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International Examinations Papers
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Resistance and resistivity: 11

TOPIC-I-V characteristics, Ohm's law, temperature dependence and resistivity

0 1 **(a)** A lamp is rated as 12 V, 36 W.

(i) Calculate the resistance of the lamp at its working temperature.

resistance = ... Ω [2]

(ii) On the axes of Fig. 6.1, sketch a graph to show the current-voltage (I–V) characteristic of the lamp. Mark an appropriate scale for current on the y-axis.

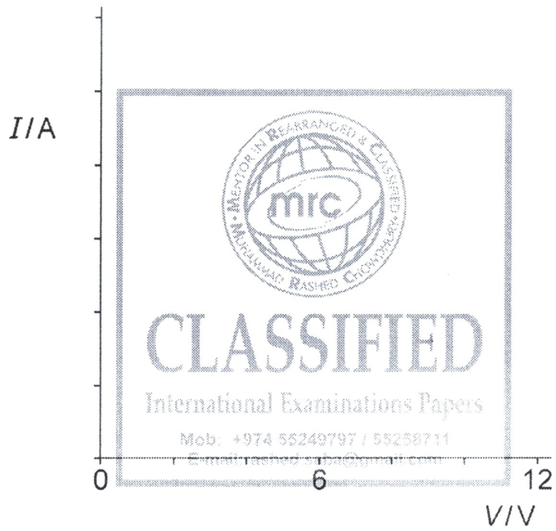


Fig. 6.1

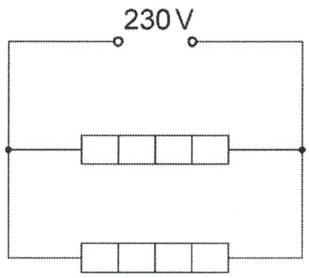
[3]

(b) Some heaters are each labelled 230 V, 1.0 kW. The heaters have constant resistance.

For Examiner's Use

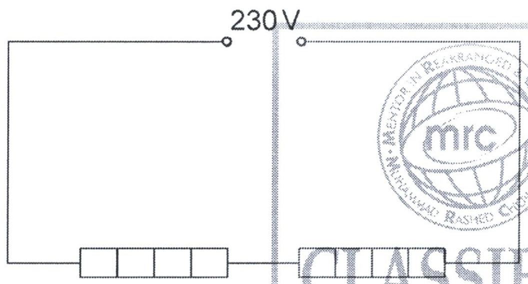
Determine the total power dissipation for the heaters connected as shown in each of the diagrams shown below.

(i)



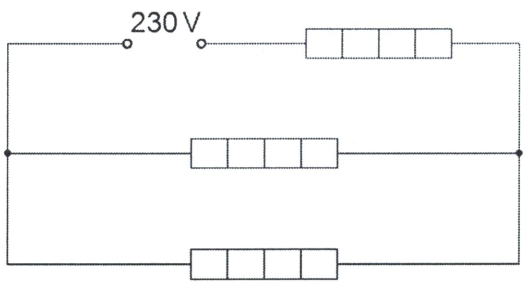
power = ... kW [1]

(ii)



power = ... kW [1]

(iii)



power = ... kW [2]

0 2 **(a)** Two resistors, each of resistance R, are connected first in series and then in parallel.

For Examiner's Use

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.

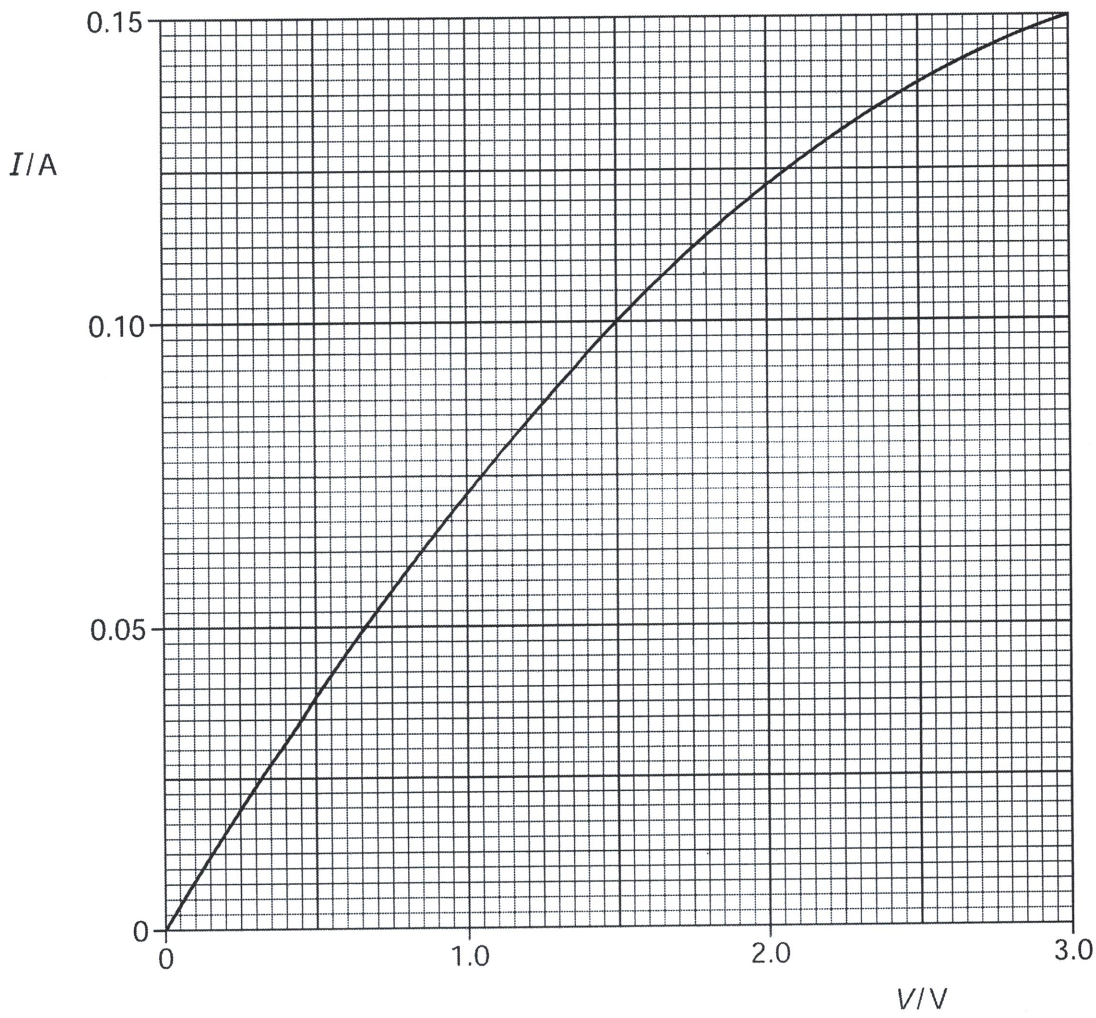


Fig. 6.1

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

For Examiner's Use

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. 3.0V 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]

03 (a) A variable resistor is used to control the current in a circuit, as shown in Fig. 5.1.

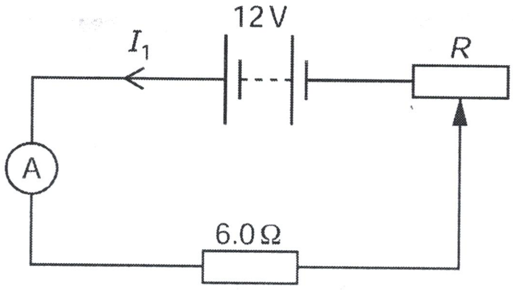


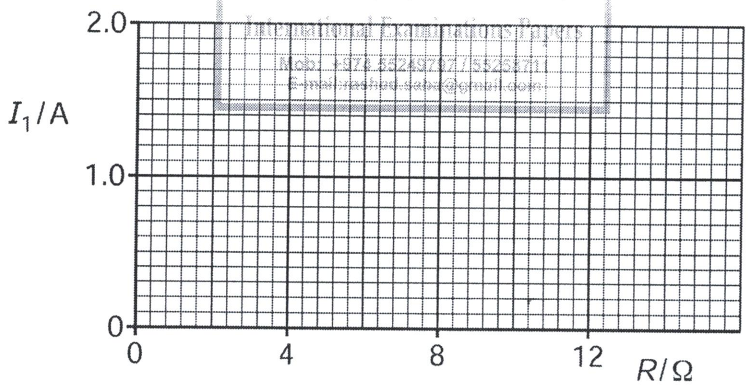
Fig. 5.1

The variable resistor is connected in series with a 12 V power supply of negligible internal resistance, an ammeter and a 6.0 Ω resistor. The resistance R of the variable resistor can be varied between 0 and 12 Ω.

(i) The maximum possible current in the circuit is 2.0 A. Calculate the minimum possible current.

minimum current = ... A [2]

(ii) On Fig. 5.2, sketch the variation with R of current I_1 in the circuit.



[2]

Fig. 5.2

(b) The variable resistor in **(a)** is now connected as a potential divider, as shown in Fig. 5.3.

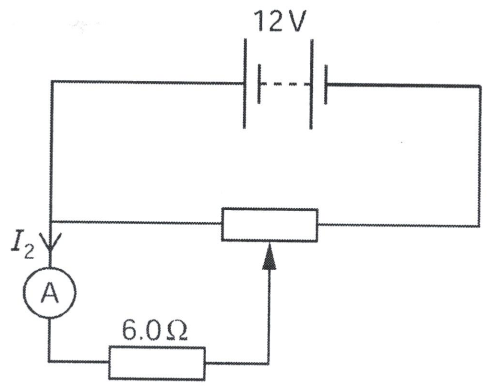


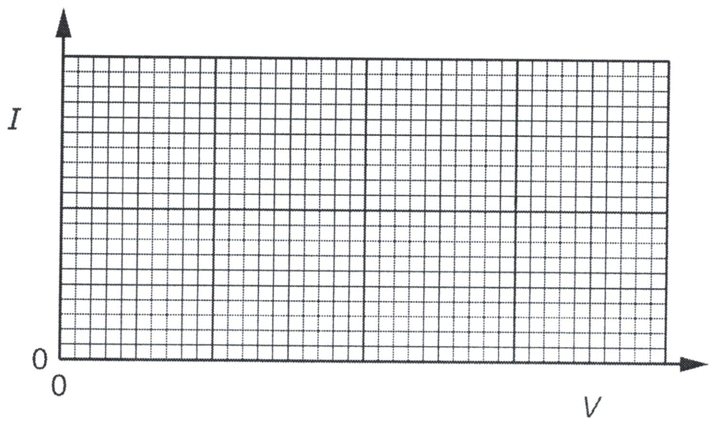
Fig. 5.3

Calculate the maximum possible and minimum possible current I_2 in the ammeter.

maximum I_2 = ... A

minimum I_2 = ... A
[2]

(c) (i) Sketch on Fig. 5.4 the $I-V$ characteristic of a filament lamp.



[2]

Fig. 5.4

(ii) The resistor of resistance 6.0 Ω is replaced with a filament lamp in the circuits of Fig. 5.1 and Fig. 5.3. State an advantage of using the circuit of Fig. 5.3, compared to the circuit of Fig 5.1, when using the circuits to vary the brightness of the filament lamp.

....

....

.... [1]

For Examiner's Use

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

For Examiner's Use

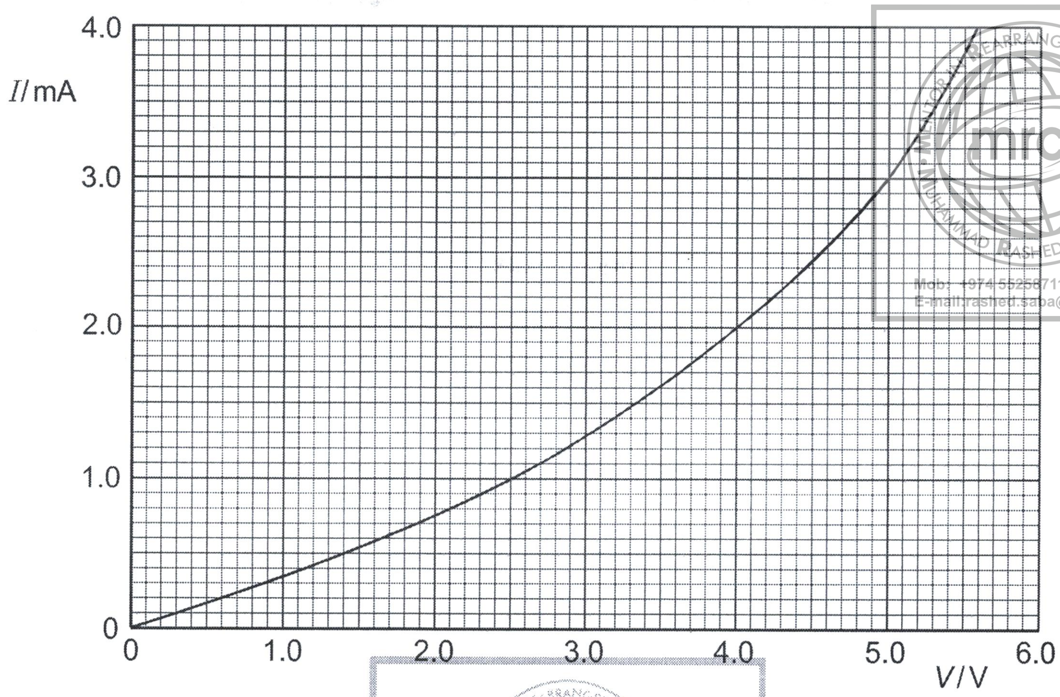


Fig. 6.1

(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.

For Examiner's Use

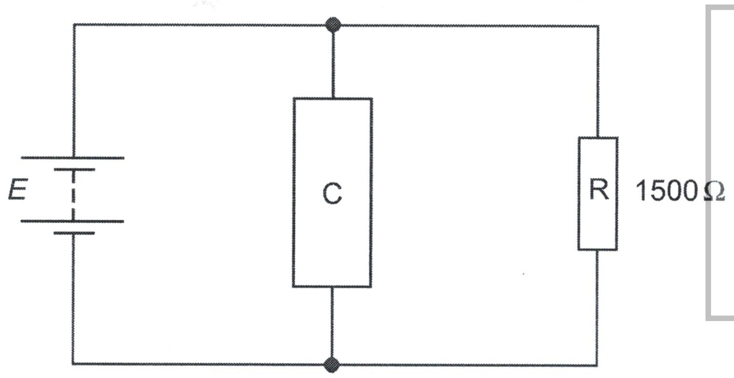


Fig. 6.2

(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]

0 5 **(a)** **(i)** State what is meant by an *electric current*.

....

.... [1]

(ii) Define electric *potential difference* (*p.d.*).

....

.... [1]

(b) A power supply of electromotive force (e.m.f.) 8.7 V and negligible internal resistance is connected by two identical wires to three filament lamps, as shown in Fig. 5.1.

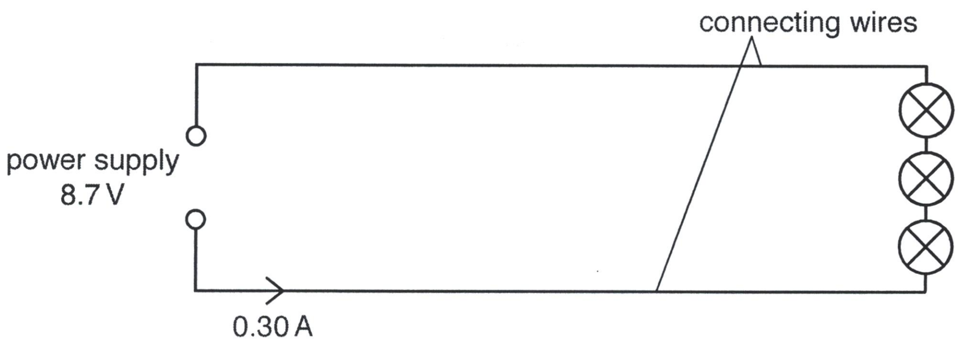


Fig. 5.1 (not to scale)

The power supply provides a current of 0.30 A to the circuit.
The filament lamps are identical. The I–V characteristic for **one** of the lamps is shown in Fig. 5.2.

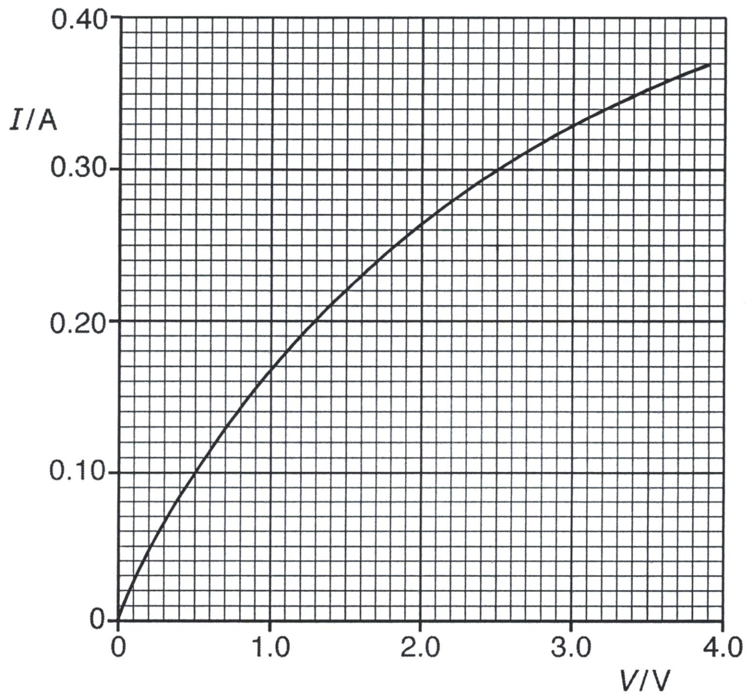


Fig. 5.2

(i) Show that the resistance of each connecting wire is 2.0 Ω.

[2]

(ii) The resistivity of the metal of the connecting wires does not vary with temperature.
On Fig. 5.2, sketch the I–V characteristic for **one** of the connecting wires. [2]

(iii) Calculate the power loss in one of the connecting wires.

power = ... W [2]

(iv) Some data for the connecting wires are given below.

cross-sectional area = 0.40 mm^2
resistivity = 1.7×10^{-8} Ω m
number density of free electrons = 8.5×10^{28} m^{-3}

Calculate

1. the length of one of the connecting wires,

length = ... m [2]

2. the drift speed of a free electron in the connecting wires.

drift speed = ... m s^{-1} [2]

[Total: 12]

06 **(a)** State Kirchhoff's second law.

....

....

....

.... [2]

(b) A battery is connected in parallel with two lamps A and B, as shown in Fig. 5.1.

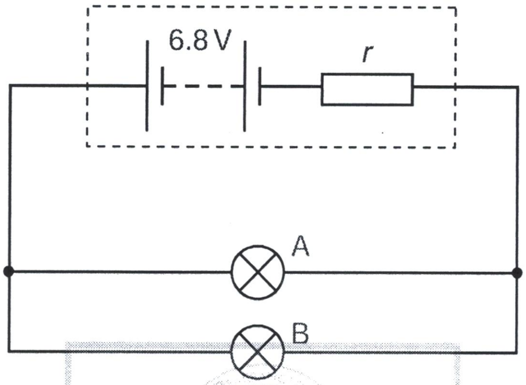


Fig. 5.1

The battery has electromotive force (e.m.f.) 6.8 V and internal resistance r.

The I–V characteristics of lamps A and B are shown in Fig. 5.2.

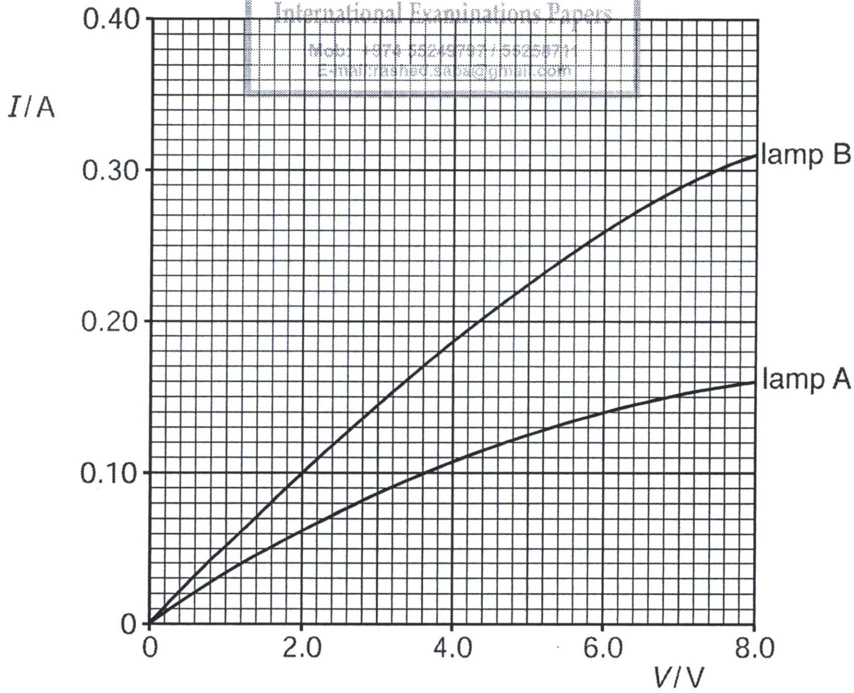


Fig. 5.2

The potential difference across the battery terminals is 6.0V.

(i) Use Fig. 5.2 to show that the current in the battery is 0.40A.

[2]

(ii) Calculate the internal resistance *r* of the battery.

r = ... Ω [2]

(iii) Determine the ratio

$$\frac{\text{resistance of lamp A}}{\text{resistance of lamp B}}.$$

ratio = ... [2]

(iv) Determine

1. the total power produced by the battery,

power = ... W [2]

2. the efficiency of the battery in the circuit.

efficiency = ... [2]

[Total: 12]

07 **(a)** The I-V characteristic of a semiconductor diode is shown in Fig. 5.1.

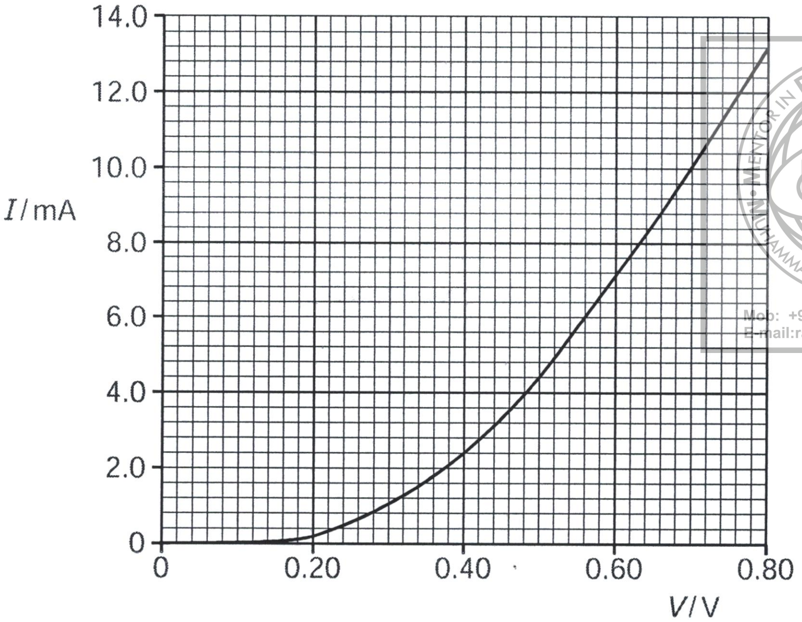


Fig. 5.1

(i) Use Fig. 5.1 to explain the variation of the resistance of the diode as V increases from zero to 0.8 V.

....

....

....

....

....

....[3]

(ii) Use Fig. 5.1 to determine the resistance of the diode for a current of 4.4 mA.

resistance = ... Ω [2]

(b) A cell of e.m.f. 1.2 V and negligible internal resistance is connected in series to a semiconductor diode and a resistor R_1, as shown in Fig. 5.2.

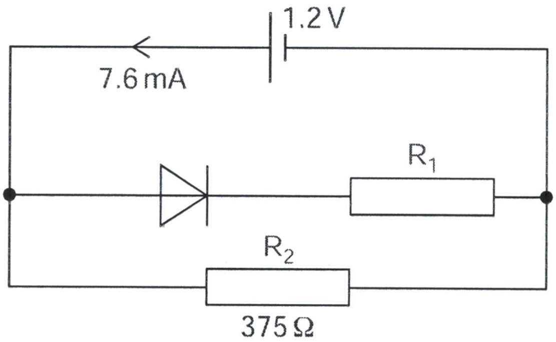


Fig. 5.2

A resistor R_2 of resistance 375 Ω is connected across the cell.
The diode has the characteristic shown in Fig. 5.1. The current supplied by the cell is 7.6 mA.

Calculate

(i) the current in R_2,

current = ... A [1]

(ii) the resistance of R_1,

resistance = ... Ω [2]

(iii) the ratio

$$\frac{\text{power dissipated in the diode}}{\text{power dissipated in } R_2}.$$

ratio = ...[2]

Q8 **(a)** **(i)** State what is meant by an *electric current*.

....

.... [1]

(ii) Define *electric potential difference*.

....

.... [1]

(b) The variation with potential difference V of the current I in a component Y and in a resistor R are shown in Fig. 6.1.

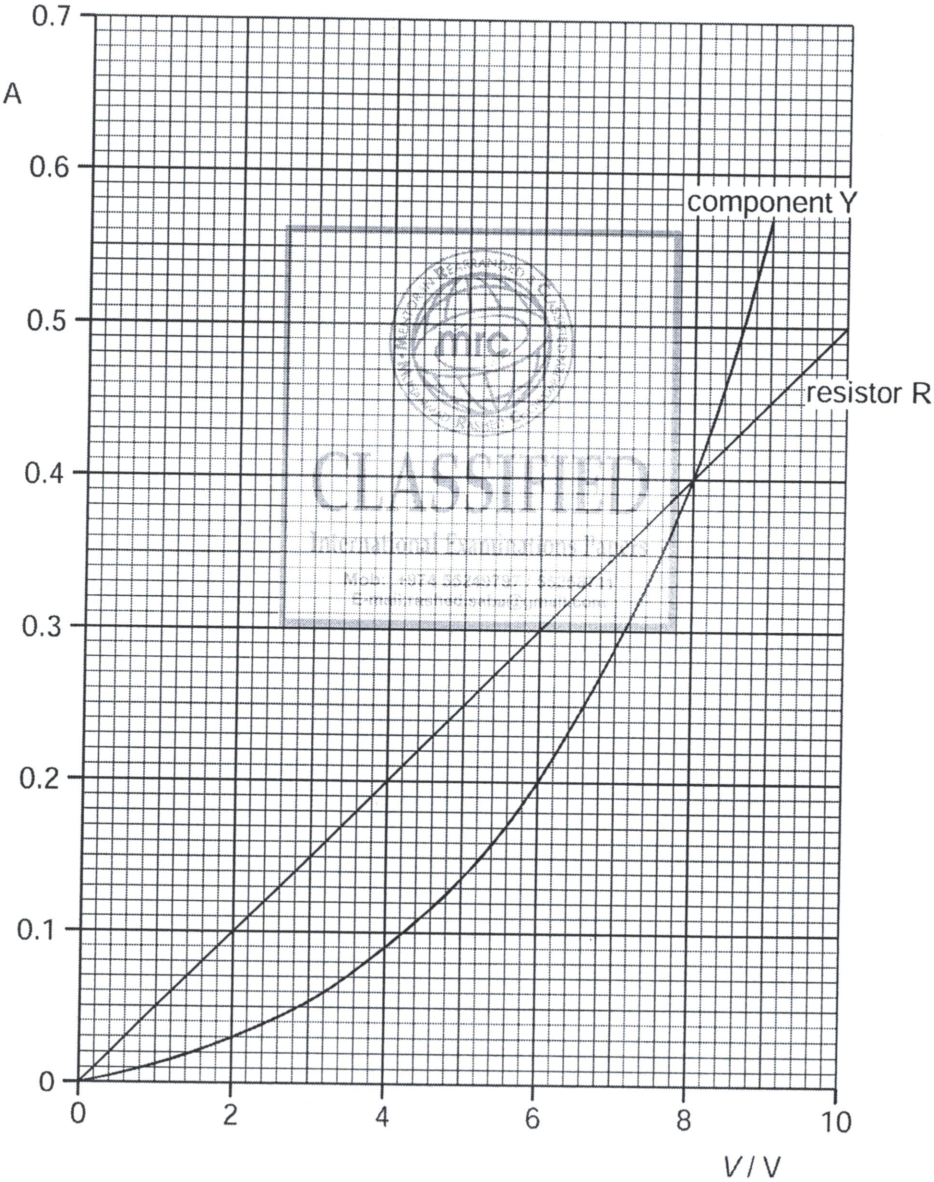


Fig. 6.1

For Examiner's Use

Use Fig. 6.1 to explain how it can be deduced that resistor R has a constant resistance of 20 Ω.

....

....

.... [2]

(c) The component Y and the resistor R in **(b)** are connected in parallel as shown in Fig. 6.2.

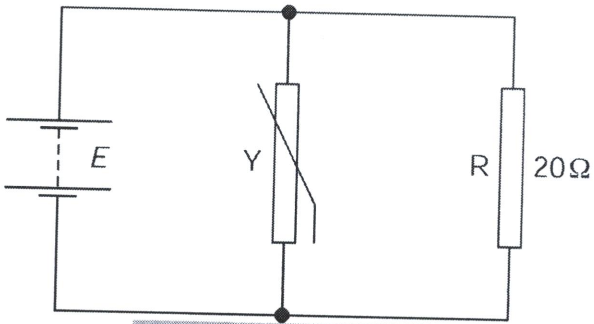


Fig. 6.2

A battery of e.m.f. *E* and negligible internal resistance is connected across the parallel combination.

Use data from Fig. 6.1 to determine

(i) the current in the battery for an e.m.f. *E* of 6.0 V,

current = ... A [1]

(ii) the total resistance of the circuit for an e.m.f. of 8.0 V.

resistance = ... Ω [2]

(d) The circuit of Fig. 6.2 is now re-arranged as shown in Fig. 6.3.

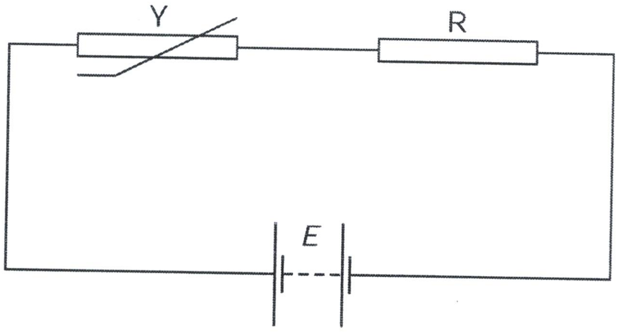


Fig. 6.3

The current in the circuit is 0.20 A.

(i) Use Fig. 6.1 to determine the e.m.f. *E* of the battery.

E = ... V [1]

(ii) Calculate the total power dissipated in component Y and resistor R.

power = ... W [2]

0 9 **(a)** Describe the I–V characteristic of

(i) a metallic conductor at constant temperature,

....

....[1]

(ii) a semiconductor diode.

....

....

....[2]

(b) Two identical filament lamps are connected in series and then in parallel to a battery of electromotive force (e.m.f.) 12 V and negligible internal resistance, as shown in Fig. 6.1a and Fig. 6.1b.

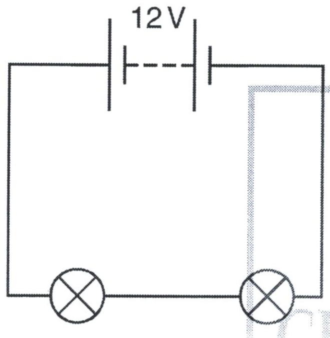


Fig. 6.1a

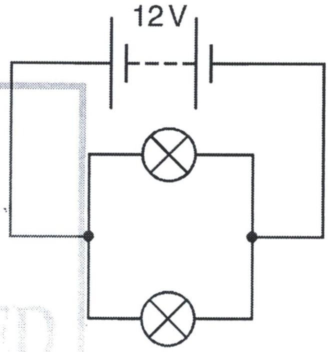


Fig. 6.1b

The I–V characteristic of each lamp is shown in Fig. 6.2.

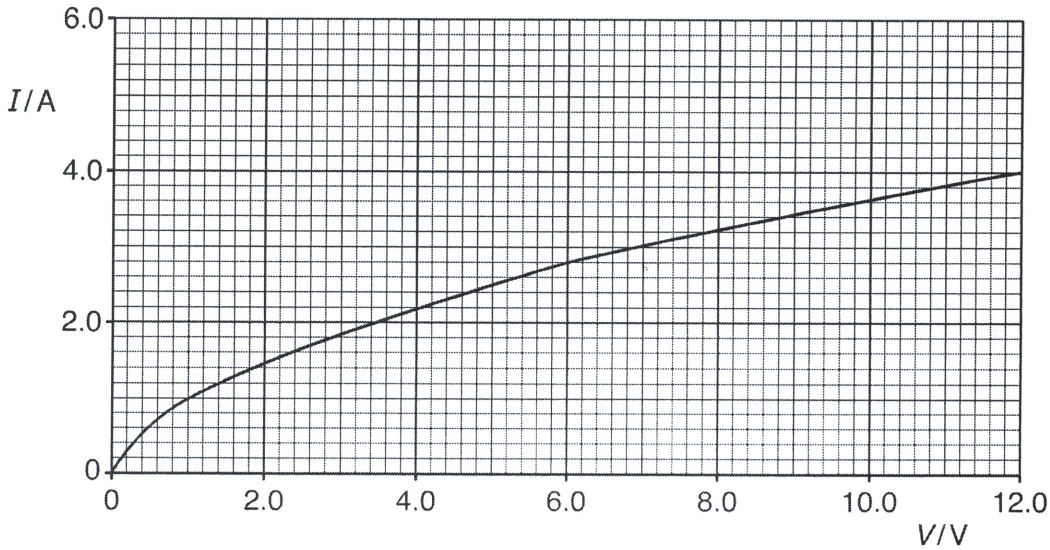


Fig. 6.2

(i) Use the information shown in Fig. 6.2 to determine the current through the battery in

1. the circuit of Fig. 6.1a,

current = ...A

2. the circuit of Fig. 6.1b.

current = ...A
[3]

(ii) Calculate the total resistance in

1. the circuit of Fig. 6.1a,

resistance = ...Ω

2. the circuit of Fig. 6.1b.

resistance = ...Ω
[3]

(iii) Calculate the ratio

$$\frac{\text{power dissipated in a lamp in the circuit of Fig. 6.1a}}{\text{power dissipated in a lamp in the circuit of Fig. 6.1b}}.$$

ratio = ...[2]

[Total: 11]

10 The variation with potential difference (p.d.) V of current I for a semiconductor diode is shown in Fig. 5.1.

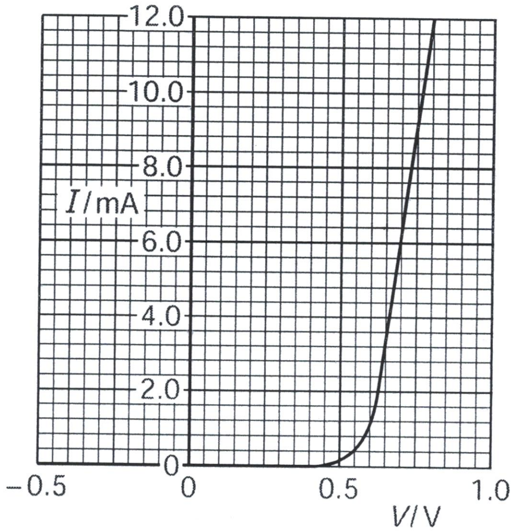


Fig. 5.1

(a) Use Fig. 5.1 to describe the variation of the resistance of the diode between $V = -0.5\,V$ and $V = 0.8\,V$.

....

....

....

.... [2]

(b) On Fig. 5.2, sketch the variation with p.d. V of current I for a filament lamp. Numerical values are not required.

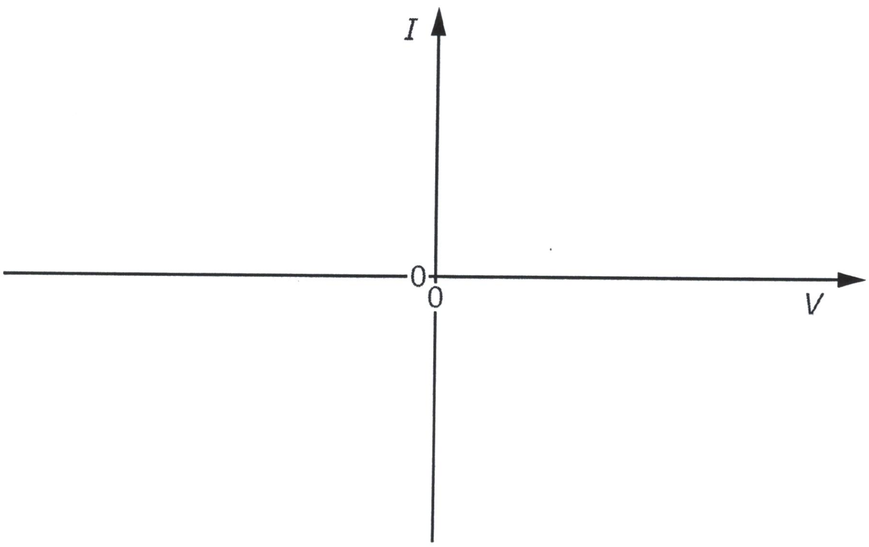


Fig. 5.2

[2]

(c) Fig. 5.3 shows a power supply of electromotive force (e.m.f.) 12V and internal resistance 0.50 Ω connected to a filament lamp and switch.

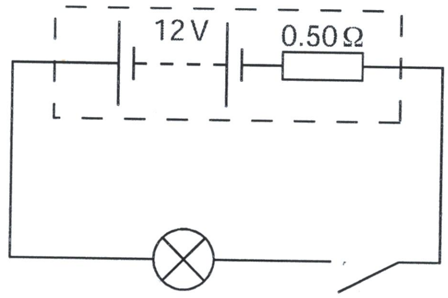


Fig. 5.3

The filament lamp has a power of 36W when the p.d. across it is 12V.

(i) Calculate the resistance of the lamp when the p.d. across it is 12V.

resistance = ... Ω [1]

(ii) The switch is closed and the current in the lamp is 2.8A. Calculate the resistance of the lamp.

resistance = ... Ω [3]

(d) Explain how the two values of resistance calculated in **(c)** provide evidence for the shape of the sketch you have drawn in **(b)**.

....

....[1]

11 Distinguish between *melting* and *evaporation*.

melting: ....

....

....

evaporation: ....

....

....

[4]

7 **(a)** A cell with internal resistance supplies a current. Explain why the terminal potential difference (p.d.) is less than the electromotive force (e.m.f.) of the cell.

....

....

.... [1]

(b) A battery of e.m.f. 12 V and internal resistance 0.50 Ω is connected to a variable resistor X and a resistor Y of constant resistance, as shown in Fig. 7.1.

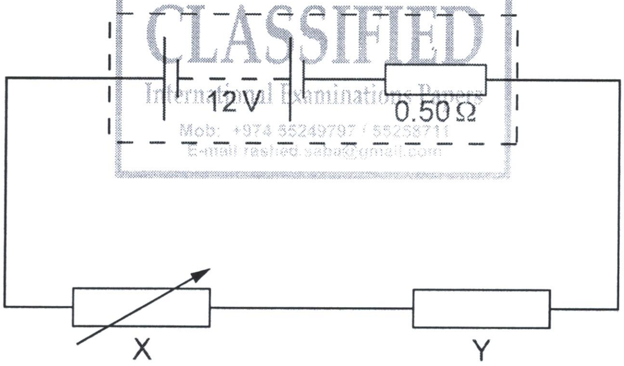


Fig. 7.1

The resistance *R* of X is increased from 2.0 Ω to 16 Ω. The variation with *R* of the current *I* in the circuit is shown in Fig. 7.2.

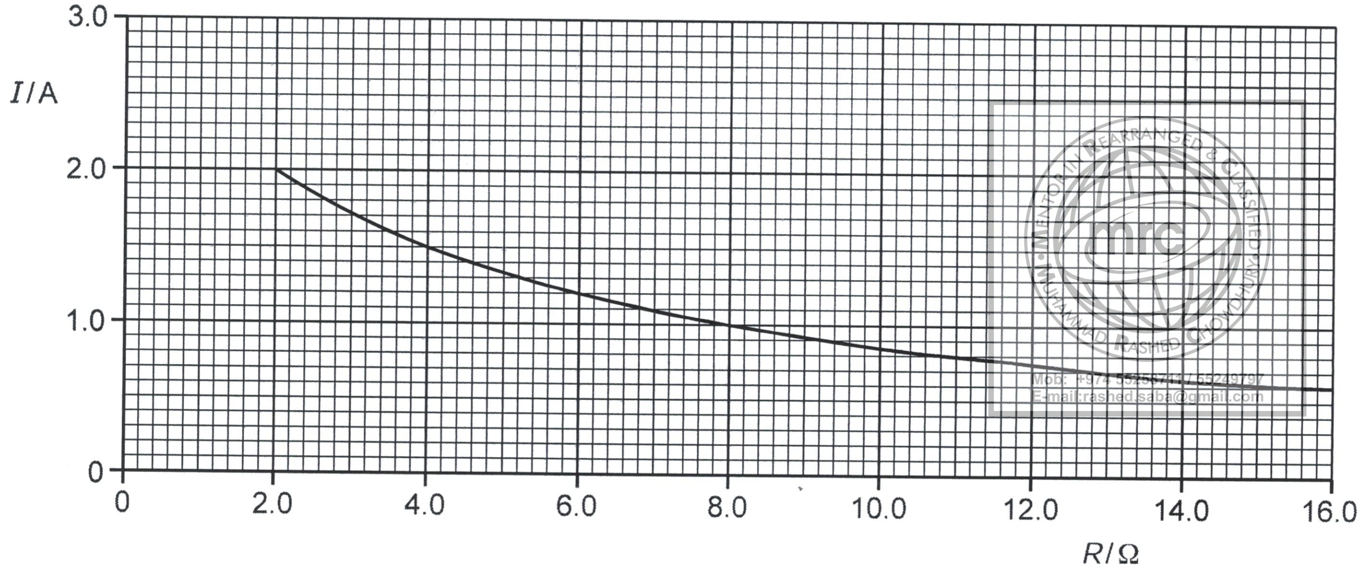


Fig. 7.2

Calculate, for I = 1.2 A,

(i) the p.d. across X,

p.d. = ... V [2]

(ii) the resistance of Y,

resistance = ... Ω [3]

(iii) the power dissipated in the battery.

power = ... W [2]

(c) Use Fig. 7.2 to explain the variation in the terminal p.d. of the battery as the resistance R of X is increased.

....

.... [1]

12 **(a)** Define electrical *resistance*.

....

.... [1]

(b) A circuit is set up to measure the resistance R of a metal wire. The potential difference (p.d.) V across the wire and the current I in the wire are to be measured.

(i) Draw a circuit diagram of the apparatus that could be used to make these measurements.

[3]

(ii) Readings for p.d. V and the corresponding current I are obtained. These are shown in Fig. 2.1.

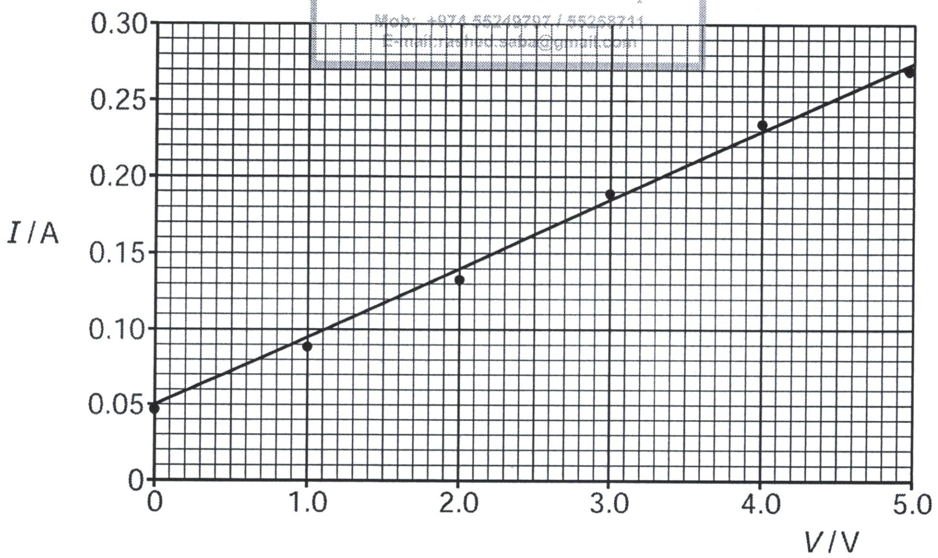


Fig. 2.1

For Examiner's Use

Explain how Fig. 2.1 indicates that the readings are subject to

1. a systematic uncertainty,

....

.... [1]

2. random uncertainties.

....

.... [1]

(iii) Use data from Fig. 2.1 to determine *R*. Explain your working.

R = ... Ω [3]

(c) In another experiment, a value of *R* is determined from the following data:

Current $I = 0.64 \pm 0.01$ A and p.d. $V = 6.8 \pm 0.1$ V.

Calculate the value of *R*, together with its uncertainty. Give your answer to an appropriate number of significant figures.

R = ... ± ....Ω [3]

13 The resistance R of a uniform metal wire is measured for different lengths l of the wire. The variation with l of R is shown in Fig. 3.1.

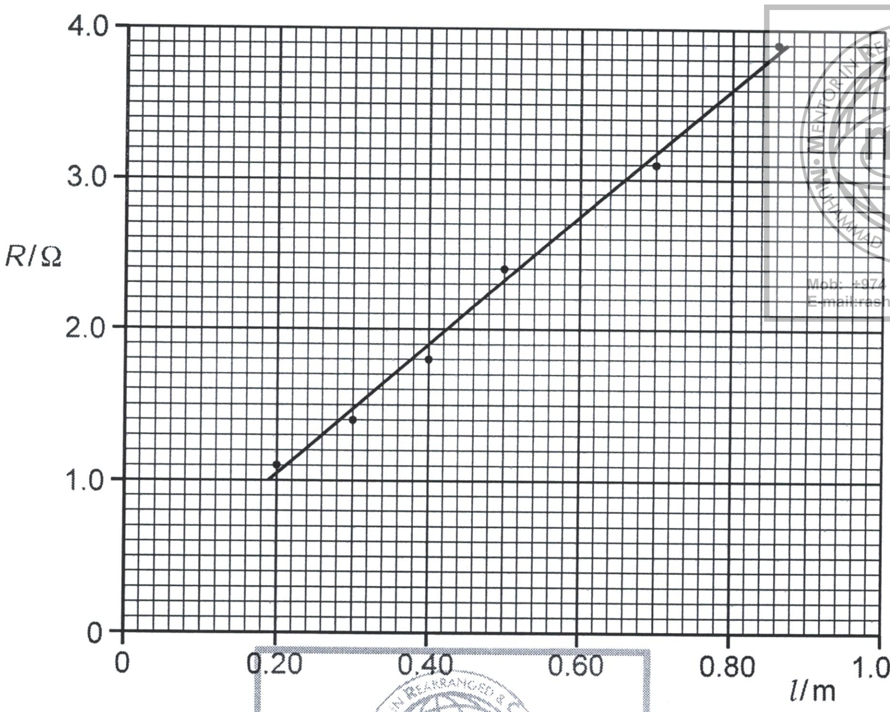


Fig. 3.1

(a) The points shown in Fig. 3.1 do not lie on the best-fit line. Suggest a reason for this.

....

.... [1]

(b) Determine the gradient of the line shown in Fig. 3.1.

gradient = ... [2]

(c) The cross-sectional area of the wire is 0.12 mm^2.

Use your answer in **(b)** to determine the resistivity of the metal of the wire.

resistivity = ... Ωm [3]

(d) The resistance R of different wires is measured. The wires are of the same metal and same length but have different cross-sectional areas A.

On Fig. 3.2, sketch a graph to show the variation with A of R.

Fig. 3.2

[2]

14 **(a)** Define the *ohm*.

.... [1]

For Examiner's Use

(b) Determine the SI base units of **resistivity**.

base units of resistivity = ... [3]

(c) A cell of e.m.f. 2.0V and negligible internal resistance is connected to a variable resistor R and a metal wire, as shown in Fig. 5.1.

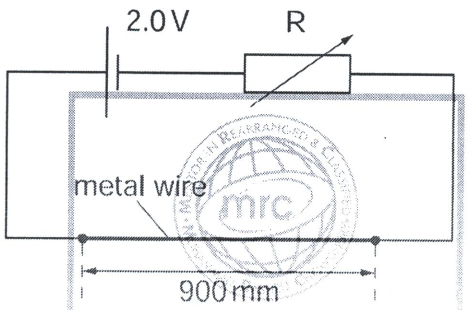


Fig. 5.1

The wire is 900mm long and has an area of cross-section of $1.3 \times 10^{-7}\,m^2$. The resistance of the wire is 3.4Ω.

(i) Calculate the resistivity of the metal wire.

resistivity = ... [2]

(ii) The resistance of R may be varied between 0 and 1500 Ω.
Calculate the maximum potential difference (p.d.) and minimum p.d. possible across the wire.

maximum p.d. = ... V

minimum p.d. = ... V
[2]

(iii) Calculate the power transformed in the wire when the potential difference across the wire is 2.0 V.

power = ... W [2]

(d) Resistance R in **(c)** is now replaced with a different variable resistor Q. State the power transformed in Q, for Q having

(i) zero resistance,

power = ... W [1]

(ii) infinite resistance.

power = ... W [1]

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

For Examiner's Use

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.

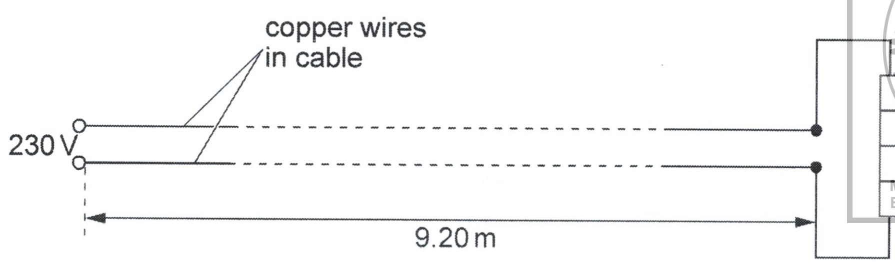


Fig. 8.1

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.

For Examiner's Use

power = ... W [3]

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

1. ....

....

2. ....

....

[2]

Please turn over for Question 9.

16 The variation with temperature of the resistance R_T of a thermistor is shown in Fig. 6.1.

For Examiner's Use

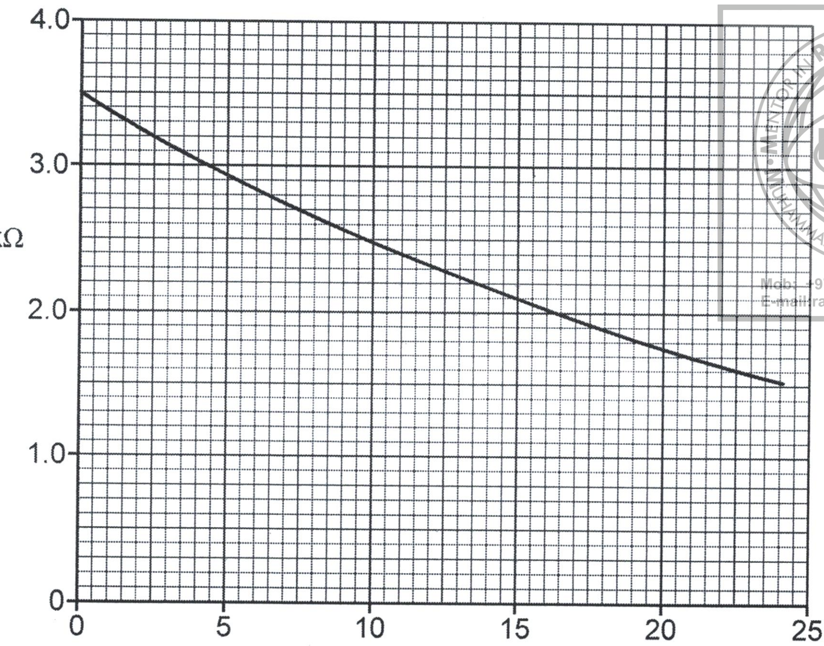


Fig. 6.1

The thermistor is connected into the circuit of Fig. 6.2.

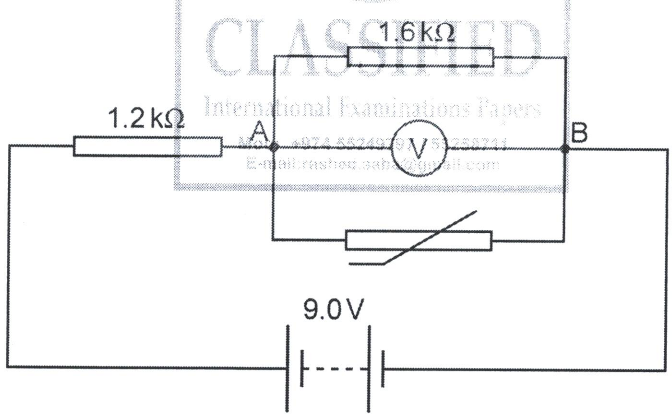


Fig. 6.2

The battery has e.m.f. 9.0V and negligible internal resistance. The voltmeter has infinite resistance.

For Examiner's Use

(a) For the thermistor at 22.5 °C, calculate

(i) the total resistance between points A and B on Fig. 6.2,

resistance = ... Ω [2]

(ii) the reading on the voltmeter.

voltmeter reading = ... V [2]

(b) The temperature of the thermistor is changed. The voltmeter now reads 4.0V. Determine

(i) the total resistance between points A and B on Fig. 6.2,

resistance = ... Ω [2]

(ii) the temperature of the thermistor.

For Examiner's Use

temperature = ... °C [2]

(c) A student suggests that the voltmeter, reading up to 10 V, could be calibrated to measure temperature.

Suggest two disadvantages of using the circuit of Fig. 6.2 with this voltmeter for the measurement of temperature in the range 0 °C to 25 °C.

1. ....

....

2. ....

....
[2]

For Examiner's Use

17 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 7.9×10^{-7} Ω 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]

18 A thermistor has resistance 3900 Ω at 0 °C and resistance 1250 Ω at 30 °C. The thermistor is connected into the circuit of Fig. 8.1 in order to monitor temperature changes.

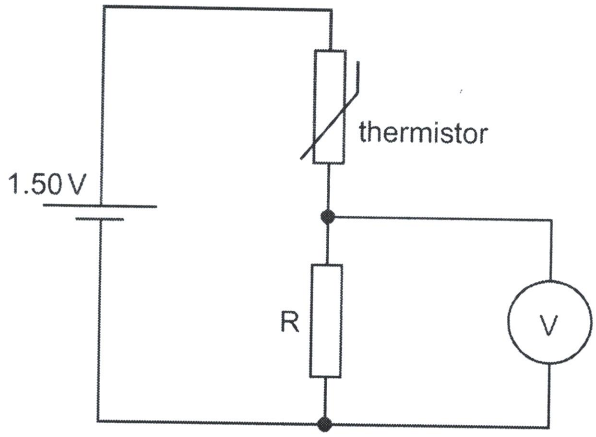


Fig. 8.1

The battery of e.m.f. 1.50 V has negligible internal resistance and the voltmeter has infinite resistance.

(a) The voltmeter is to read 1.00 V at 0 °C. Show that the resistance of resistor R is 7800 Ω.

[2]

(b) The temperature of the thermistor is increased to 30 °C. Determine the reading on the voltmeter.

reading = ... V [2]

(c) The voltmeter in Fig. 8.1 is replaced with one having a resistance of 7800 Ω. Calculate the reading on this voltmeter for the thermistor at a temperature of 0 °C.

reading = ... V [2]

For Examiner's Use

19 An electric heater is to be made from nichrome wire. Nichrome has a resistivity of $1.0 \times 10^{-6}\,\Omega\,m$ at the operating temperature of the heater.
The heater is to have a power dissipation of 60 W when the potential difference across its terminals is 12 V.

(a) For the heater operating at its designed power,

(i) calculate the current,

current = ... A [2]

(ii) show that the resistance of the nichrome wire is 2.4 Ω.

[2]

(b) Calculate the length of nichrome wire of diameter 0.80 mm required for the heater.

length = ... m [3]

(c) A second heater, also designed to operate from a 12V supply, is constructed using the same nichrome wire but using half the length of that calculated in **(b)**.
Explain quantitatively the effect of this change in length of wire on the power of the heater.

....

....

....

.... [3]

5 **(a)** **(i)** On Fig. 5.1, sketch the I – V characteristic for a filament lamp.

Fig. 5.1

[2]

(ii) Explain how the resistance of the lamp may be calculated for any voltage from its I – V characteristic.

....

.... [1]

(b) Two identical filament lamps are connected first in series, and then in parallel, to a 12 V power supply that has negligible internal resistance. The circuits are shown in Fig. 5.2 and Fig. 5.3 respectively.

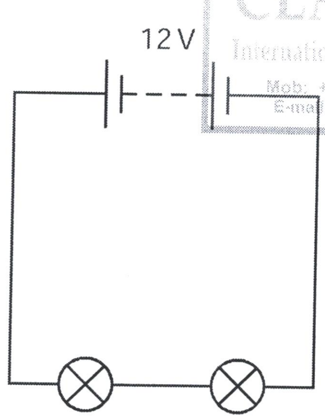


Fig. 5.2

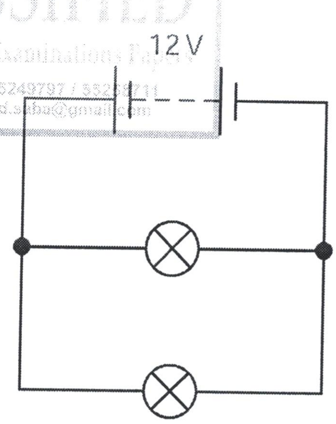


Fig. 5.3

(i) State and explain why the resistance of each lamp when they are connected in series is different from the resistance of each lamp when they are connected in parallel.

For Examiner's Use

....

....

....

....

.... [3]

(ii) Each lamp is marked with a rating '12 V, 50 W'. Calculate the total resistance of the circuit for the two lamps connected such that each lamp uses this power.

total resistance = ... Ω [3]

21 **(a)** On Fig. 5.1, sketch the temperature characteristic of a thermistor.

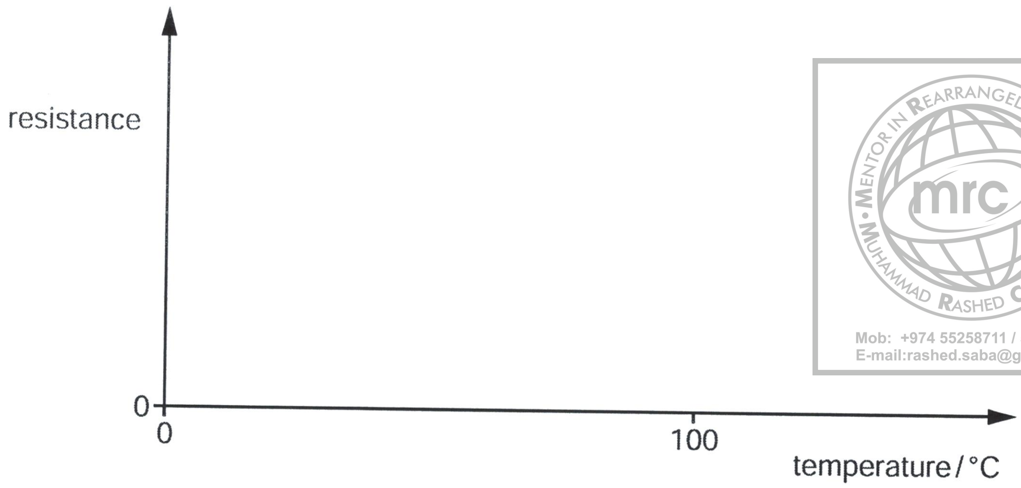


Fig. 5.1

[2]

(b) A potential divider circuit is shown in Fig. 5.2.

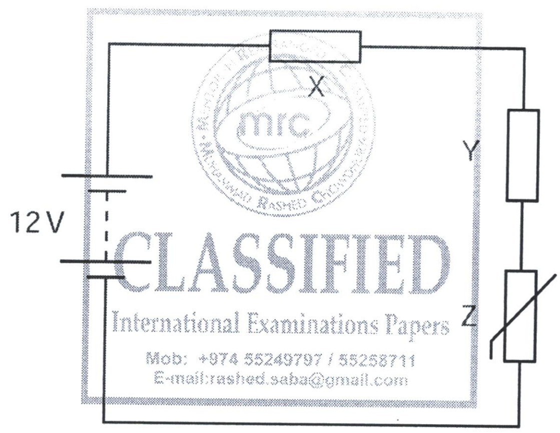


Fig. 5.2

The battery of electromotive force (e.m.f.) 12 V and negligible internal resistance is connected in series with resistors X and Y and thermistor Z. The resistance of Y is 15 kΩ and the resistance of Z at a particular temperature is 3.0 kΩ. The potential difference (p.d.) across Y is 8.0 V.

(i) Explain why the power transformed in the battery equals the total power transformed in X, Y and Z.

.... [1]

(ii) Calculate the current in the circuit.

current = ... A [2]

(iii) Calculate the resistance of X.

resistance = ... Ω [3]

(iv) The temperature of Z is increased.

State and explain the effect on the potential difference across Z.

....

....

....

.... [2]

2 2 A battery is connected in series with resistors X and Y, as shown in Fig. 6.1.

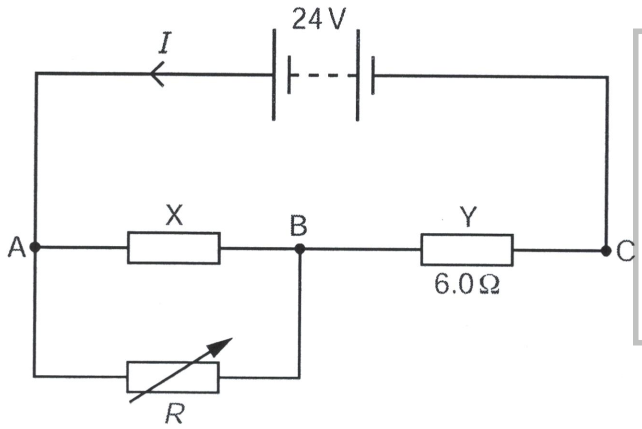


Fig. 6.1

The resistance of X is constant. The resistance of Y is 6.0 Ω. The battery has electromotive force (e.m.f.) 24 V and zero internal resistance. A variable resistor of resistance R is connected in parallel with X.

The current I from the battery is changed by varying R from 5.0 Ω to 20 Ω. The variation with R of I is shown in Fig. 6.2.

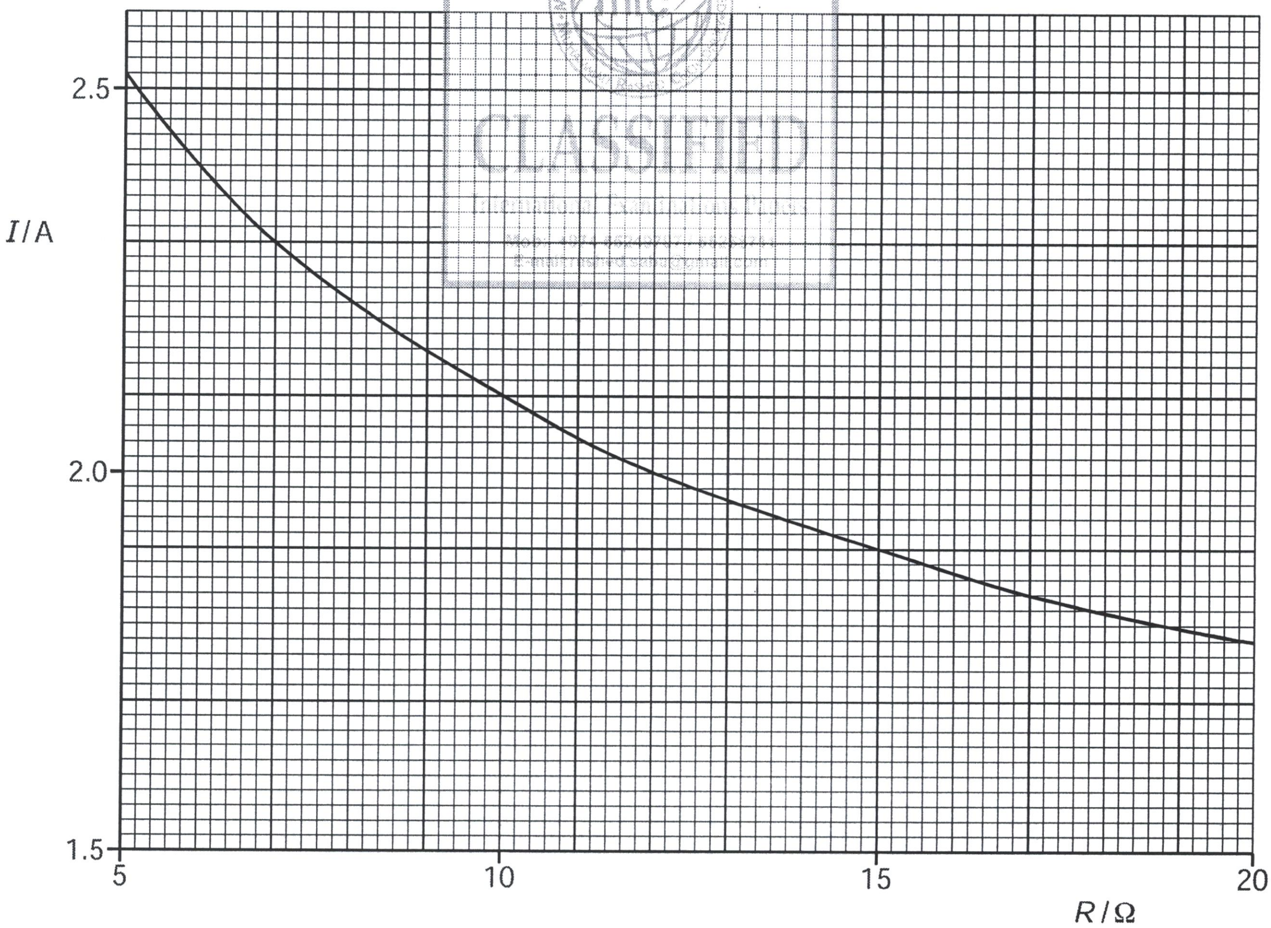


Fig. 6.2

(a) Explain why the potential difference (p.d.) between points A and C is 24 V for all values of R.

....

.... [1]

(b) Use Fig. 6.2 to state and explain the variation of the p.d. across resistor Y as R is increased. Numerical values are not required.

....

....

.... [2]

(c) For $R = 6.0\,\Omega$,

(i) show that the p.d. between points A and B is 9.6 V,

[2]

(ii) calculate the resistance of X,

resistance = ... Ω [3]

(iii) calculate the power provided by the battery.

power = ... W [2]

(d) State and explain qualitatively how the power provided by the battery changes as the resistance R is increased.

....

.... [1]

2 3 **(a)** A metal wire of constant resistance is used in an electric heater.
In order not to overload the circuit for the heater, the supply voltage to the heater is reduced from 230V to 220V.

For Examiner's Use

Determine the percentage reduction in the power output of the heater.

reduction = ... % [2]

(b) A uniform wire AB of length 100cm is connected between the terminals of a cell of e.m.f. 1.5V and negligible internal resistance, as shown in Fig. 6.1.

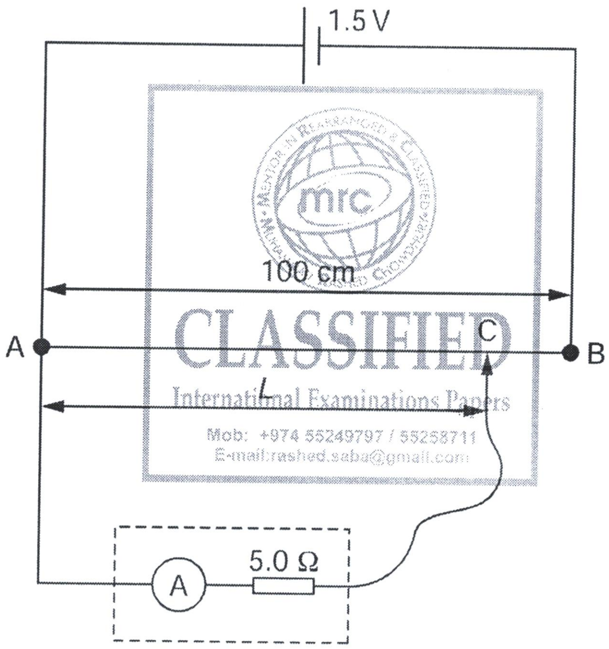


Fig. 6.1

An ammeter of internal resistance 5.0Ω is connected to end A of the wire and to a contact C that can be moved along the wire.

Determine the reading on the ammeter for the contact C placed

(i) at A,

reading = ... A [1]

(ii) at B.

For Examiner's Use

reading = ... A [1]

(c) Using the circuit in **(b)**, the ammeter reading I is recorded for different distances L of the contact C from end A of the wire. Some data points are shown on Fig. 6.2.

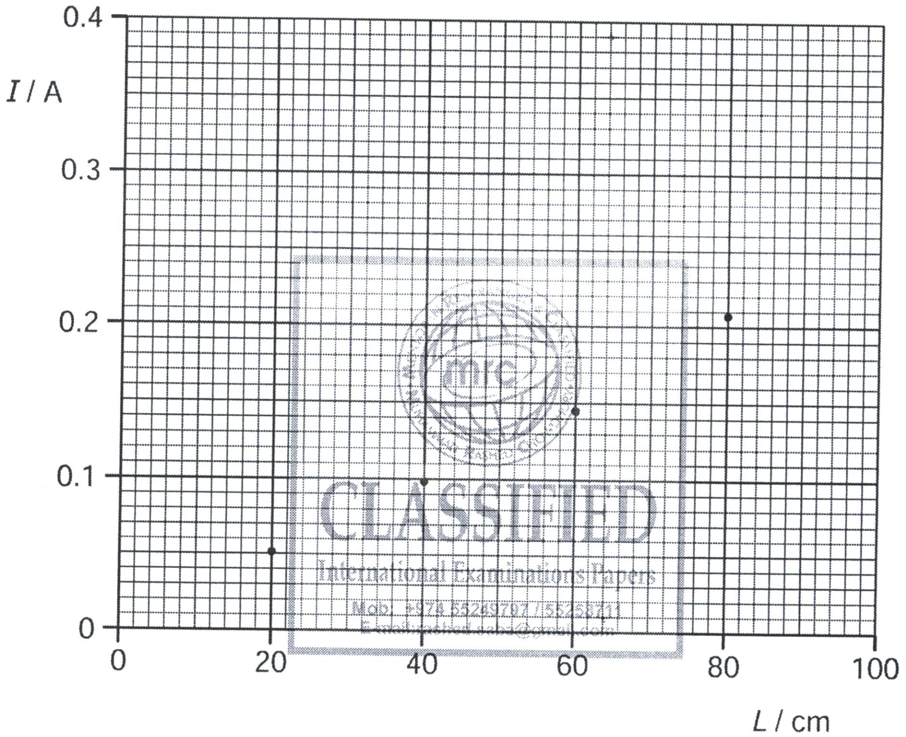


Fig. 6.2

(i) Use your answers in **(b)** to plot data points on Fig. 6.2 corresponding to the contact C placed at end A and at end B of the wire. [1]

(ii) Draw a line of best fit for all of the data points and hence determine the ammeter reading for contact C placed at the midpoint of the wire.

reading = ... A [1]

(iii) Use your answer in **(ii)** to calculate the potential difference between A and the contact C for the contact placed at the midpoint of AB.

For Examiner's Use

potential difference = ... V [2]

(d) Explain why, although the contact C is at the midpoint of wire AB, the answer in **(c)(iii)** is **not** numerically equal to one half of the e.m.f. of the cell.

....

....

.... [2]

For Examiner's Use

2 4 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.

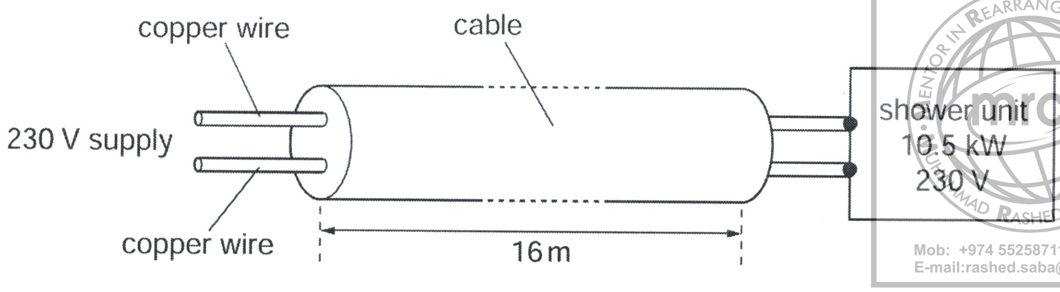


Fig. 6.1

(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 $1.8 \times 10^{-8}\,\Omega$ m.
Assuming that the current in the wires is 46 A, calculate

(i) the maximum resistance of the cable,

resistance = ... Ω [3]

For Examiner's Use

(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 210V, rather than 230V, and that its resistance is unchanged, determine the ratio

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

ratio = ... [2]

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

....

....

.... [2]

25 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.

For Examiner's Use

(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 $\frac{\Delta R}{R}$ is equal to the strain in the wire.

[2]

(b) A steel wire has area of cross-section 1.20×10^{-7} m^2 and a resistance of 4.17 Ω.

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]

26 Two resistors A and B have resistances R_1 and R_2 respectively. The resistors are connected in series with a battery, as shown in Fig. 6.1.

For Examiner's Use

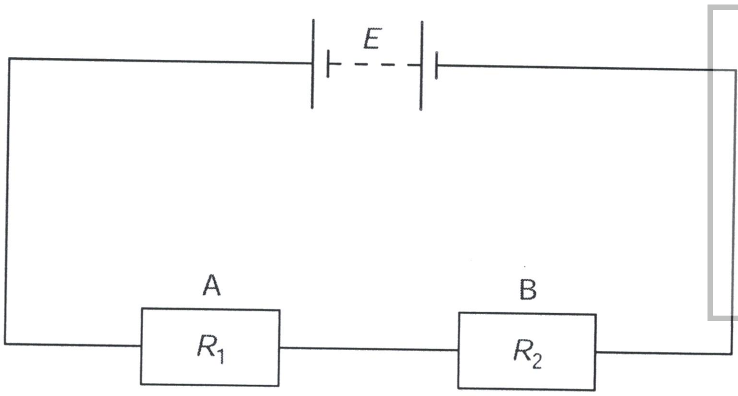


Fig. 6.1

The battery has electromotive force (e.m.f.) E and zero internal resistance.

(a) State the energy transformation that occurs in

(i) the battery,

....

.... [1]

(ii) the resistors.

....

.... [1]

(b) The current in the circuit is I.

State the rate of energy transformation in

(i) the battery,

.... [1]

(ii) the resistor A.

.... [1]

(c) The resistors are made from metal wires. Data for the resistors are given in Fig. 6.2.

resistor	A	B
resistivity of metal	ρ	$\rho/2$
length of wire	l	l
diameter of wire	d	$2d$

Fig. 6.2

Use information from Fig. 6.2 to determine the ratio

$$\frac{\text{power dissipated in A}}{\text{power dissipated in B}}.$$

ratio = ... [3]

(d) The resistors A and B are connected in parallel across the same battery of e.m.f. E. Determine the ratio

$$\frac{\text{power dissipated in A}}{\text{power dissipated in B}}.$$

ratio = ... [2]

27 **(a)** Define *potential difference* (p.d.).

.... [1]

(b) A power supply of e.m.f. 240 V and zero internal resistance is connected to a heater as shown in Fig. 6.1.

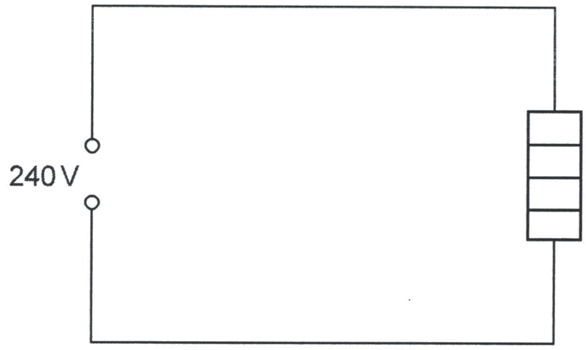


Fig. 6.1

The wires used to connect the heater to the power supply each have length 75 m. The wires have a cross-sectional area 2.5 mm^2 and resistivity 18 nΩ m. The heater has a constant resistance of 38 Ω.

(i) Show that the resistance of each wire is 0.54 Ω.

[3]

(ii) Calculate the current in the wires.

current = ... A [3]

(iii) Calculate the power loss in the wires.

power = ... W [3]

(c) The wires to the heater are replaced by wires of the same length and material but having a cross-sectional area of 0.50 mm^2. Without further calculation, state and explain the effect on the power loss in the wires.

....

....

.... [2]

For Examiner's Use

28 A battery of e.m.f. 4.50 V and negligible internal resistance is connected in series with a fixed resistor of resistance 1200 Ω and a thermistor, as shown in Fig. 7.1.

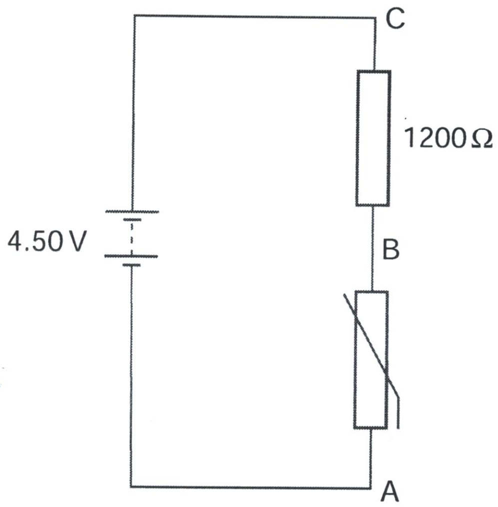


Fig. 7.1

(a) At room temperature, the thermistor has a resistance of 1800 Ω. Deduce that the potential difference across the thermistor (across AB) is 2.70 V.

[2]

(b) A uniform resistance wire PQ of length 1.00 m is now connected in parallel with the resistor and the thermistor, as shown in Fig. 7.2.

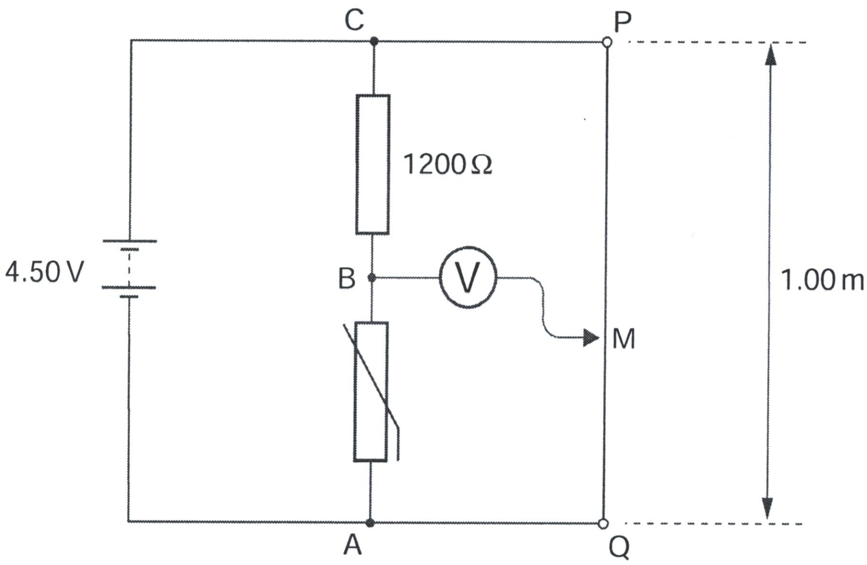


Fig. 7.2

A sensitive voltmeter is connected between point B and a moveable contact M on the wire.

(i) Explain why, for constant current in the wire, the potential difference between any two points on the wire is proportional to the distance between the points.

....

....

....[2]

(ii) The contact M is moved along PQ until the voltmeter shows zero reading.

1. State the potential difference between the contact at M and the point Q.

potential difference = ... V [1]

2. Calculate the length of wire between M and Q.

length = ... cm [2]

(iii) The thermistor is warmed slightly. State and explain the effect on the length of wire between M and Q for the voltmeter to remain at zero deflection.

....

....

....[2]