Resistivity Questions for AS Physics

Q1. (a) A pencil "lead" is made from non-metallic material which has a resistivity, at room temperature, of 4.0×10^{-3} Ωm. A piece of this material has a length of 20mm and a diameter of 1.40 mm.

Show that the resistance of this specimen, to two significant figures, is 52 Ω.

(2)

(b) Given a specimen of the pencil "lead" described in part (a) with similar dimensions, describe an experiment you could carry out in the school or college laboratory to verify that the resistivity of the material is equal to the value quoted in part (a).

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.

(8)

(c) During an experiment such as that described in part (b), a specimen of pencil "lead" is found to have a resistance of 52 Ω when the current through it is 250 mA.

Calculate the power dissipated in the specimen under these conditions.

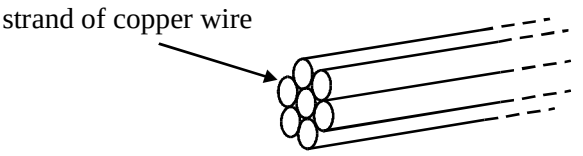
(2)

(Total 12 marks)

Q2. (a) Show that the unit of resistivity is Ω m.

(1)

(b) A cable consists of seven straight strands of copper wire each of diameter 1.35 mm as shown in the diagram.



Calculate

(i) the cross-sectional area of **one strand** of copper wire,

(ii) the resistance of a 100 m length of the **cable**, given that the resistivity of copper is 1.6×10^{-8} Ωm.

(4)

(c) (i) If the cable in part (b) carries a current of 20 A, what is the potential difference between the ends of the cable?

(ii) If a single strand of the copper wire in part (b) carried a current of 20 A, what would be the potential difference between its ends?

(2)

(d) State **one** advantage of using a stranded rather than a solid core cable with copper of the same total cross-sectional area.

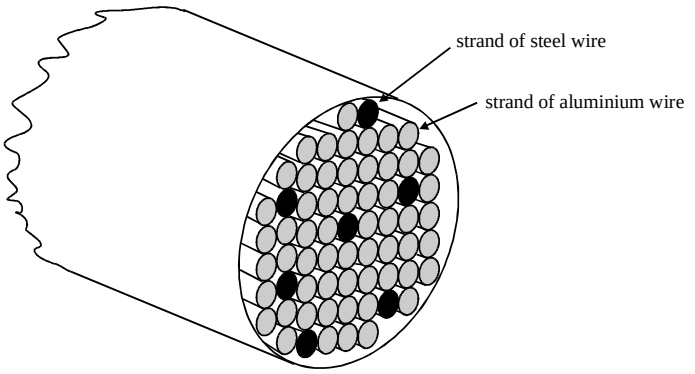
(1)

(Total 8 marks)

Q3. A particular heating element consists of a 3.0 m length of a metal alloy wire of diameter 1.2 mm and resistivity 9.3×10^{-6} Ωm at the element's operating temperature. The element is designed for use with a 230 V supply. Calculate the rating, in W, of the heating element when in use.

(Total 4 marks)

Q4. The cable shown in the diagram is used to transmit electricity and is made from strands of steel wire and strands of aluminium wire. The strands of wire are in electrical contact with each other along the length of the cable. (Resistivity of aluminium = 2.65×10^{-8} Ωm)



(a) Calculate the resistance of one strand of aluminium wire with a diameter of 3.2 mm and a length of 1.0km.

(b) The resistance of one strand of steel wire in a 1.0 km length of cable is 19.9 Ω. Calculate the resistance of 1.0 km of the cable made up of seven strands of steel wire and fifty four strands of aluminium wire.

(Total 5 marks)

5. (a) Write down an equation relating the electrical resistivity of a material to the resistance of a particular sample. Define the symbols used.

(2)

(b) (i) A cylindrical sample of graphite 10mm long and with diameter 6.0mm has a resistance of 450 Ω. Calculate the electrical resistivity of graphite.

(ii) Calculate the resistance of a specimen of copper ($\rho = 1.7 \times 10^{-8}$ Ωm) of the same dimensions as that of the graphite specimen in part (b)(i).

(5)

(Total 7 marks)

6. A 15 A fuse uses a 55 mm length of copper wire of diameter 0.508 mm. Calculate the resistance of the copper wire at 20 °C.

(resistivity of copper at 20 °C = 1.7×10^{-8} Ωm)

(Total 3 marks)

7. (a) The resistivity of a material in the form of a uniform resistance wire is to be measured. The area of cross-section of the wire is known.

The apparatus available includes a battery, a switch, a variable resistor, an ammeter and a voltmeter.

(i) Draw a circuit diagram using some or all of this apparatus, which would enable you to determine the resistivity of the material.

(ii) Describe how you would make the necessary measurements, ensuring that you have a range of values.

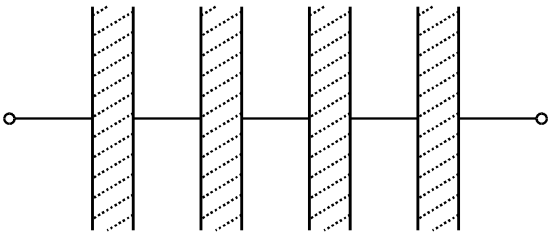
(iii) Show how a value of the resistivity is determined from your measurements.

(9)

(b) A sheet of carbon-reinforced plastic measuring 80 mm × 80 mm × 1.5 mm has its two large surfaces coated with highly conducting metal film. When a potential difference of 240V is applied between the metal films, there is a current of 2.0 mA in the plastic. Calculate the resistivity of the plastic.

(3)

(c) If four of the units described in part (b) are connected as shown in the diagram, calculate the total resistance of the combination.



(2)

(Total 14 marks)

8. (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.

(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)

(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.

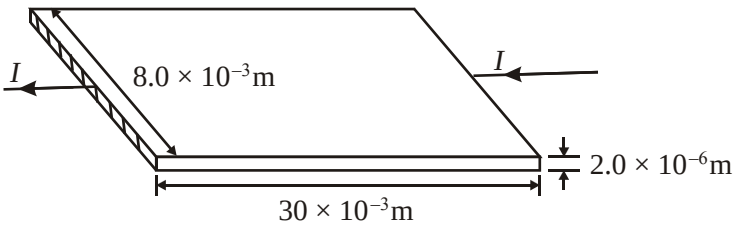
(6)

(Total 8 marks)

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

(2)

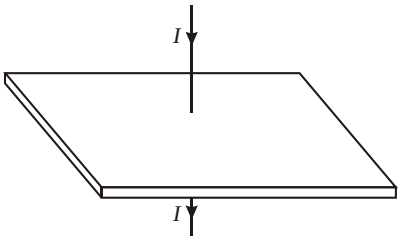
(b) A thin film of carbon may be used in some electronic systems. Typical dimensions of such a film are shown on the right.



(i) Calculate the resistance of the carbon film to a current I passing through it as shown above.

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

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



(4)
(Total 6 marks)

10. (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)

(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*.

(2)
(Total 4 marks)