A Level · OCR · Physics

34 mins 3 questions

Structured Questions

Resistance & Resistivity

Resistance / Ohm's Law & I-V Characteristics / Investigating Electrical Characteristics of Components / The Light-Dependent Resistor (LDR) / Resistivity / Determining the Resistivity of a Metal / Thermistors

Medium (2 questions)	/22
Hard (1 question)	/12
Total Marks	**/34**

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Medium Questions

1 (a) State **one** S.I. base quantity other than length, mass and time.

.....

(1 mark)

(b) Fig. 17 shows two resistors **X** and **Y** connected in series.

Fig. 17

The resistors are wires. Both wires have the same length L and diameter d. The material of **X** has resistivity ρ and the material of **Y** has resistivity 2ρ.

i) Show that the total resistance R of the wires is given by the equation

$$R = \frac{12\rho L}{\pi d^2}$$

[2]

ii) A student uses the equation in **(i)** to determine R.

The table below shows the data recorded by the student in her lab book.

Quantity	Value
ρ	$4.7 \times 10^{-7}\ \Omega$ m
L	9.5 ± 0.1 cm
d	0.270 ± 0.003 mm

1. Name the likely instruments used by the student to measure *L* and *d*.

L: .....

d: .....

[1]

2. Use the data in the table and the equation in **(i)** to determine *R* and the absolute uncertainty. Write your answer to the correct number of significant figures.

R = ... ± ..... Ω **[4]**

3. The instrument used to measure d has a zero-error. The measured *d* is much **larger** than the actual value.

Discuss how the actual value of R compares with the value calculated above.

[1]

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(8 marks)

2 (a) This question is about a resistance wire made of nichrome.

It is suggested that the resistance R of a length of nichrome wire varies with temperature θ in °C according to the equation

$$R = R_0 (1 + k\theta)$$

where R_0 is the resistance of the wire at 0 °C and k is a constant for the wire.

Fig. 1.1 shows a diagram of the arrangement of apparatus in an experiment to test the relationship between R and θ and to determine the value of k.

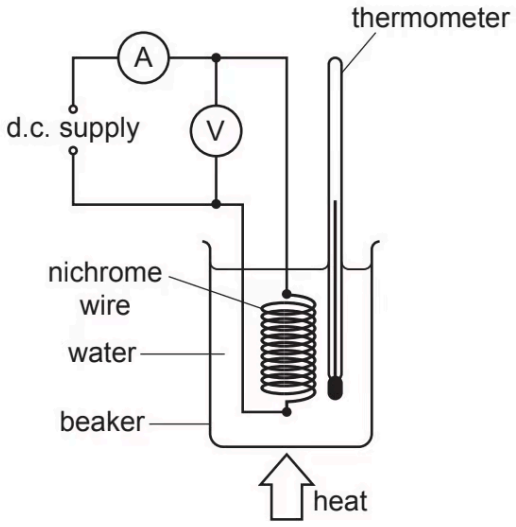

Fig. 1.1

The resistance wire is coiled and placed in a water bath.

Describe how you would carry out the experiment, analyse the data to verify the relationship between R and θ and determine a value for k.

In your description, state any precautions that you would take to improve the accuracy and precision of the measurements.

(6 marks)

(b) A student is investigating a 230 V, 1.0 kW heating element. The heating element is shown in Fig. 1.2.

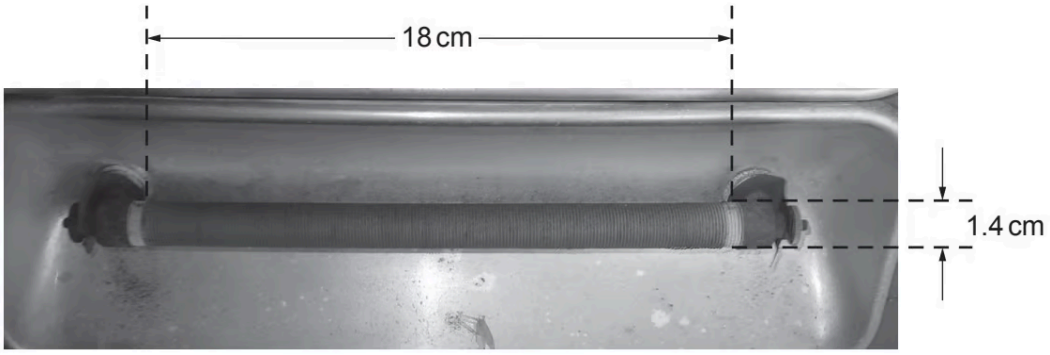

Fig. 1.2

A length of nichrome wire is wound in a spiral groove along 18 cm of a ceramic cylinder of diameter 1.4 cm. The distance between the centres of adjacent turns of the wire is 1.5 mm.

The numbers labelling the reels of loose wire on the laboratory shelf are the imperial standard wire gauge (swg). The student wishes to find out which reel holds the same wire as that wound on the heating element of Fig. 1.2.

The book of data gives the following information:

resistivity of nichrome at operating temperature = $1.1 \times 10^{-6}\ \Omega\ m$

swg	24	26	28	30	32
diameter of wire / 10^{-3} m	0.56	0.46	0.38	0.32	0.27
cross-sectional area/10^{-6} m^2	0.25	0.16	0.11	0.08	0.06

i) Show that the resistance of the nichrome wire wound on the ceramic cylinder is 53 Ω.

[2]

ii) Show that the length of wire wound on the heating element is 5.3 m.

[2]

iii) Use the information given in **(i)** and **(ii)** to determine the swg number of the wire used as the heating element.

swg number = ... **[3]**

(7 marks)

Hard Questions

1 (a) State Kirchhoff's second law **and** the physical quantity that is conserved according to this law.

.....

.....

(2 marks)

(b) The S.I. base units for the ohm (Ω) are kg m^2 $s^{-3}A^{-2}$.

Use the equation $R = \frac{\rho L}{A}$ to determine the S.I. base units for resistivity ρ.

base units for ρ .....

.....

.....

(2 marks)

(c) Fig. 18.1 shows a circuit used by a student to determine the resistivity of the material of a wire.

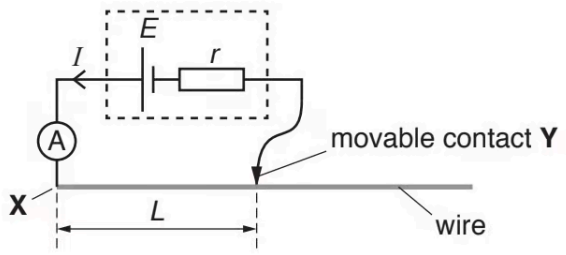

Fig. 18.1

The wire is uniform and has diameter 0.38 mm. The cell has electromotive force (e.m.f.) *E* and internal resistance *r*. The length of the wire between **X** and **Y** is *L*.

The student varies the length *L* and measures the current I in the circuit for each length.

Fig. 18.2 shows the data points plotted by the student.

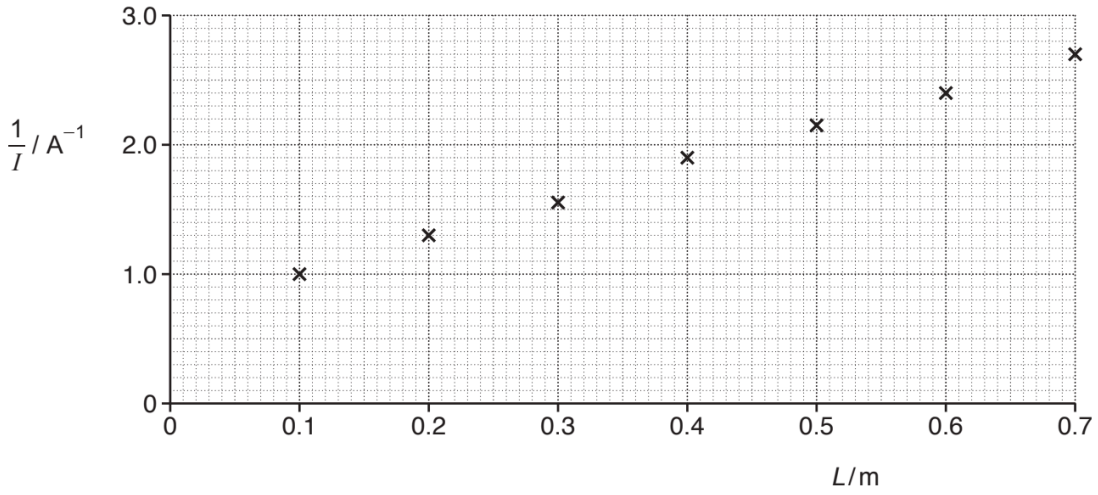

Fig. 18.2

i) On Fig. 18.2 draw the straight line of best fit. Determine the gradient of this line.

gradient = ... A^{-1}m^{-1} **[2]**

ii) Show that the gradient of the line is $\frac{\rho}{AE}$, where ρ is the resistivity of the material of the wire, *A* is the area of cross-section of the wire and *E* is the e.m.f. of the cell.

[2]

iii) The e.m.f. *E* of the cell is 1.5 V. The diameter of the wire is 0.38 mm.

Use your answer to **(i)** and the equation given in **(ii)** to determine ρ.

ρ = ... Ωm **[2]**

iv) Fig. 18.3 illustrates how the student had incorrectly measured all the lengths *L* of the wire.

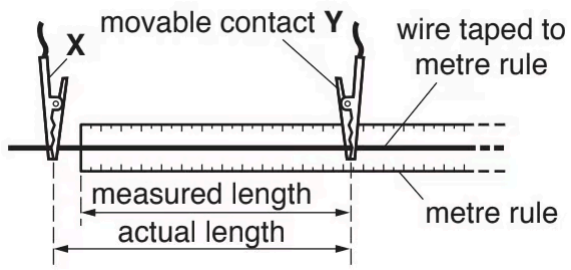

Fig. 18.3

According to the student, re-plotting the data points using the **actual** lengths of the wire will not affect the value of the resistivity obtained in **(iii)**.

Explain why the student is correct.

[2]

(8 marks)