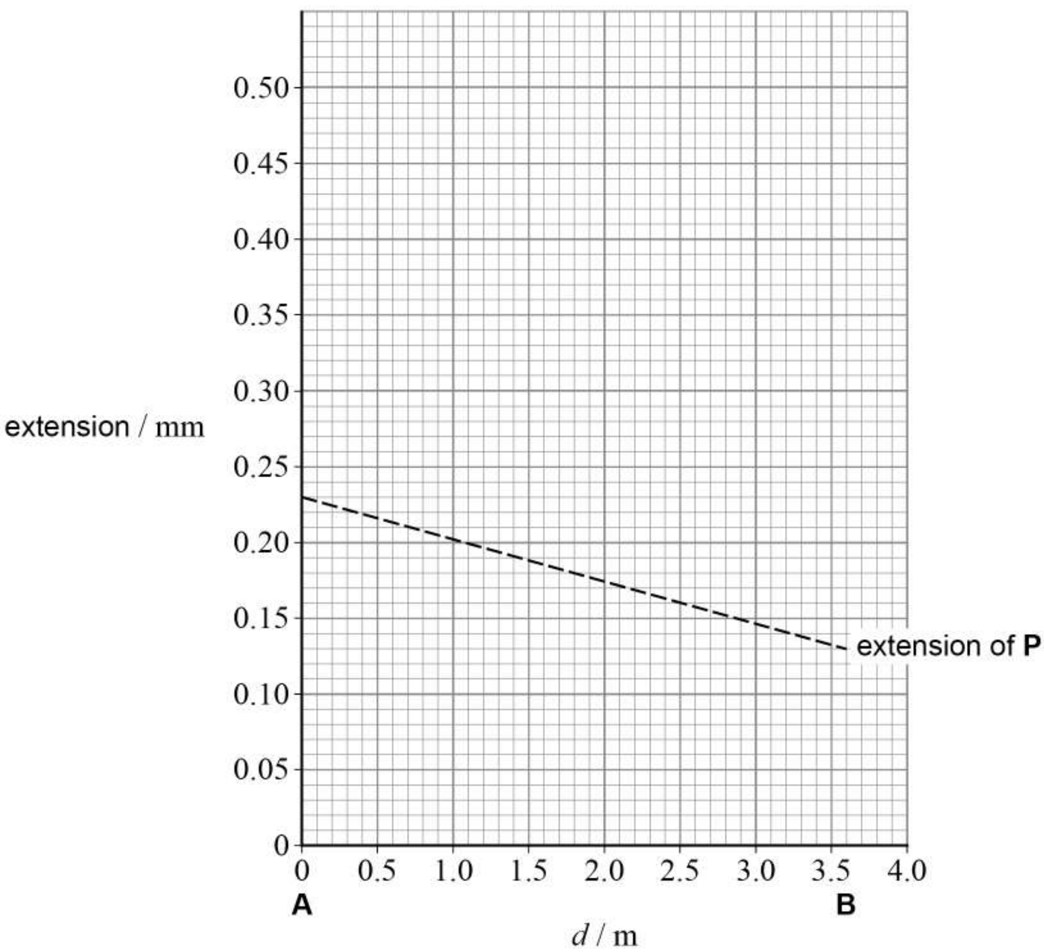
	Unstretched length	**Radius**	**Young modulus of cable material**
Original cables	L	r	E
Replacement cables	L	$\frac{r}{2}$	$2E$

After the cables have been replaced, the worker walks slowly from **A** to **B**.

Draw on **Figure 7** a line to show the variation of the extension of the replacement left-hand cable with d.
The original line from **Figure 6** is shown on **Figure 7** as a dashed line to help you.

[3 marks]

Figure 7

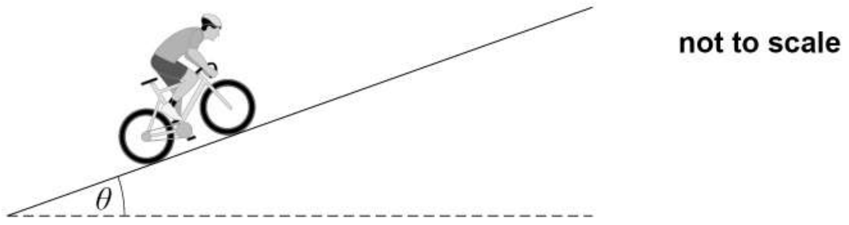


9

Turn over for the next question

0 7 . 1 **Figure 8** shows a cyclist going up a hill.

Figure 8



The angle θ of the slope of the hill is constant.
The total mass m of the cyclist and bicycle is $65\ \text{kg}$.

Write an expression for the component of the total weight parallel to the slope.

[1 mark]

____

0 7 . 2 The useful power output of the cyclist is $310\ \text{W}$.
The cyclist has a steady speed of $1.63\ \text{m s}^{-1}$.

Assume that air resistance is negligible at this speed.

Calculate θ.

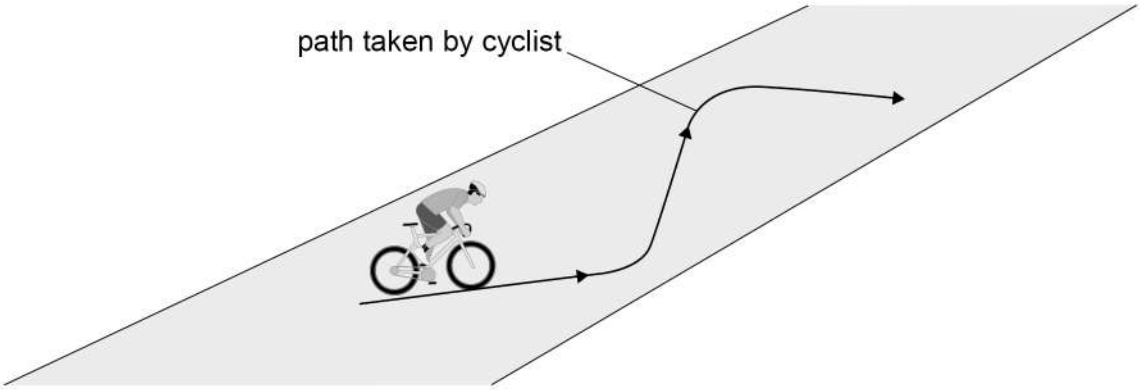
[2 marks]

$\theta =$ ______________________ °

Do not write outside the box

Figure 9 shows an alternative 'zig-zag' path taken by the cyclist up the same hill. She maintains a steady speed of 1.63 m s^{-1}.

Figure 9



0 7 . 3 Discuss how her useful power output when taking the path in **Figure 9** compares with her useful power output in Question **07.2**.

[3 marks]

Question 7 continues on the next page

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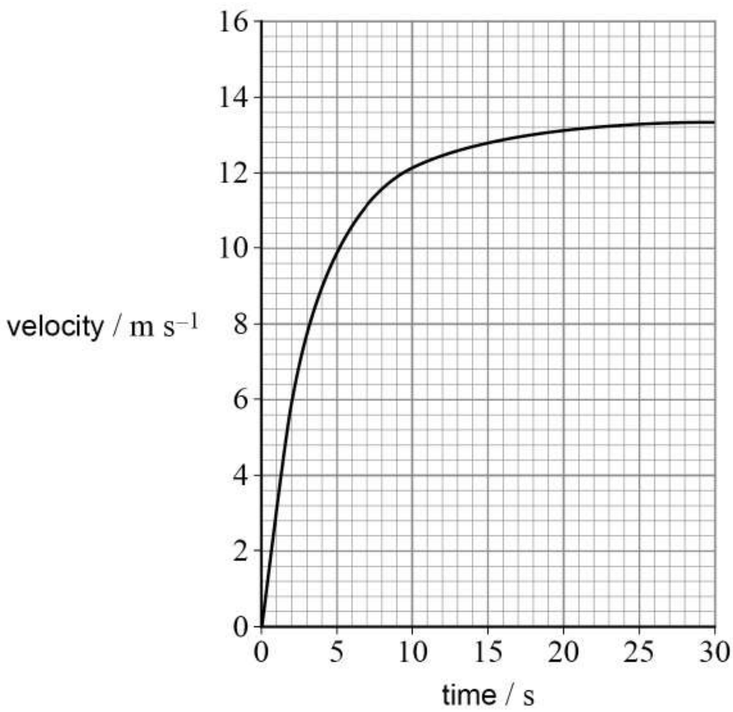
The cyclist reaches the top of the hill. She then travels back down the hill in a straight line. The bicycle rolls freely without the cyclist pushing the pedals or applying the brakes.

Figure 10 shows the variation of her velocity with time as she goes down the hill.

Figure 10



0 7 . 4 Determine the acceleration of the cyclist 10.0 s after she begins to go down the hill.

[3 marks]

acceleration = ____________________ m s^{-2}

Do not write outside the box

0 7 . 5 Energy transfers occur as the cyclist travels down the hill.

Outline how these energy transfers explain the shape of the graph in **Figure 10**.

[4 marks]

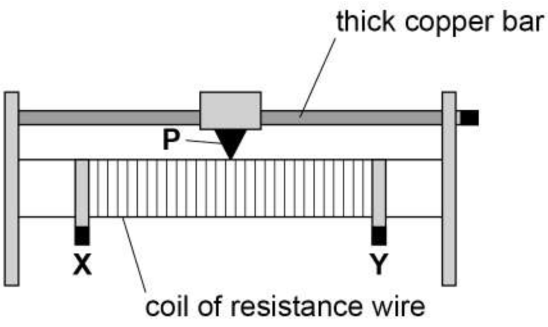
13

Turn over for the next question

Do not write outside the box

0 8 **Figure 11** shows a variable resistor that has a maximum resistance of $25\ \Omega$.
A sliding contact **P** is mounted on a thick copper bar. **P** can be set to any position between **X** and **Y**.

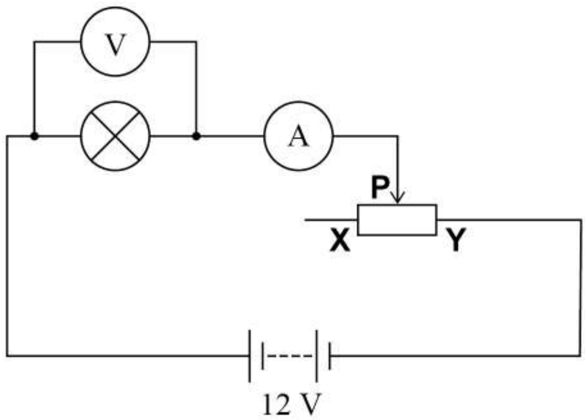
Figure 11



0 8 . 1 **Figure 12** shows the variable resistor being used to investigate the variation of current with voltage for a filament lamp.
The normal operating voltage of the lamp is $12\ V$.

The $12\ V$ battery has negligible internal resistance.

Figure 12



The position of **P** is adjusted so that the reading on the voltmeter is at its minimum value of $0.75\ V$.

Calculate the resistance of the lamp when the voltmeter reading is $0.75\ V$.

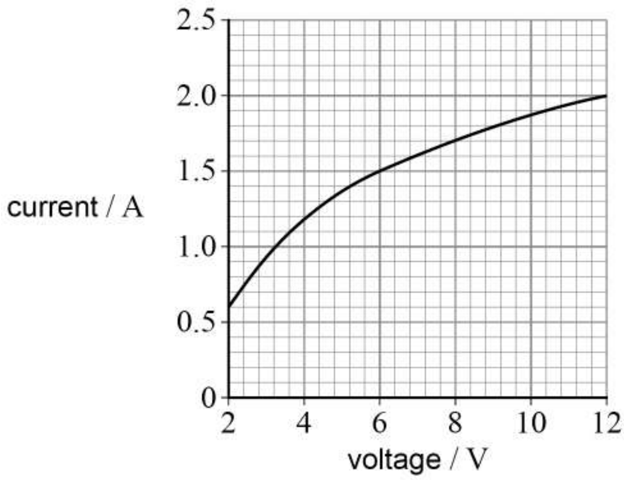
[2 marks]

resistance = ____________________ Ω

Do not write outside the box

0 8 . 2 **Figure 13** shows the variation of current with voltage for the lamp between 2 V and 12 V.

Figure 13



Calculate the resistance of the lamp when the voltage across the lamp is 8.0 V.

[2 marks]

resistance = ______________________ Ω

0 8 . 3 Explain, in terms of electron movement, why the resistance of the filament lamp changes as the voltage changes as shown in **Figure 13**.

[3 marks]

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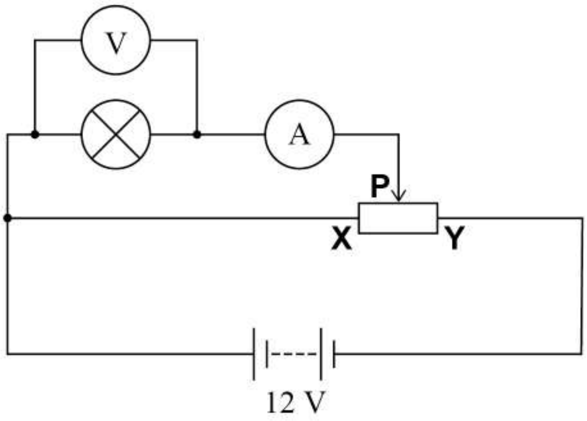
Question 8 continues on the next page

0 8 . 4 **Figure 14** shows an alternative circuit used to investigate the variation of current with voltage for the lamp.

Figure 14



The circuit components are the same as in **Figure 12**.
When the voltage across the lamp is $12\ \text{V}$ its resistance is $6.0\ \Omega$.

P is moved to position **Y**.

Calculate the total resistance of the circuit.

[2 marks]

total resistance = ____________________ Ω

0 8 . 5 Calculate the power transferred by the battery when **P** is at position **Y**.

[2 marks]

power = ____________________ W

Do not write outside the box

0 8 . 6 A student wants to control the brightness of the lamp.

He gives two reasons why the circuit in **Figure 14** is better than the circuit in **Figure 12** for controlling the brightness. The two reasons are:

- the **Figure 14** circuit can achieve a greater range of voltages across the lamp
- the **Figure 14** circuit is more efficient at transferring energy to the lamp.

Discuss, without calculation, whether either of these two reasons is correct.

[3 marks]

14

END OF QUESTIONS

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