Current & Resistance

Q1. (a) A metal wire of length 1.4 m has a uniform cross-sectional area = 7.8×10^{-7} m^2. Calculate the resistance, R, of the wire.

resistivity of the metal = 1.7×10^{-8} Ωm

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(2)

(b) The wire is now stretched to twice its original length by a process that keeps its volume constant. If the resistivity of the metal of the wire remains constant, show that the resistance increases to 4R.

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(2)
(Total 4 marks)

Q2. (a) Some materials exhibit the property of *superconductivity* under certain conditions.

- State what is meant by superconductivity.
- Explain the required conditions for the material to become superconducting.

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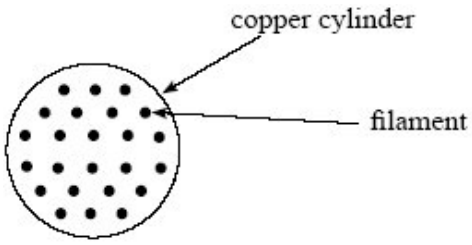
(3)

(b) The diagram below shows the cross–section of a cable consisting of parallel filaments that can be made superconducting, embedded in a cylinder of copper.



(i) The cross–sectional area of the copper in the cable is 2.28×10^{-7} m^2. The resistance of the copper in a 1.0 m length of the cable is 0.075 Ω. Calculate the resistivity of the copper, stating an appropriate unit.

answer = ...

(3)

(ii) State and explain what happens to the resistance of the cable when the embedded filaments of wire are made superconducting.

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(3)

(Total 9 marks)

Q3. (a) A sample of conducting putty is rolled into a cylinder which is 6.0×10^{-2} m long and has a radius of 1.2×10^{-2} m.

resistivity of the putty = 4.0×10^{-3} Ωm.

(i) Calculate the resistance between the ends of the cylinder of conducting putty. Your answer should be given to an appropriate number of significant figures.

answer = ... Ω

(4)

(ii) The putty is now reshaped into a cylinder with half the radius and a length which is four times as great. Determine how many times greater the resistance now is.

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(2)

(b) Given the original cylinder of the conducting putty described in part (a), describe how you would use a voltmeter, ammeter and other standard laboratory equipment to determine a value for the resistivity of the putty.

Your description should include

- a labelled circuit diagram,
- details of the measurements you would make,
- an account of how you would use your measurements to determine the result,
- details of how to improve the precision of your measurements.

The quality of your written communication will be assessed in this question.

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(8)
(Total 14 marks)

Q4. (a) For a conductor in the form of a wire of uniform cross-sectional area, give an equation which relates its resistance to the resistivity of the material of the conductor. Define the symbols used in the equation.

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(2)

(b) (i) An electrical heating element, made from uniform nichrome wire, is required to dissipate 500 W when connected to the 230 V mains supply.

The cross-sectional area of the wire is 8.0×10^{-8} m^2. Calculate the length of nichrome wire required.

resistivity of nichrome = 1.1×10^{-6} Ω m

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(ii) Two heating elements, each rated at 230 V, 500 W are connected to the 230 mains supply

(A) in series,
(B) in parallel.

Explain why only one of the circuits will provide an output of 1 kW.

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(6)
(Total 8 marks)

Q5. (a) Give an expression for the *resistivity* of a material in the form of a uniform wire. Define all the symbols used.

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(2)

(b) A thin film of carbon may be used in some electronic systems. Typical dimensions of such a film are shown in **Figure 1**.

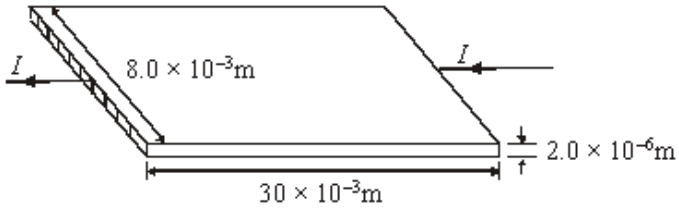

Figure 1

(i) Calculate the resistance of the carbon film to a current *I* passing through it as shown in **Figure 1**.

resistivity of carbon = 4.0×10^{-5} Ω m

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(ii) Without recalculating the resistance of the carbon film, explain how you would expect the resistance to change if the current flowed as in **Figure 2**. You should consider the numerical ratio or factor by which each dimension affecting the resistance has changed.

You may be awarded marks for the quality of written communication in your answer.

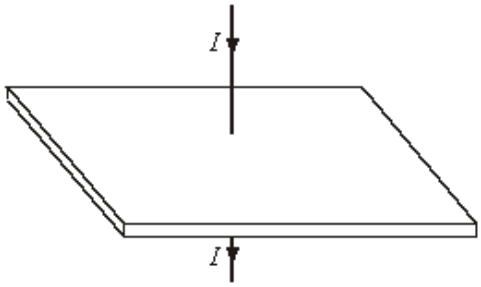

Figure 2

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(4)
(Total 6 marks)

Q6. A battery is connected across a uniform conductor. The current in the conductor is 40 mA.

(i) Calculate the total charge that flows past a point in the conductor in 3 minutes.

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(ii) Using data from the Data Sheet calculate the number of electron charge carriers passing the same point in the conductor in this time.

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(iii) If 8.6 J of energy are transferred to the conductor in this time, calculate the potential difference across the conductor.

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(iv) Calculate the resistance of the conductor.

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(Total 6 marks)

Q7. (a) A steady current of 0.25 A passes through a torch bulb for 6 minutes. Calculate the charge which flows through the bulb in this time.

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(2)

(b) The torch bulb is now connected to a battery of negligible internal resistance. The battery supplies a steady current of 0.25 A for 20 hours. In this time the energy transferred in the bulb is 9.0×10^4 J. Calculate

(i) the potential difference across the bulb,

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(ii) the power of the bulb.

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(3)
(Total 5 marks)

Q8. A student wishes to collect data so he can plot the *I*-*V* curve for a semiconductor diode.

(a) (i) Draw a suitable diagram of the circuit that would enable the student to collect this data.

(3)

(ii) Describe the procedure the student would follow in order to obtain an *I*-*V* curve for the semiconductor diode.

The quality of your written communication will be assessed in this question.

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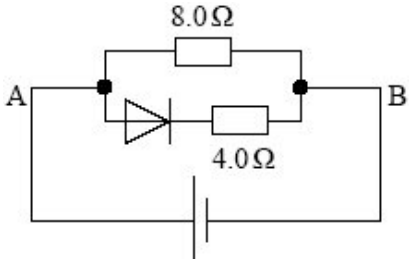
(6)

(b) The diagram below shows an arrangement of a semiconducting diode and two resistors.



A 12.0 V battery is connected with its positive terminal to A and negative terminal to B.

(i) Calculate the current in the 8.0 Ω resistor

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answer ..... A

(2)

(ii) Calculate the current in the 4.0 Ω resistor if the p.d. across the diode, when in forward bias, is 0.65 V expressing your answer to an appropriate number of significant figures.

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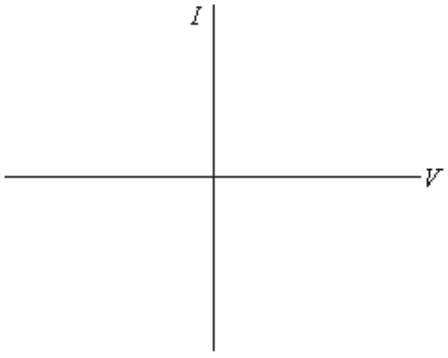
answer ..... A

(3)

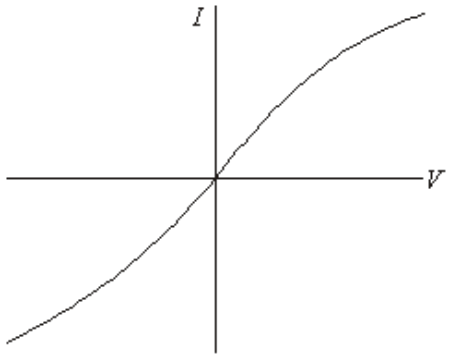
(Total 14 marks)

Q9. (a) On the axes below draw the *I* – *V* characteristic for a silicon semiconductor diode in both forward bias and reverse bias. Indicate any relevant voltage values on the axis.



(4)

(b) The figure below shows the *I* – *V* characteristic for a filament lamp. Explain the shape of the characteristic.



You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(4)
(Total 8 marks)

Q10. (a) A student wishes to measure the resistance of a fixed length of uniform constantan wire. The apparatus available includes a battery, a switch, a milliammeter and a voltmeter.

You may be awarded marks for the quality of written communication in your answer.

(i) Draw a circuit diagram using the apparatus listed above. Include in your diagram an extra piece of apparatus which will enable a range of measurements to be made.

(ii) State how the student should make the necessary measurements, ensuring that a range of readings is recorded.

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(iii) Describe how the results would be used to determine an accurate value for the resistance of the wire.

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(8)

(b) A heating element for an electric fire consists of a single strand of nichrome wire wound around an insulator. The heater is required to produce 1.2 kW when connected to the 230 Vrms ac mains.

(i) Calculate the working resistance of the nichrome wire.

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(ii) Calculate the length of nichrome wire required to make the element.

cross-sectional area of the wire = 9.4×10^{-8} m^2
resistivity of nichrome = 1.1×10^{-6} Ω m

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(5)
(Total 13 marks)

Q11. (a) A metal wire of length 1.4 m has a uniform cross-sectional area = 7.8×10^{-7} m^2. Calculate the resistance, *R*, of the wire.
resistivity of the metal = 1.7×10^{-8} Ωm

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(2)

(b) The wire is now stretched to twice its original length by a process that keeps its volume constant. If the resistivity of the metal of the wire remains constant, show that the resistance increases to 4*R*.

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(2)
(Total 4 marks)