Resistance & Resistivity

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Current of Electricity
Sub Topic	Resistance & Resistivity
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: **80 minutes**

Score: **/66**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 An electric heater has a constant resistance and is rated as 1.20 kW, 230 V.

The heater is connected to a 230 V supply by means of a cable that is 9.20 m long, as illustrated in Fig. 8.1.

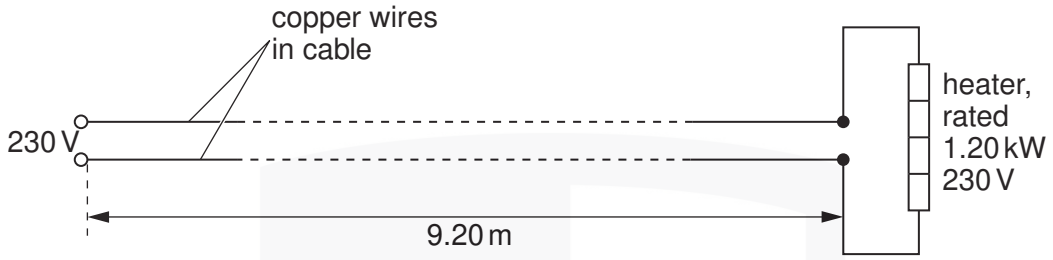

Fig. 8.1

The two copper wires that make up the cable each have a circular cross-section of diameter 0.900 mm. The resistivity of copper is $1.70 \times 10^{-8}\,\Omega\,\text{m}$.

(a) Show that

(i) the resistance of the heater is 44.1 Ω,

[2]

(ii) the total resistance of the cable is 0.492 Ω.

[2]

(b) The current in the cable and heater is switched on. Determine, to three significant figures, the power dissipated in the heater.

power = ... W [3]

(c) Suggest two disadvantages of connecting the heater to the 230 V supply using a cable consisting of two thinner copper wires.

1. .....

.....

2. .....

.....

[2]

2 **(a)** Two resistors, each of resistance R, are connected first in series and then in parallel.

Show that the ratio

$$\frac{\text{combined resistance of resistors connected in series}}{\text{combined resistance of resistors connected in parallel}}$$

is equal to 4.

[1]

(b) The variation with potential difference V of the current I in a lamp is shown in Fig. 6.1.

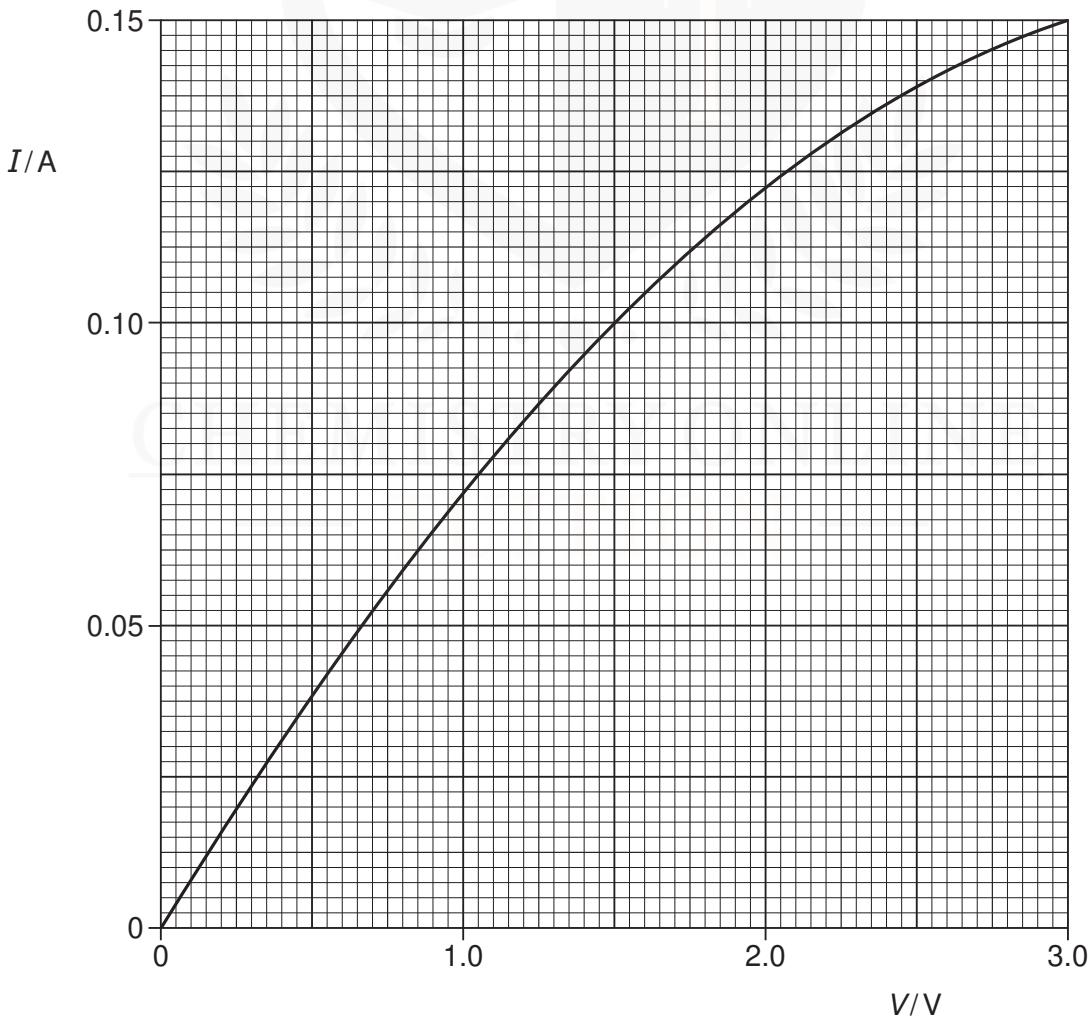

Fig. 6.1

Calculate the resistance of the lamp for a potential difference across the lamp of 1.5 V.

resistance = ... Ω [2]

(c) Two lamps, each having the I-V characteristic shown in Fig. 6.1, are connected first in series and then in parallel with a battery of e.m.f. 3.0 V and negligible internal resistance.

Complete the table of Fig. 6.2 for the lamps connected to the battery.

	p.d. across each lamp / V	resistance of each lamp / Ω	combined resistance of lamps / Ω
lamps connected in series	.....	.....	.....
lamps connected in parallel	.....	.....	.....

Fig. 6.2

[4]

(d) **(i)** Use data from the completed Fig. 6.2 to calculate the ratio

$$\frac{\text{combined resistance of lamps connected in series}}{\text{combined resistance of lamps connected in parallel}}.$$

ratio = ... [1]

(ii) The ratios in **(a)** and **(d)(i)** are not equal.

By reference to Fig. 6.1, state and explain qualitatively the change in the resistance of a lamp as the potential difference is changed.

.....

.....

.....

..... [3]

3 An electric shower unit is to be fitted in a house. The shower is rated as 10.5 kW, 230 V. The shower unit is connected to the 230 V mains supply by a cable of length 16 m, as shown in Fig. 6.1.

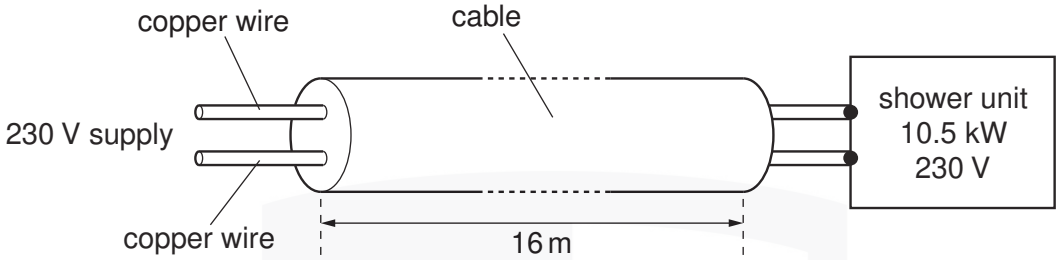

Fig. 6.1

(a) Show that, for normal operation of the shower unit, the current is approximately 46 A.

[2]

(b) The resistance of the two wires in the cable causes the potential difference across the shower unit to be reduced. The potential difference across the shower unit must not be less than 225 V.
The wires in the cable are made of copper of resistivity $1.8 \quad 10^{-8}\,\Omega\,m$.
Assuming that the current in the wires is 46 A, calculate

(i) the maximum resistance of the cable,

resistance = ... Ω [3]

(ii) the minimum area of cross-section of each wire in the cable.

area = ... m^2 [3]

(c) Connecting the shower unit to the mains supply by means of a cable having wires with too small a cross-sectional area would significantly reduce the power output of the shower unit.

(i) Assuming that the shower is operating at 210 V, rather than 230 V, and that its resistance is unchanged, determine the ratio

$$\frac{\text{power dissipated by shower unit at 210 V}}{\text{power dissipated by shower unit at 230 V}}.$$

ratio = ... [2]

(ii) Suggest and explain one further disadvantage of using wires of small cross-sectional area in the cable.

.....

.....

..... [2]

4 A straight wire of unstretched length L has an electrical resistance R. When it is stretched by a force F, the wire extends by an amount ΔL and the resistance increases by ΔR. The area of cross-section A of the wire may be assumed to remain constant.

(a) **(i)** State the relation between R, L, A and the resistivity ρ of the material of the wire.

.....

..... [1]

(ii) Show that the fractional change in resistance $\frac{\Delta R}{R}$ ain in the wire.

[2]

(b) A steel wire has area of cross-section $1.20 \times 10^{-7}\,\text{m}^2$ and a resistance of $4.17\,\Omega$.

The Young modulus of steel is 2.10×10^{11} Pa.

The tension in the wire is increased from zero to 72.0 N. The wire obeys Hooke's law at these values of tension.

Determine the strain in the wire and hence its change in resistance. Express your answer to an appropriate number of significant figures.

change = ... Ω [5]

5 Fig. 6.1 shows the variation with applied potential difference V of the current I in an electrical component C.

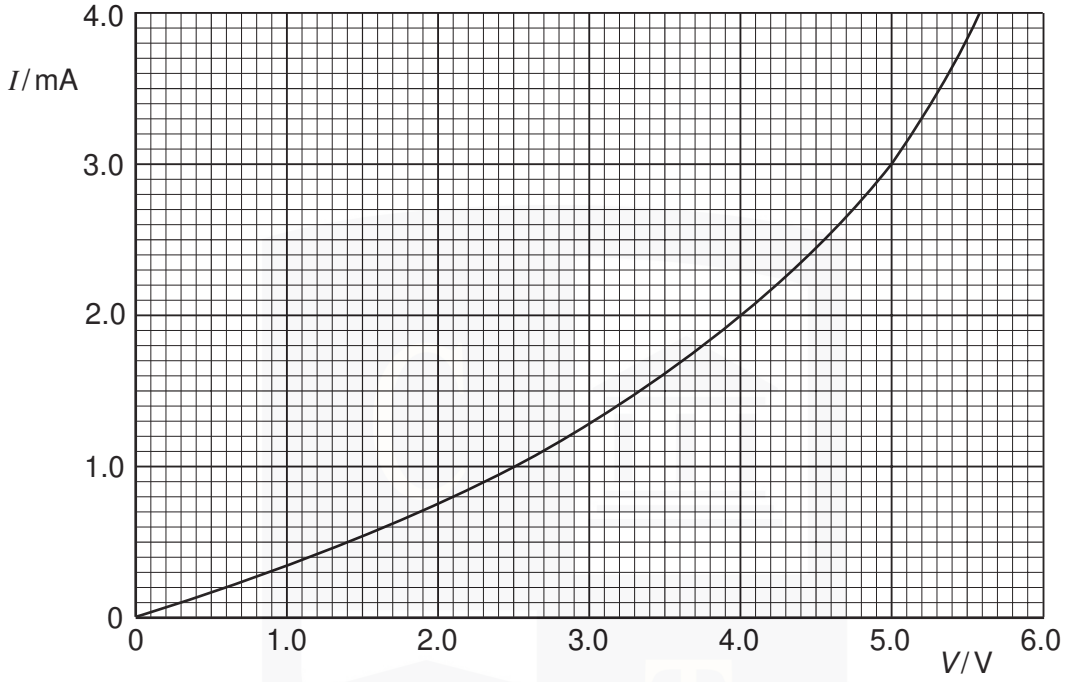

Fig. 6.1

(a) **(i)** State, with a reason, whether the resistance of component C increases or decreases with increasing potential difference.

.....

..... [2]

(ii) Determine the resistance of component C at a potential difference of 4.0 V.

resistance = …….. Ω [2]

(b) Component C is connected in parallel with a resistor R of resistance 1500 Ω and a battery of e.m.f. *E* and negligible internal resistance, as shown in Fig. 6.2.

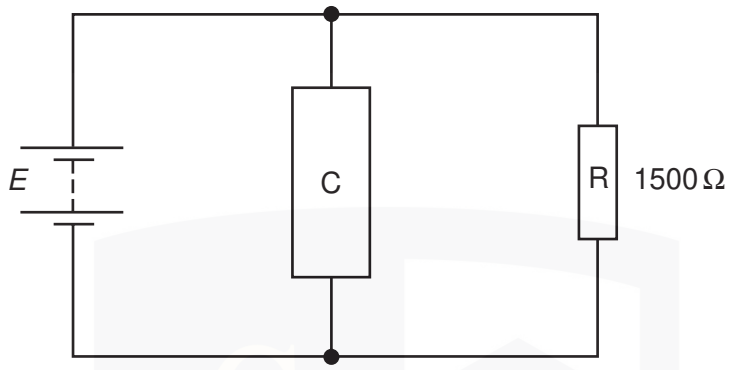

Fig. 6.2

(i) On Fig. 6.1, draw a line to show the variation with potential difference *V* of the current *I* in resistor R. [2]

(ii) Hence, or otherwise, use Fig. 6.1 to determine the current in the battery for an e.m.f. of 2.0 V.

current = ... A [2]

(c) The resistor R of resistance 1500 Ω and the component C are now connected in series across a supply of e.m.f. 7.0 V and negligible internal resistance.

Using information from Fig. 6.1, state and explain which component, R or C, will dissipate thermal energy at a greater rate.

.....

.....

.....

..... [3]

6 A household electric lamp is rated as 240 V, 60 W. The filament of the lamp is made from tungsten and is a wire of constant radius 6.0×10^{-6} m. The resistivity of tungsten at the normal operating temperature of the lamp is $7.9 \times 10^{-7}\ \Omega\,\text{m}$.

(a) For the lamp at its normal operating temperature,

(i) calculate the current in the lamp,

current = ... A

(ii) show that the resistance of the filament is 960 Ω.

[3]

(b) Calculate the length of the filament.

length = ... m [3]

(c) Comment on your answer to **(b)**.

.....

..... [1]

7 A filament lamp operates normally at a potential difference (p.d.) of 6.0 V. The variation witl p.d. V of the current I in the lamp is shown in Fig. 5.1.

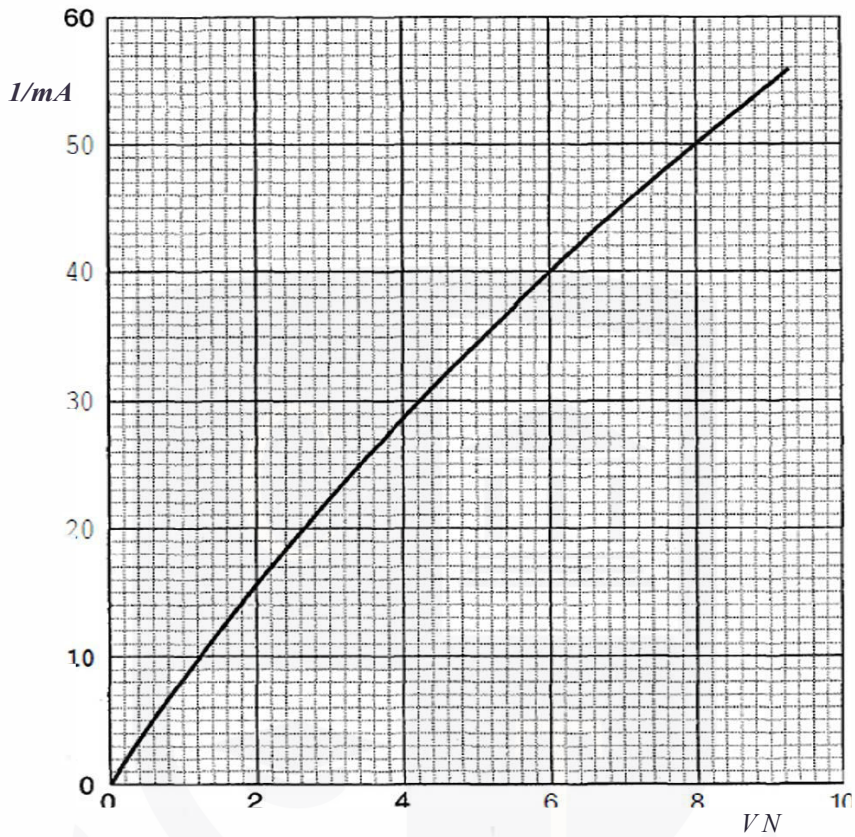

Fig.5.1

(a) Use Fig. 5.1 to determine, for this lamp,

the resistance when it is operating at a p.d. of 6.0 V,

resistance = ... n

(ii) the change in resistance when the p.d. increases from 6.0 V to 8.0 V.

change in resistance = ... Ω

[4]

(b) The lamp is connected into the circuit of Fig. 5.2.

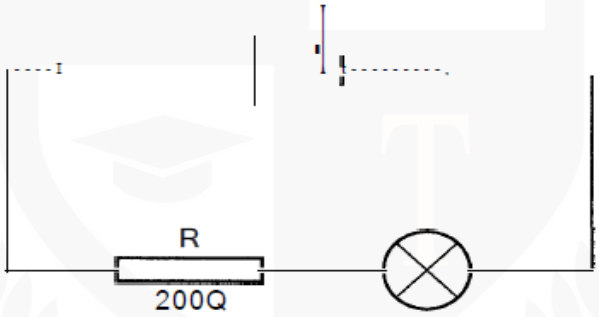

Fig.5.2

R is a fixed resistor of resistance 200 Ω. The battery has e.m.f. E and negligible internal resistance.

(i) On Fig. 5.1, draw a line to show the variation with p.d. **V** of the current **I** in the resistor R.

(ii) Determine the e.m.f. of the battery for the lamp to operate normally.

e.m.f. = ... V

[4]