

Questions

Q1.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .

A small metal cube, with sides of length x , is connected in a circuit. The current through the cube, between opposite faces, is I and the potential difference across the cube is V .

Which of the following gives the resistivity of the metal?

☐ **A** $\frac{Vx}{I}$

☐ **B** $\frac{V}{Ix}$

☐ **C** $\frac{Ix}{V}$

☐ **D** $\frac{I}{Vx}$

(Total for question = 1 mark)

Q2.

A student carried out an experiment to determine the resistivity of a metal in the form of a wire. She made the following measurements:

length of wire = 0.20 m
resistance of wire = 50 mΩ
diameter of wire = 0.36 mm

Determine the metal of the wire using information from the table below.

Metal	Resistivity / $\Omega \text{ m}$
aluminium	2.7×10^{-8}
tungsten	5.6×10^{-8}
iron	1.0×10^{-7}

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(Total for question = 3 marks)

Q3.

A wire has a resistance of 65 m Ω . The length of the wire is 0.25 m.

The wire has a circular cross-sectional area.

Calculate the diameter of the wire.

resistivity of the metal of the wire = $5.6 \times 10^{-8} \Omega \text{ m}$

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Diameter =

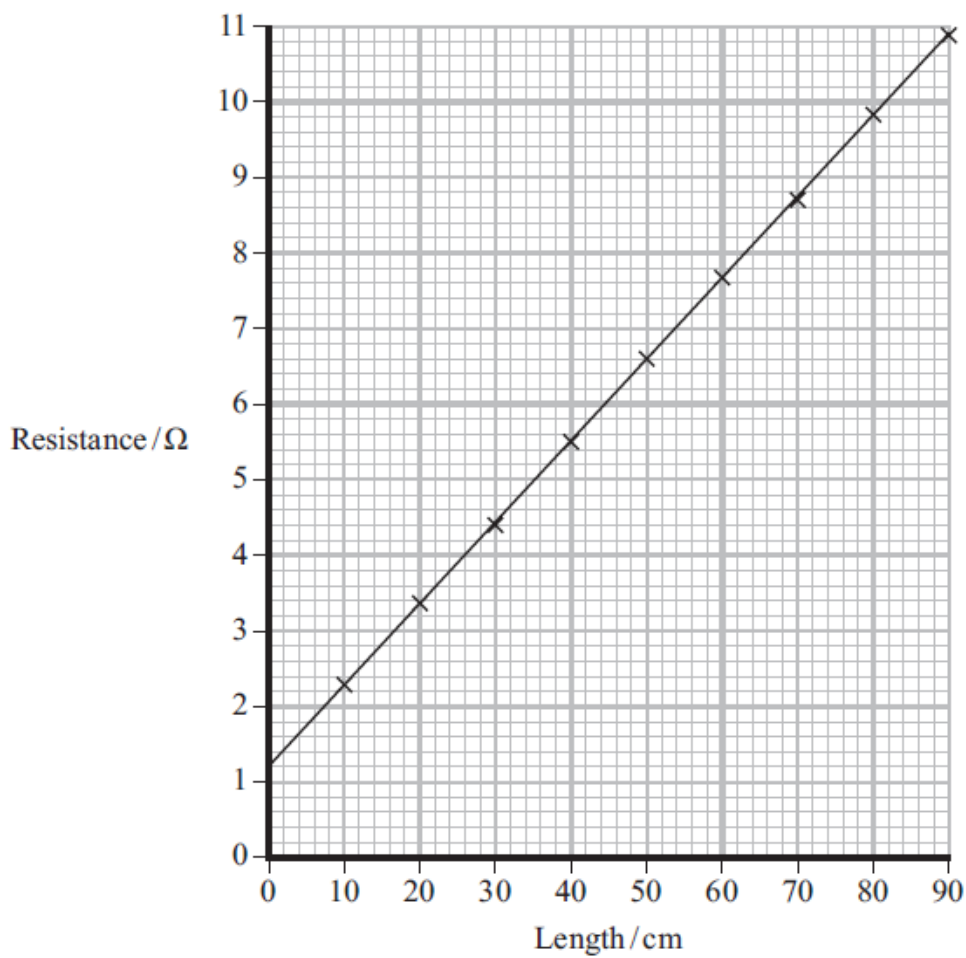
(Total for question = 3 marks)

Q4.

A student determined the resistivity for a metal in the form of a wire.

The student measured the resistance for different lengths of the wire.

She plotted the graph shown.



The table shows the resistivity of some metals.

Metal	Resistivity / $\Omega \text{ m}$
constantan	4.90×10^{-7}
nichrome	1.07×10^{-6}
copper	1.55×10^{-8}

Deduce which of these metals the wire was made from.

diameter of wire = 0.24 mm

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(Total for question = 5 marks)

Q5.

An electrical cutting tool uses a heated metal wire to cut polystyrene. The temperature of the metal wire increases when the cutting tool is switched on.

(a) Explain how the resistance of the wire changes as the temperature of the wire increases.

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(b) When the wire is at the correct temperature for cutting, the resistance of the wire is $0.67\ \Omega$.

The wire has a circular cross-section.

Calculate the resistivity of the wire when it is at the correct temperature for cutting.

diameter of wire = 0.51 mm

length of wire = 0.14 m

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Resistivity =

(Total for question = 6 marks)

Q6.

A student is planning an experiment to determine a value for the resistivity of a metal in the form of a wire, by a graphical method.

(a) State the physical quantities she should measure, suggesting a suitable measuring instrument for each quantity.

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(b) Describe how she should use her measurements to determine an accurate value for the resistivity of the wire using a graphical method.

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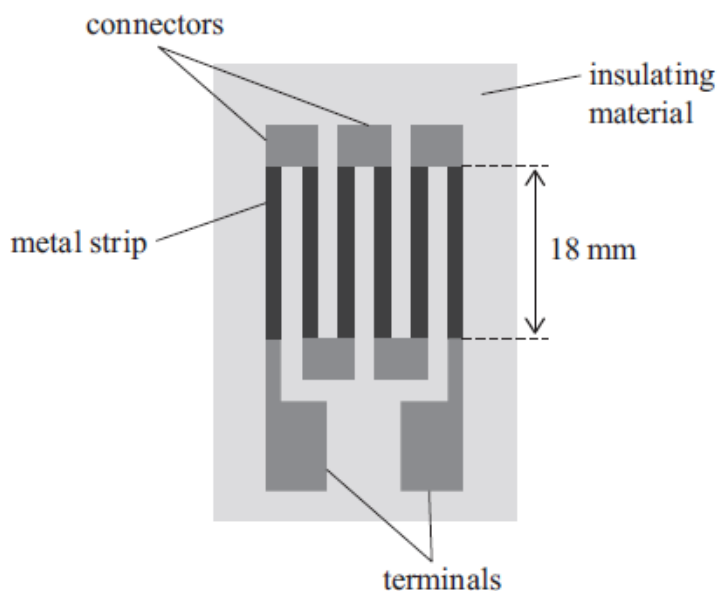
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(Total for question = 6 marks)

Q7.

A strain gauge is an electrical component that can be attached to an object to measure mechanical strain.

The strain gauge shown has 6 metal strips attached to a small piece of insulating material. The metal strips are joined together by connectors. The initial length of each metal strip is 18 mm.



(a) Each metal strip has a rectangular cross-section of width 1.40 mm and thickness 0.23 mm.

The resistance between the terminals is $0.16\ \Omega$.

The connectors and terminals have negligible resistance.

Determine the resistivity of the metal used to make the strips.

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Resistivity =

(b) The strain gauge is stretched and the length l of the metal strips increases. The metal strips change shape uniformly along their length.

Explain why a graph of the resistance of the strain gauge against l^2 would be a straight line.

The temperature of the metal strips is constant.

Assume that the volume of each metal strip is constant.

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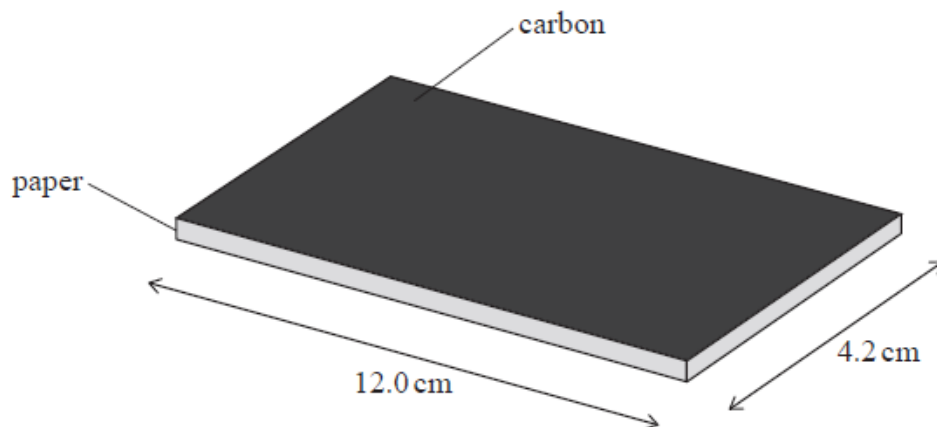
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(Total for question = 7 marks)

Q8.

'Resistivity paper' is paper covered with a thin layer of carbon.

The distance between the ends of a piece of resistivity paper is 12.0 cm. The resistivity paper is 4.2 cm wide as shown.



The resistance between the ends of the resistivity paper is $8.8 \, \Omega$.

(a) Calculate the thickness of the layer of carbon.

resistivity of carbon = $3.7 \times 10^{-5} \, \Omega \, \text{m}$

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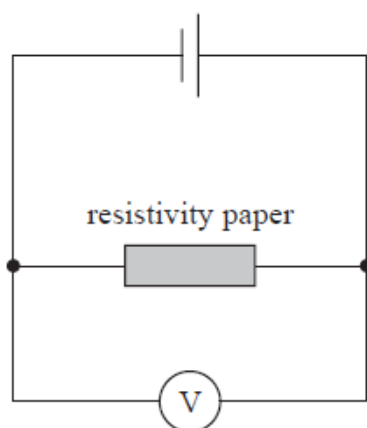
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Thickness of layer of carbon =

(b) A student connected the ends of the resistivity paper to a cell of e.m.f. 1.5 V and a voltmeter, as shown.



(i) The reading on the voltmeter was 1.4 V.

Calculate the internal resistance of the cell.

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Internal resistance =

(ii) The connection to the right-hand terminal of the voltmeter was moved to a distance of 3.0 cm from the left-hand side of the resistivity paper.

Determine the reading on the voltmeter.

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Reading on voltmeter =

(Total for question = 7 marks)

Q9.

A filament lamp is marked 12 V 60 W. The filament is made from a long metal wire with a diameter of 0.25 mm. The metal has a resistivity of $5.6 \times 10^{-8} \Omega \text{ m}$ when the wire is at normal operating temperature.

(a) Calculate the length of the wire in the filament.

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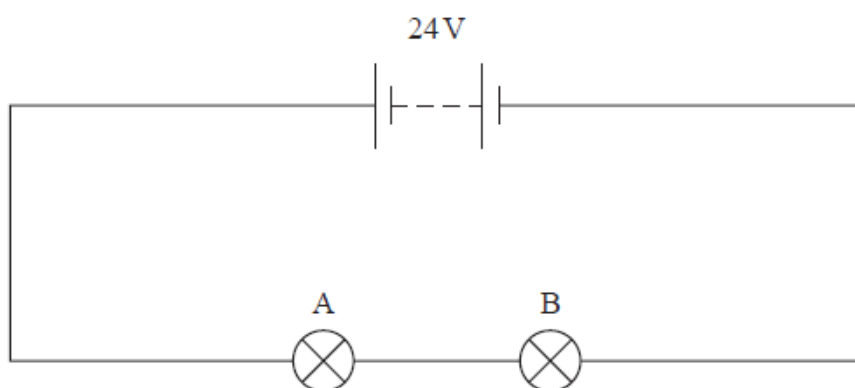
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Length of wire =

(b) A student has two filament lamps. Lamp A is marked 12 V 60 W and lamp B is marked 12 V 30 W. The student sets up the circuit shown.



The student states that both lamps will operate normally.

Evaluate whether the student's statement is correct.

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(Total for question = 7 marks)

Q10.

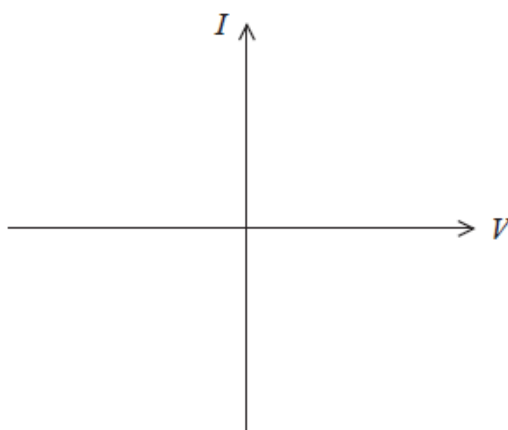
The photograph shows a thin, coiled, tungsten wire used in a filament light bulb.



(Source: © goran cakmazovic/Shutterstock)

(a) Complete the sketch graph to show how current varies with potential difference for a filament bulb.

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(b) The tungsten wire has a diameter of 0.046 mm and a length of 580 mm. When emitting light, there is a current of 0.44 A in the filament and a potential difference of 140 V across the filament.

(i) Calculate the drift velocity v of the electrons in the tungsten wire.

number of charge carriers per m^3 in tungsten = 1.26×10^{29}

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$V =$

(ii) When the potential difference across the tungsten filament is 140 V the current in the filament is 0.44 A.

The table shows typical resistivity values for tungsten at different temperatures.

Temperature / °C	20	700	1700	2700	3200
Resistivity / Ωm	0.55×10^{-7}	2.43×10^{-7}	5.57×10^{-7}	9.04×10^{-7}	10.85×10^{-7}

Deduce the temperature of the filament.

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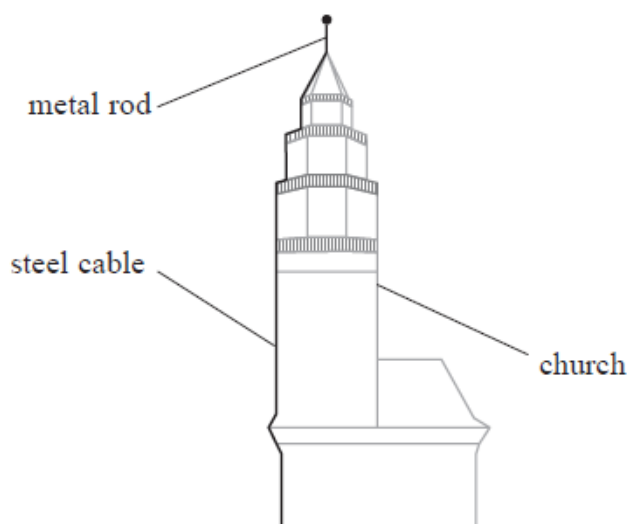
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(Total for question = 8 marks)

Q11.

A metal rod on top of a church may have been the world's first lightning conductor.

The metal rod is connected to the ground by a steel cable as shown.



When lightning strikes, charge is transferred to the metal rod and is conducted to the ground through the steel cable.

(a) The steel cable has a diameter of 12 mm. The total resistance of the cable is $0.078 \, \Omega$.

Calculate the total length of the cable.

resistivity of steel = $1.4 \times 10^{-7} \, \Omega \, \text{m}$

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Total length of cable =

(b) During a lightning strike, there was a potential difference (p.d.) of $1.5 \times 10^8 \, \text{V}$ between the metal rod and the ground. This p.d. caused a current of $1.2 \times 10^4 \, \text{A}$ in the cable for a time of $70 \, \mu\text{s}$.

Calculate the work done as the charge is conducted to the ground.

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Work done =

(c) The steel cable is replaced with a copper cable. The copper cable has the same length and diameter as the steel cable.

During a thunderstorm, the p.d. between the metal rod and the ground is the same for the copper cable as it was for the steel cable.

Copper has a lower resistivity than steel. There is a greater number of conduction electrons per unit volume in copper than in steel.

A student states that the drift velocities of electrons will be the same in both cables.

Assess the student's statement.

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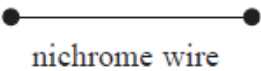
(Total for question = 8 marks)

Q12.

A student carried out an experiment to determine the resistivity of nichrome wire. Her circuit included an ammeter, a voltmeter and a variable resistor.

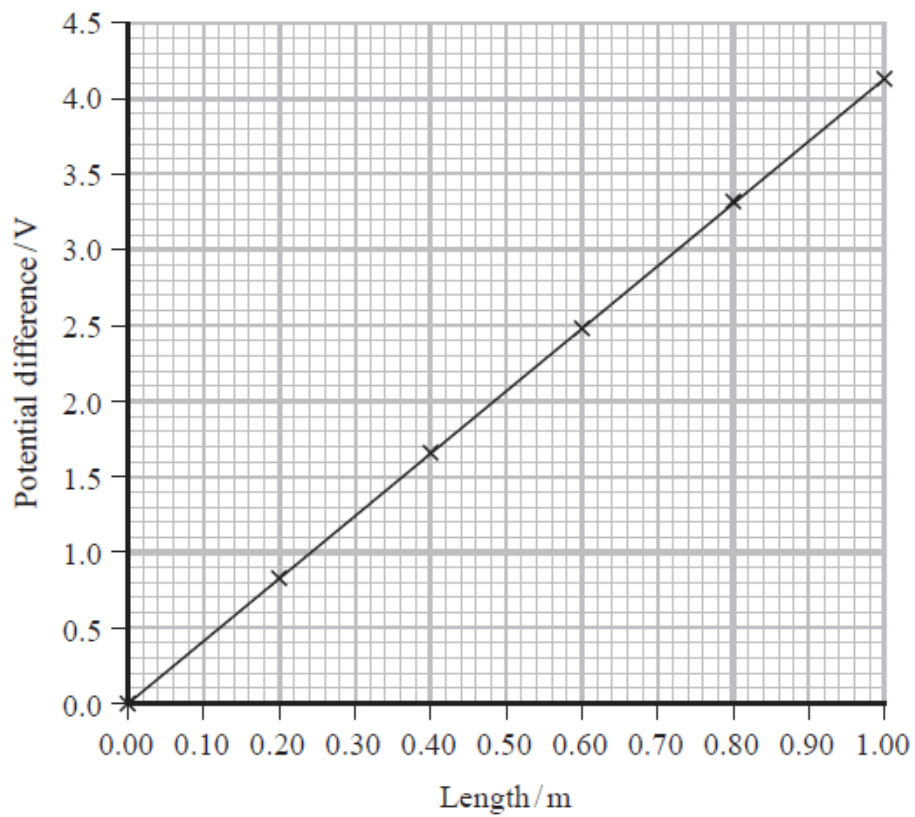
(a) Complete the circuit diagram for this experiment.

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(b) The student varied the length of the nichrome wire in the circuit. For each length, she measured the potential difference across the nichrome wire. She used the variable resistor to keep the current in the wire at 0.200 A during the experiment.

The student plotted a graph of potential difference against length of nichrome wire.



(i) Determine the resistivity of nichrome.

cross sectional area of nichrome wire = $5.31 \times 10^{-8} \text{ m}^2$

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Resistivity of nichrome =

(ii) Calculate the power dissipated from the nichrome wire to the surroundings when the length of the wire is 0.75 m.

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Power dissipated =

(Total for question = 9 marks)

Q13.

The photograph shows a typical lightning strike which occurs as a result of an electrical discharge through the atmosphere in a narrow channel between a cloud and the ground.



(Source: © Joshua Lewis/EyeEm/Getty Images)

The high current in a lightning strike heats the air sufficiently to cause rapid expansion; the resulting shock wave is heard as thunder.

(a) A teacher says that a lightning strike taking place 1 km away from the observer will result in a time of 3 s between seeing the lightning and hearing the thunder.

Determine whether the teacher is correct.

speed of sound in air = 340 m s^{-1}

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(b) The following data was collected for one particular lightning strike:

- distance between cloud and ground = 400 m
- current = 25 000 A
- duration of lightning strike = 30 μ s
- potential difference between cloud and ground = 1.2×10^9 V
- diameter of lightning channel = 5.0 cm

(i) Calculate the total charge transferred during the lightning strike.

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Total charge transferred =

(ii) Calculate the power dissipated by the lightning strike.

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Power dissipated =

(iii) Show that the resistivity of the air in the lightning channel is about $0.2 \Omega \text{ m}$.

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(iv) The accepted value for the resistivity of air is $10^{16} \Omega \text{ m}$.

Suggest why the value calculated from the data is so much less than the accepted value.

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(c) Air consists mainly of nitrogen and oxygen molecules. Analysis of the light produced during a lightning strike shows a weak line spectrum.

(i) Explain the process by which nitrogen atoms produce a line spectrum.

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(ii) State why the line spectrum produced by oxygen atoms in the air would be different from the line spectrum produced by nitrogen atoms.

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(Total for question = 16 marks)