Electricity

For Examiner's Use

1 A student has available some resistors, each of resistance 100 Ω.

(a) Draw circuit diagrams, one in each case, to show how a number of these resistors may be connected to produce a combined resistance of

(i) 200 Ω,

(ii) 50 Ω,

(iii) 40 Ω.

[4]

(b) The arrangement of resistors shown in Fig. 8.1 is connected to a battery.

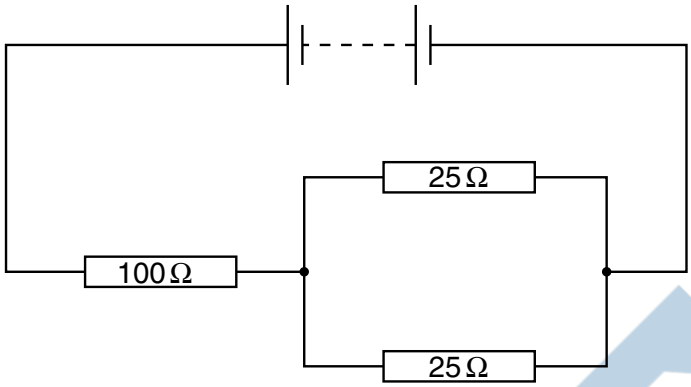

Fig. 8.1

The power dissipation in the 100 Ω resistor is 0.81 W. Calculate

(i) the current in the circuit,

current = ... A

(ii) the power dissipation in each of the 25 Ω resistors.

power = ... W

[4]

2 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 $7.9 \times 10^{-7}\ \Omega$ 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]

3 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.

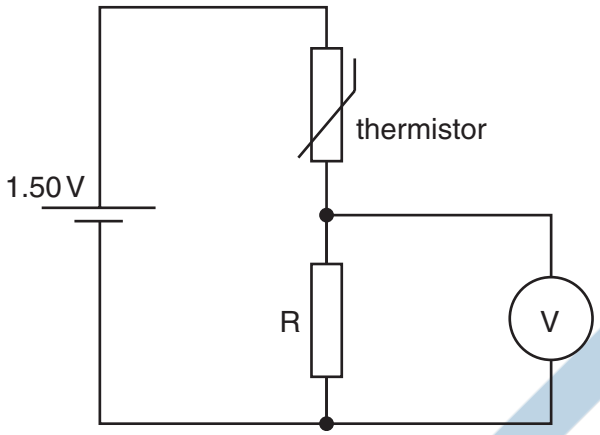

Fig. 8.1

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]

4 **(a)** Define the *resistance* of a resistor.

.....

.....[1]

(b) In the circuit of Fig. 7.1, the battery has an e.m.f. of 3.00 V and an internal resistance *r*. R is a variable resistor. The resistance of the ammeter is negligible and the voltmeter has an infinite resistance.

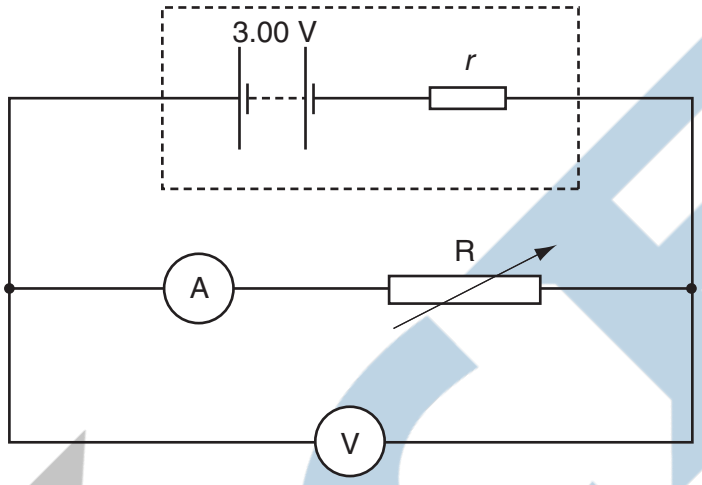

Fig. 7.1

The resistance of R is varied. Fig. 7.2 shows the variation of the power *P* dissipated in R with the potential difference *V* across R.

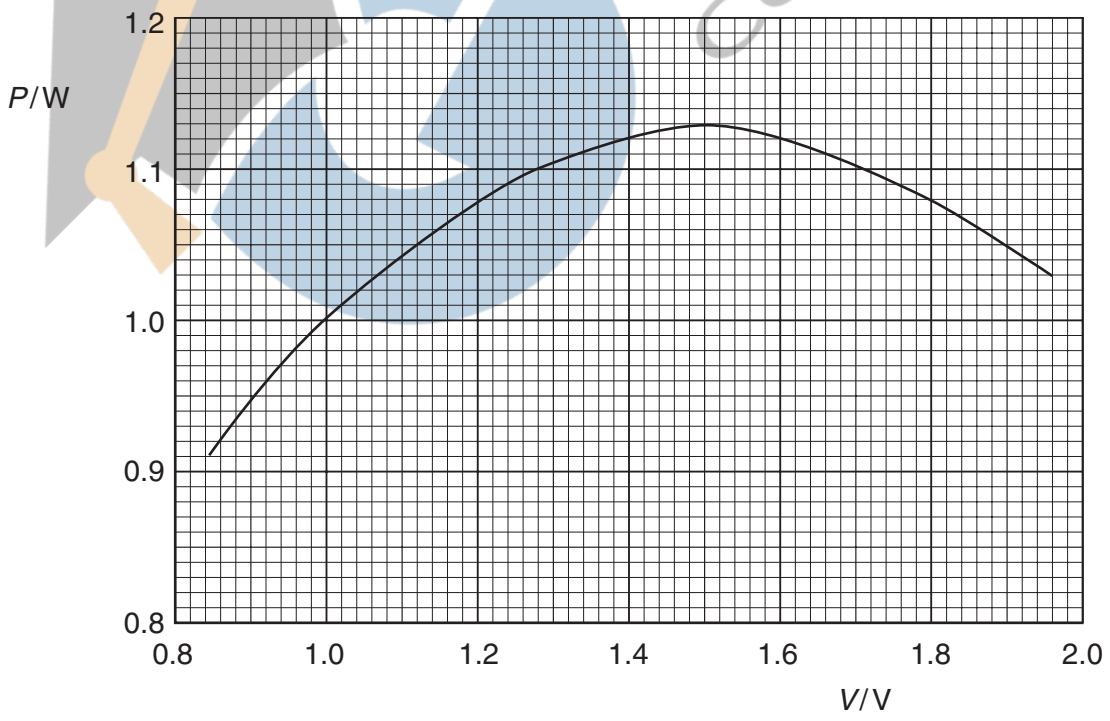

Fig. 7.2

(i) Use Fig. 7.2 to determine

1. the maximum power dissipation in R,

maximum power = ... W

2. the potential difference across R when the maximum power is dissipated.

potential difference = ... V
[1]

(ii) Hence calculate the resistance of R when the maximum power is dissipated.

resistance = ... Ω [2]

(iii) Use your answers in **(i)** and **(ii)** to determine the internal resistance *r* of the battery.

r = ... Ω [3]

(c) By reference to Fig. 7.2, it can be seen that there are two values of potential difference *V* for which the power dissipation is 1.05 W.
State, with a reason, which value of *V* will result in less power being dissipated in the internal resistance.

.....

.....

.....

.....[3]

5 A circuit contains three similar lamps A, B and C. The circuit also contains three switches, S_1, S_2 and S_3, as shown in Fig. 7.1.

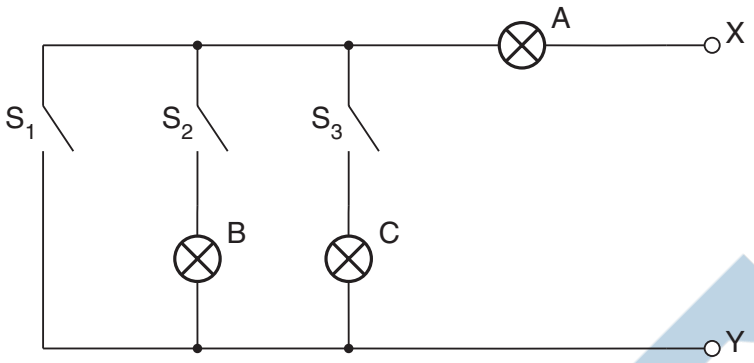

Fig. 7.1

One of the lamps is faulty. In order to detect the fault, an ohm-meter (a meter that measures resistance) is connected between terminals X and Y. When measuring resistance, the ohm-meter causes negligible current in the circuit.

Fig. 7.2 shows the readings of the ohm-meter for different switch positions.

switch			meter reading
S_1	S_2	S_3	/ Ω
open	open	open	∞
closed	open	open	15 Ω
open	closed	open	30 Ω
open	closed	closed	15 Ω

Fig. 7.2

(a) Identify the faulty lamp, and the nature of the fault.

faulty lamp: .....

nature of fault: ..... [2]

(b) Suggest why it is advisable to test the circuit using an ohm-meter that causes negligible current rather than with a power supply.

.....

..... [1]

(c) Determine the resistance of one of the non-faulty lamps, as measured using the ohm-meter.

resistance = ... Ω [1]

(d) Each lamp is marked 6.0 V, 0.20 A.

Calculate, for one of the lamps operating at normal brightness,

(i) its resistance,

resistance = ... Ω [2]

(ii) its power dissipation.

power = ... W [2]

(e) Comment on your answers to **(c)** and **(d)(i)**.

.....

.....

.....[2]

6 A car battery has an internal resistance of 0.060 Ω. It is re-charged using a battery charger having an e.m.f. of 14 V and an internal resistance of 0.10 Ω, as shown in Fig. 6.1.

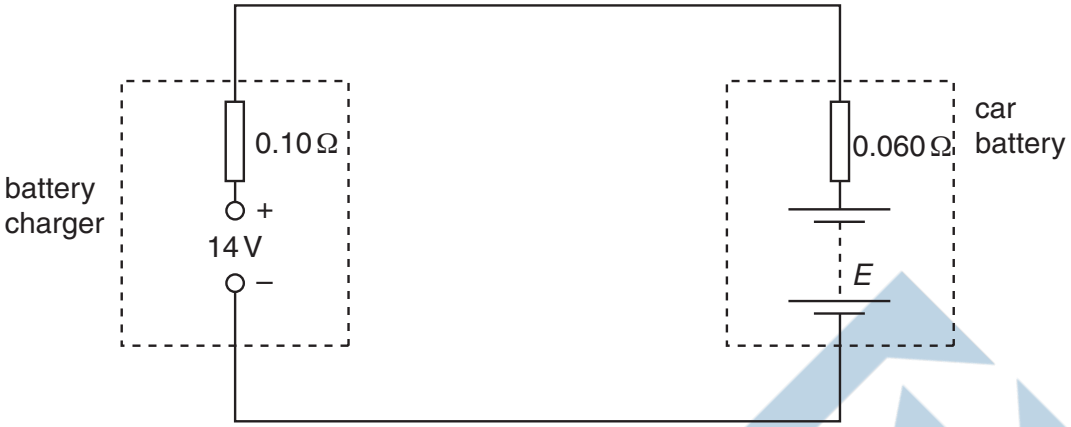

Fig. 6.1

(a) At the beginning of the re-charging process, the current in the circuit is 42 A and the e.m.f. of the battery is *E* (measured in volts).

(i) For the circuit of Fig. 6.1, state

1. the magnitude of the total resistance,

resistance = ... Ω

2. the total e.m.f. in the circuit. Give your answer in terms of *E*.

e.m.f. = ... V

[2]

(ii) Use your answers to **(i)** and data from the question to determine the e.m.f. of the car battery at the beginning of the re-charging process.

e.m.f. = ...V [2]

(b) For the majority of the charging time of the car battery, the e.m.f. of the car battery is 12 V and the charging current is 12.5 A. The battery is charged at this current for 4.0 hours. Calculate, for this charging time,

(i) the charge that passes through the battery,

charge = ... C [2]

(ii) the energy supplied from the battery charger,

energy = ... J [2]

(iii) the total energy dissipated in the internal resistance of the battery charger and the car battery.

energy = ... J [2]

(c) Use your answers in **(b)** to calculate the percentage efficiency of transfer of energy from the battery charger to stored energy in the car battery.

efficiency = ...% [2]

7 An electric heater consists of three similar heating elements A, B and C, connected as shown in Fig. 6.1.

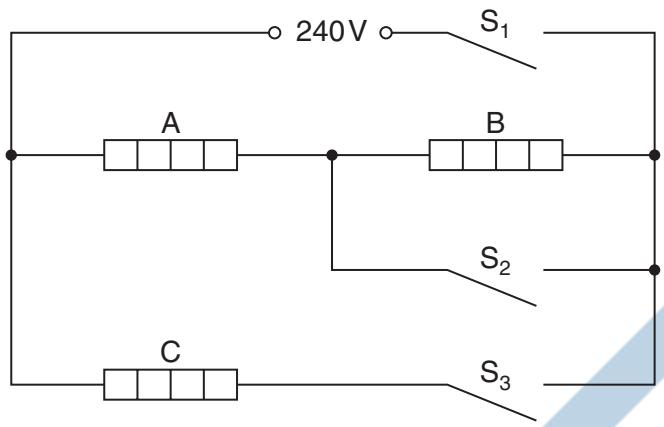

Fig. 6.1

Each heating element is rated as 1.5 kW, 240 V and may be assumed to have constant resistance.
The circuit is connected to a 240 V supply.

(a) Calculate the resistance of one heating element.

resistance = ... Ω [2]

(b) The switches S_1, S_2 and S_3 may be either open or closed.

Complete Fig. 6.2 to show the total power dissipation of the heater for the switches in the positions indicated.

S_1	S_2	S_3	total power / kW
open	closed	closed	.....
closed	closed	open	.....
closed	closed	closed	.....
closed	open	open	.....
closed	open	closed	.....

[5]

Fig. 6.2

8 A network of resistors, each of resistance R, is shown in Fig. 7.1.

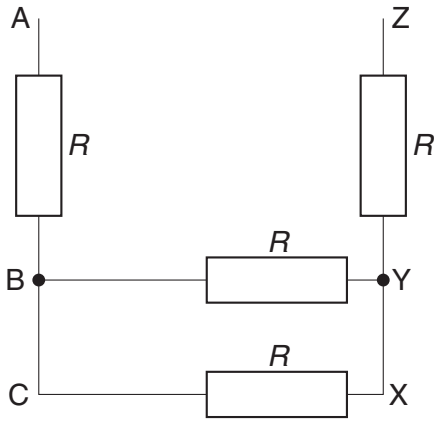

Fig. 7.1

(a) Calculate the total resistance, in terms of R, between points

(i) A and C,

resistance = ... [1]

(ii) B and X,

resistance = ... [1]

(iii) A and Z.

resistance = ... [1]

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(b) Two cells of e.m.f. E_1 and E_2 and negligible internal resistance are connected into the network in **(a)**, as shown in Fig. 7.2.

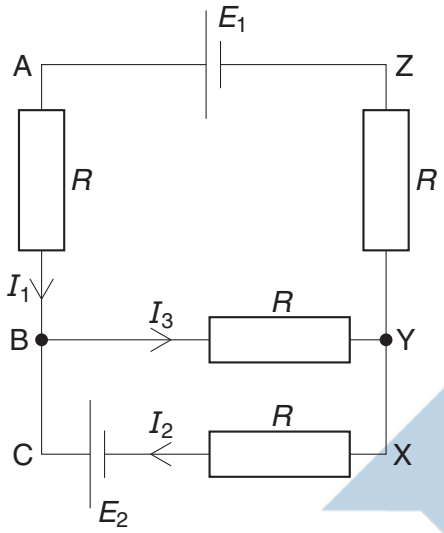

Fig. 7.2

The currents in the network are as indicated in Fig. 7.2.

Use Kirchhoff's laws to state the relation

(i) between currents I_1, I_2 and I_3,

..... [1]

(ii) between E_2, R, I_2 and I_3 in loop BCXYB,

..... [1]

(iii) between E_1, E_2, R, I_1 and I_2 in loop ABCXYZA.

..... [1]

For Examiner's Use

9 **(a)** A student has been asked to make an electric heater. The heater is to be rated as 12 V 60 W, and is to be constructed of wire of diameter 0.54 mm. The material of the wire has resistivity $4.9 \times 10^{-7}\ \Omega\,m$.

(i) Show that the resistance of the heater will be 2.4 Ω.

[2]

(ii) Calculate the length of wire required for the heater.

length = ... m [3]

(b) Two cells of e.m.f. E_1 and E_2 are connected to resistors of resistance R_1, R_2 and R_3 as shown in Fig. 7.1.

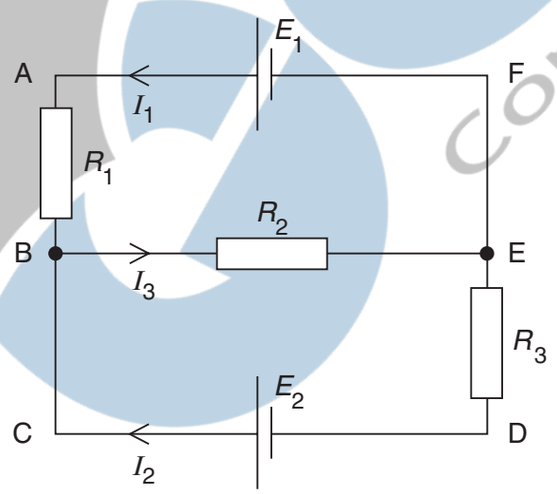

Fig. 7.1

The currents I_1, I_2 and I_3 in the various parts of the circuit are as shown.

(i) Write down an expression relating I_1, I_2 and I_3.

.....[1]

(ii) Use Kirchhoff's second law to write down a relation between

1. E_1, R_1, R_2, I_1 and I_3 for loop ABEFA,

.....

2. E_1, E_2, R_1, R_3, I_1 and I_2 for loop ABCDEFA.

.....
[2]

10 A student set up the circuit shown in Fig. 7.1.

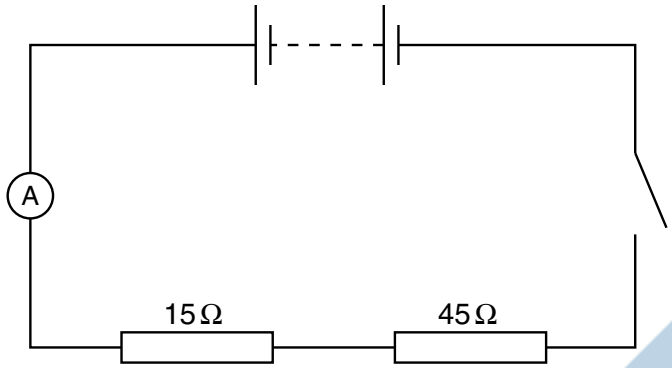

Fig. 7.1

The resistors are of resistance 15 Ω and 45 Ω. The battery is found to provide 1.6×10^5 J of electrical energy when a charge of 1.8×10^4 C passes through the ammeter in a time of 1.3×10^5 s.

(a) Determine

(i) the electromotive force (e.m.f.) of the battery,

e.m.f. = ... V

(ii) the average current in the circuit.

current = ... A

[4]

(b) During the time for which the charge is moving, 1.1×10^5 J of energy is dissipated in the 45 Ω resistor.

(i) Determine the energy dissipated in the 15 Ω resistor during the same time.

energy = ... J

(ii) Suggest why the total energy provided is greater than that dissipated in the two resistors.

.....

.....

[4]

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

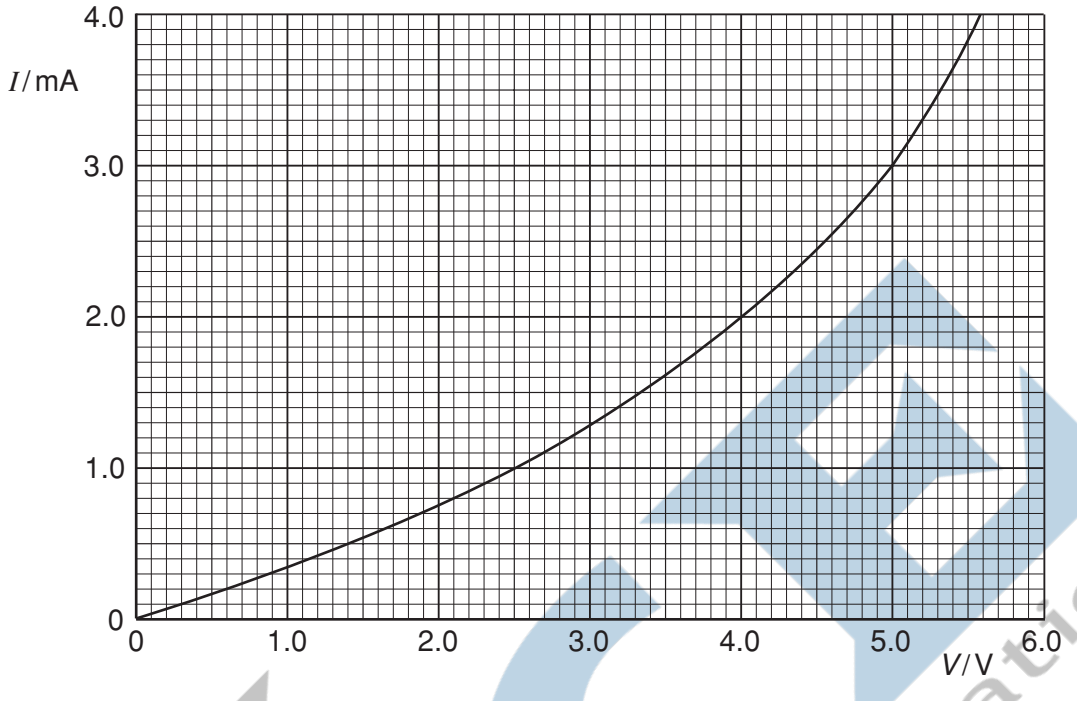

Fig. 6.1

(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.

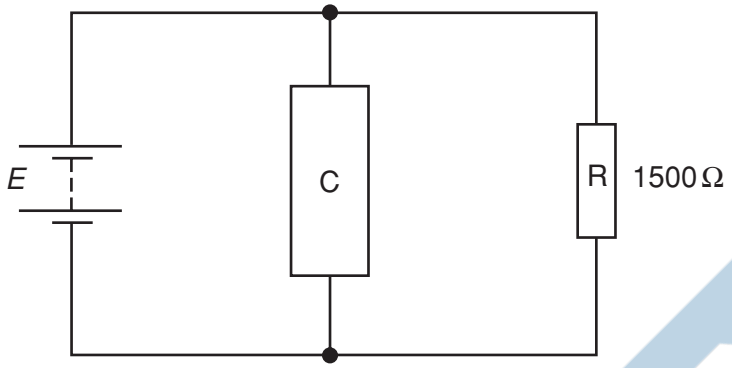

Fig. 6.2

(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]

12 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.

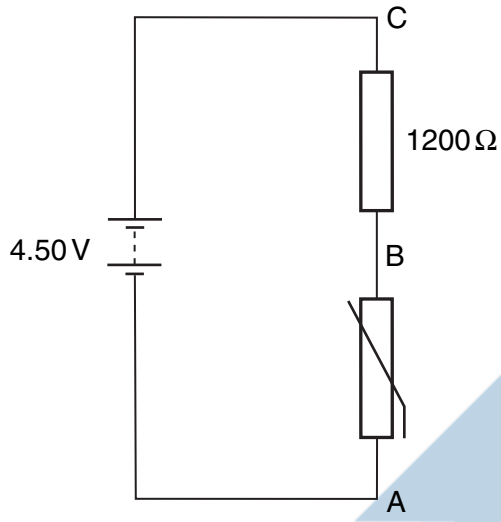

Fig. 7.1

(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.

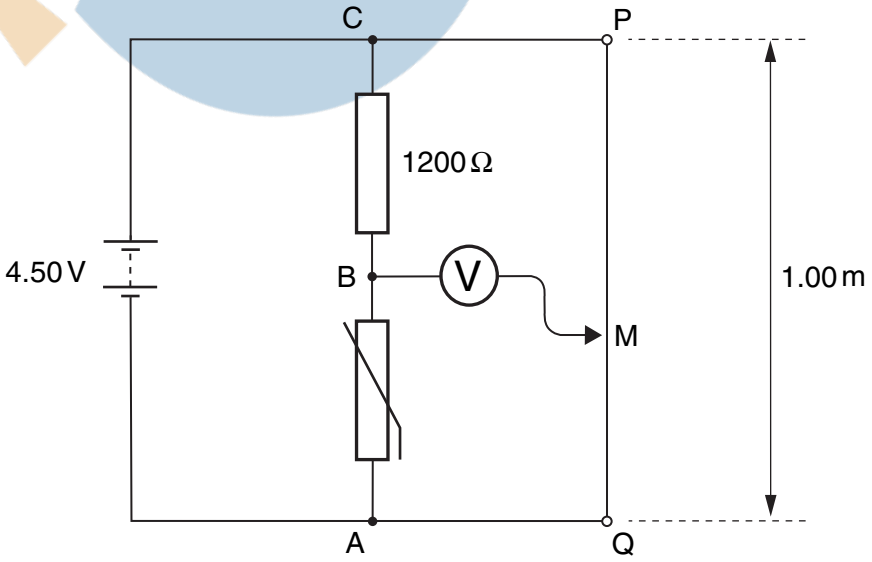

Fig. 7.2

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

For Examiner's Use

(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]

13 **(a)** Distinguish between the electromotive force (e.m.f.) of a cell and the potential difference (p.d.) across a resistor.

.....

.....

.....

..... [3]

(b) Fig. 7.1. is an electrical circuit containing two cells of e.m.f. E_1 and E_2.

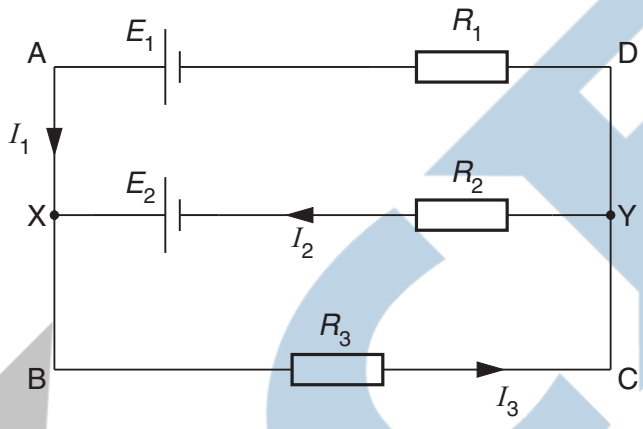

Fig. 7.1

The cells are connected to resistors of resistance R_1, R_2 and R_3 and the currents in the branches of the circuit are I_1, I_2 and I_3, as shown.

(i) Use Kirchhoff's first law to write down an expression relating I_1, I_2 and I_3.

..... [1]

(ii) Use Kirchhoff's second law to write down an expression relating

1. E_2, R_2, R_3, I_2 and I_3 in the loop XBCYX,

..... [1]

2. E_1, E_2, R_1, R_2, I_1 and I_2 in the loop AXYDA.

..... [1]

14 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.

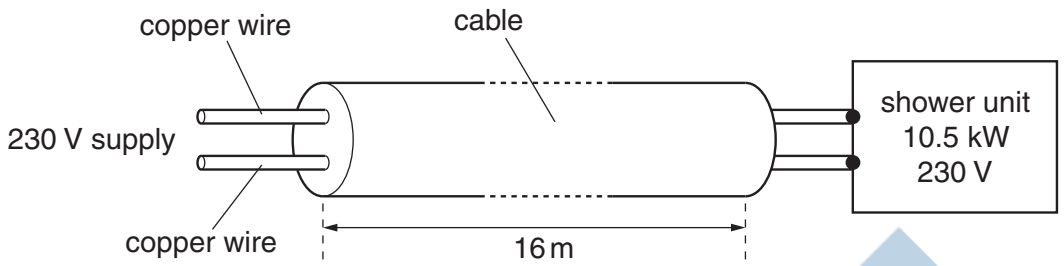

Fig. 6.1

(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]

(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

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

ratio = ... [2]

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

.....

.....

..... [2]

15 A potential divider circuit consists of two resistors of resistances P and Q, as shown in Fig. 7.1.

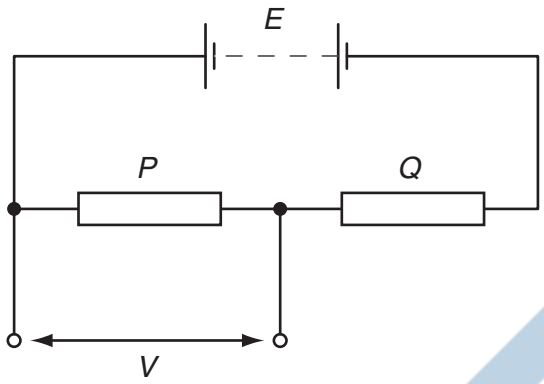

Fig. 7.1

The battery has e.m.f. E and negligible internal resistance.

(a) Deduce that the potential difference V across the resistor of resistance P is given by the expression

$$V = \frac{P}{P + Q} E.$$

[2]

(b) The resistances *P* and *Q* are 2000 Ω and 5000 Ω respectively.
A voltmeter is connected in parallel with the 2000 Ω resistor and a thermistor is connected in parallel with the 5000 Ω resistor, as shown in Fig. 7.2.

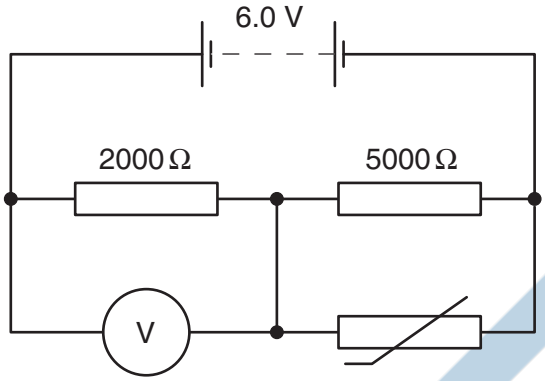

Fig. 7.2

The battery has e.m.f. 6.0 V. The voltmeter has infinite resistance.

(i) State and explain qualitatively the change in the reading of the voltmeter as the temperature of the thermistor is raised.

.....

.....

.....

..... [3]

(ii) The voltmeter reads 3.6 V when the temperature of the thermistor is 19 °C.
Calculate the resistance of the thermistor at 19 °C.

resistance = ... Ω [4]

16 A cell has electromotive force (e.m.f.) E and internal resistance r. It is connected in series with a variable resistor R, as shown in Fig. 6.1.

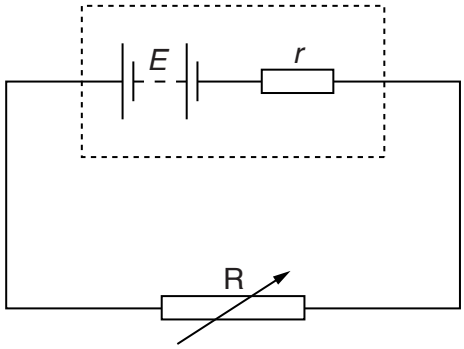

Fig. 6.1

(a) Define electromotive force (e.m.f.).

.....

.....

..... [2]

(b) The variable resistor R has resistance X. Show that

$$\frac{\text{power dissipated in resistor R}}{\text{power produced in cell}} = \frac{X}{X + r}.$$

[3]

(c) The variation with resistance X of the power P_R dissipated in R is shown in Fig. 6.2.

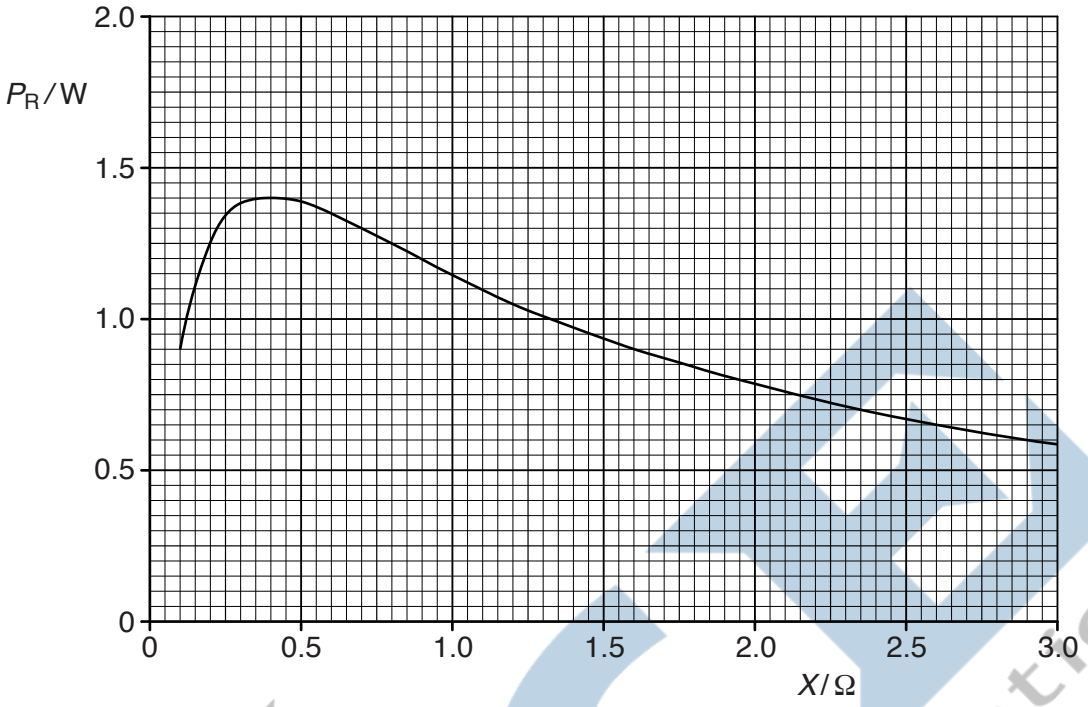

Fig. 6.2

(i) Use Fig. 6.2 to state, for maximum power dissipation in resistor R, the magnitude of this power and the resistance of R.

maximum power = ... W

resistance = ... Ω
[2]

(ii) The cell has e.m.f. 1.5 V.
Use your answers in **(i)** to calculate the internal resistance of the cell.

internal resistance = ... Ω [3]

(d) In Fig. 6.2, it can be seen that, for larger values of X, the power dissipation decreases. Use the relationship in **(b)** to suggest one advantage, despite the lower power output, of using the cell in a circuit where the resistance X is larger than the internal resistance of the cell.

.....

..... [1]

17 **(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.

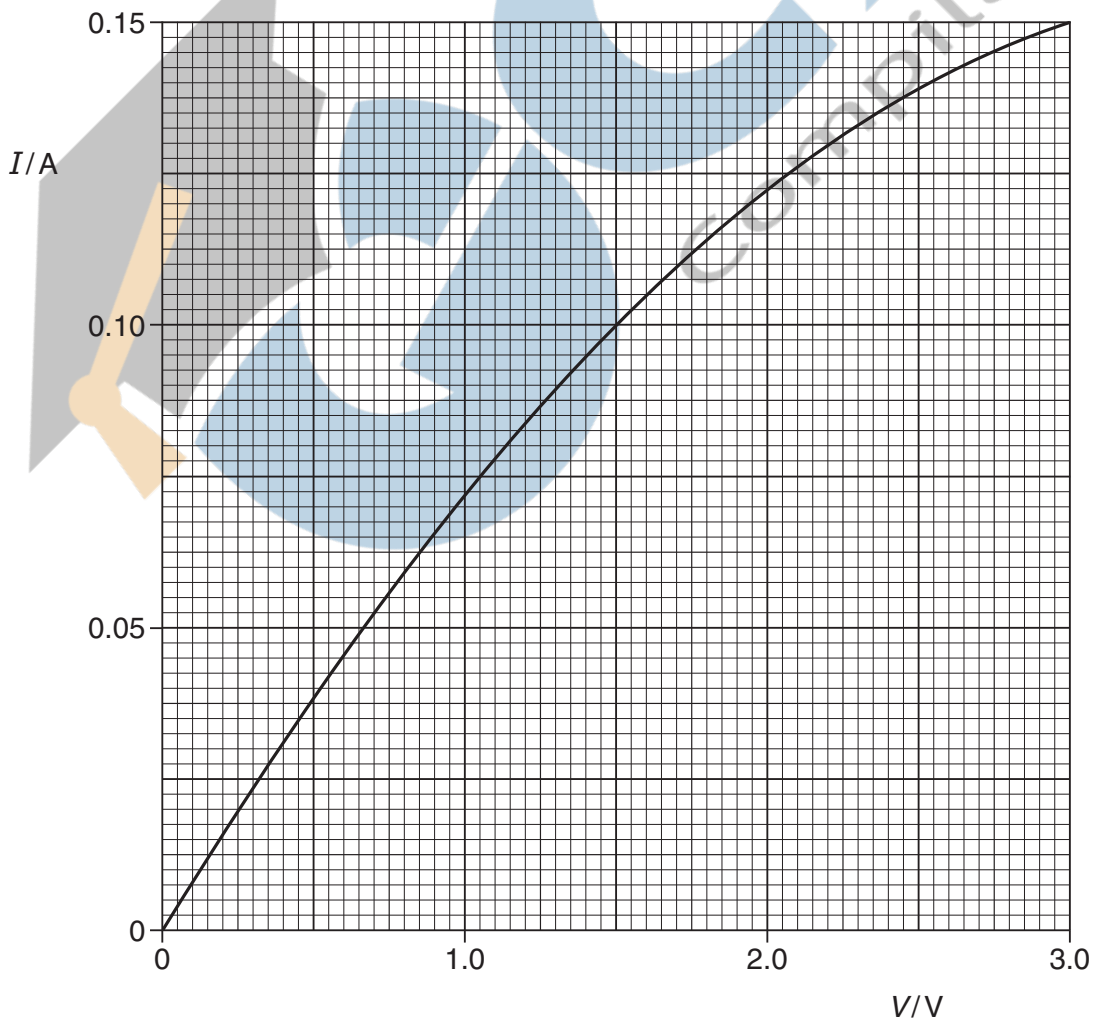

Fig. 6.1

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

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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]

For Examiner's Use

18 **(a)** A network of resistors, each of resistance *R*, is shown in Fig. 7.1.

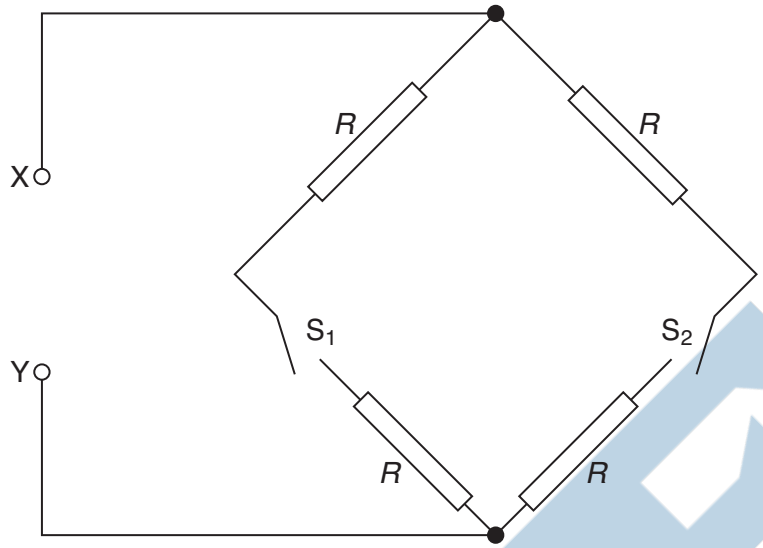


Fig. 7.1

Switches S_1 and S_2 may be 'open' or 'closed'.

Complete Fig. 7.2 by calculating the resistance, in terms of *R*, between points X and Y for the switches in the positions shown.

switch S_1	switch S_2	resistance between points X and Y
open	open	.....
open	closed	.....
closed	closed	.....

Fig. 7.2

[3]

For Examiner's Use

(b) Two cells of e.m.f. E_1 and E_2 and negligible internal resistance are connected into a network of resistors, as shown in Fig. 7.3.

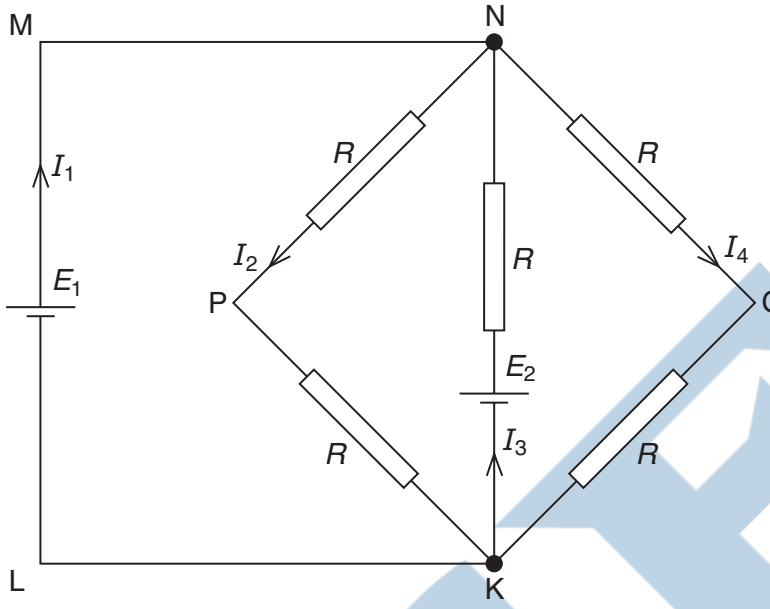


Fig. 7.3

The currents in the network are as indicated in Fig. 7.3.

Use Kirchhoff's laws to state the relation

(i) between currents I_1, I_2, I_3 and I_4,

.....[1]

(ii) between E_1, E_2, R, and I_3 in loop NKLMN,

.....[1]

(iii) between E_2, R, I_3 and I_4 in loop NKQN.

.....[1]

6 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]

[Turn over

(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.

For Examiner's Use

.....

.....

.....

.....[3]

For Examiner's Use

6 **(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 230 V to 220 V.

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

reduction = ... % [2]

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

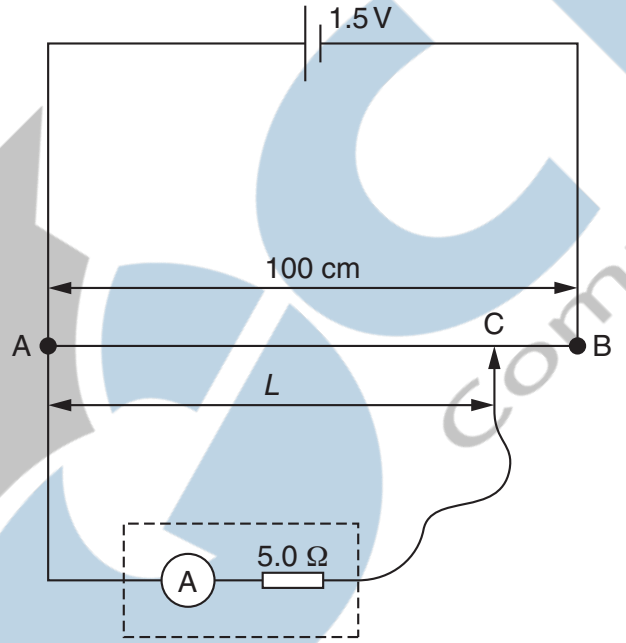


Fig. 6.1

An ammeter of internal resistance 5.0 Ω 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.

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.

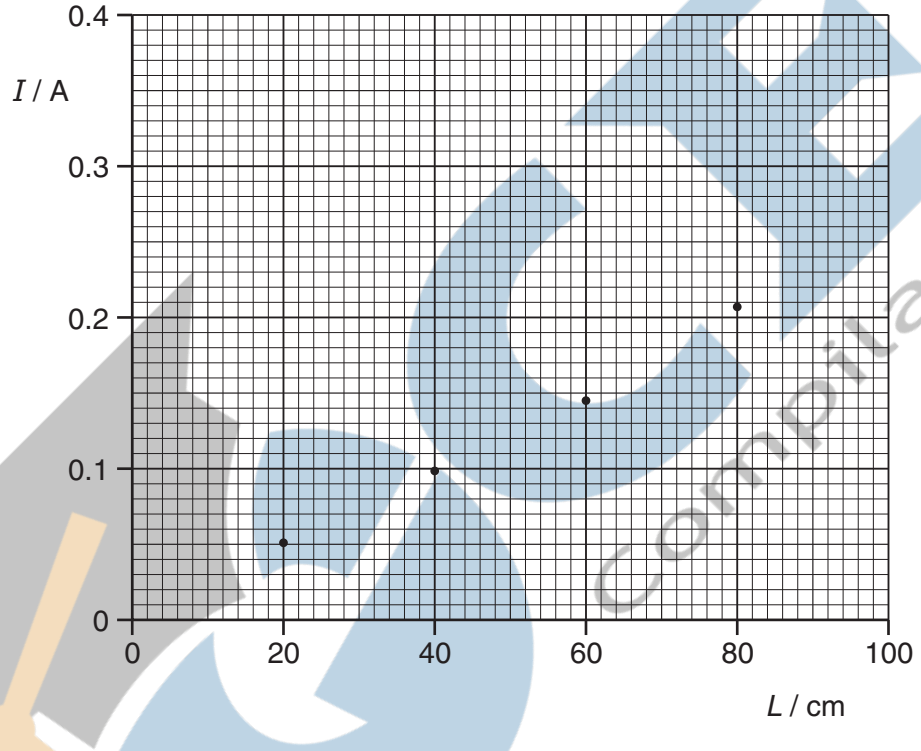


Fig. 6.2

(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

6 **(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.

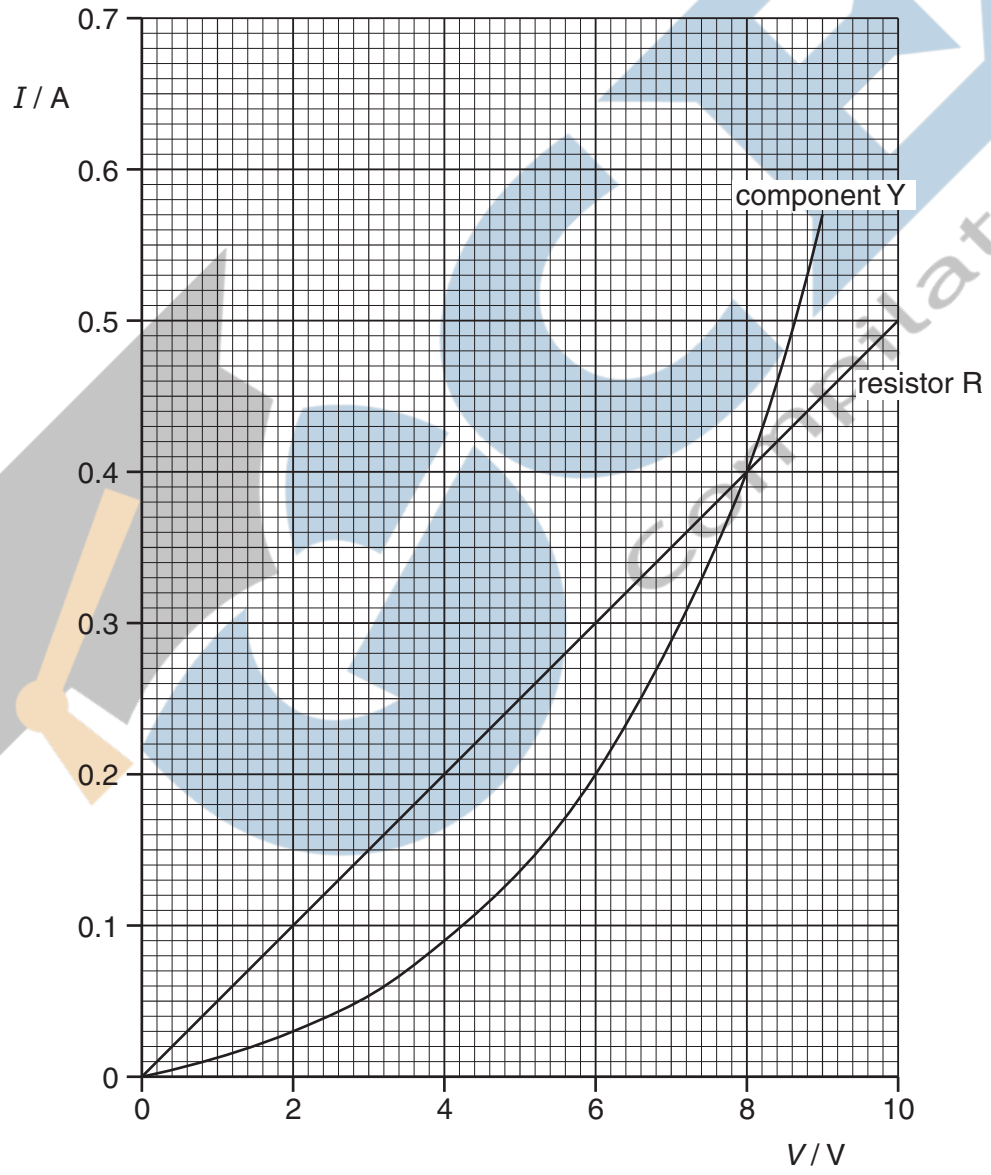


Fig. 6.1

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

For Examiner's Use

.....

.....

.....[2]

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

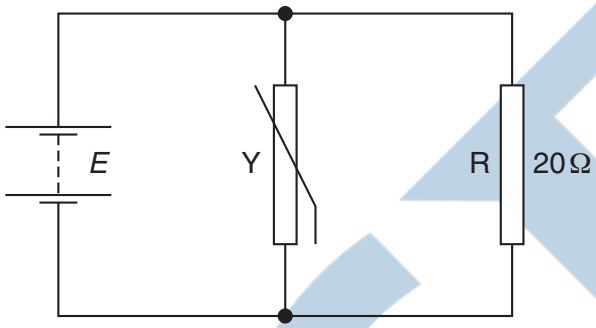


Fig. 6.2

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]

[Turn over

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

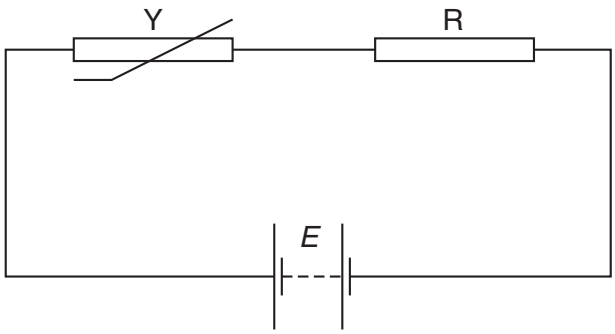


Fig. 6.3

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]

For Examiner's Use

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

(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.

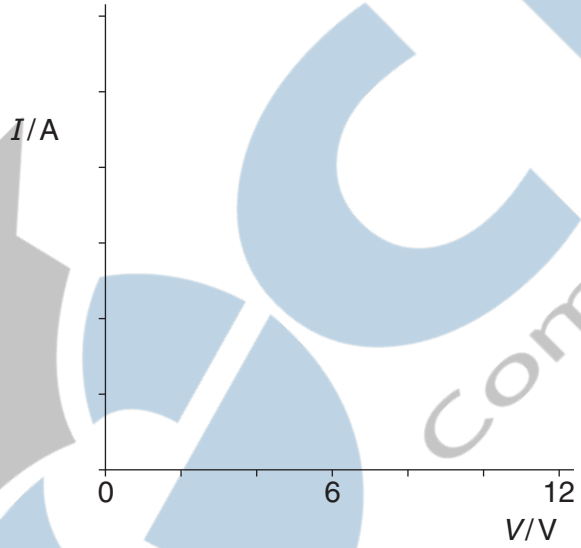


Fig. 6.1

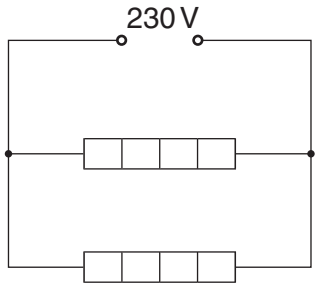
[3]

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

For Examiner's Use

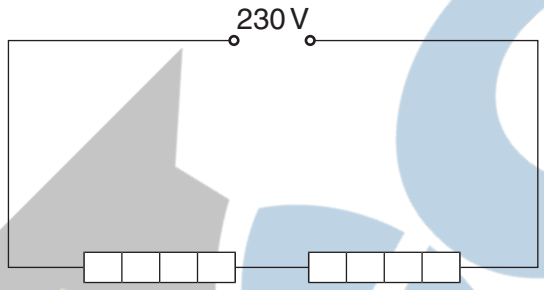
Determine the total power dissipation for the heaters connected as shown in each of the diagrams shown below.

(i)



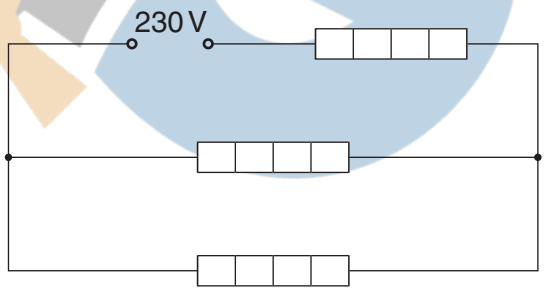
power = ... kW [1]

(ii)



power = ... kW [1]

(iii)



power = ... kW [2]

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

For Examiner's Use

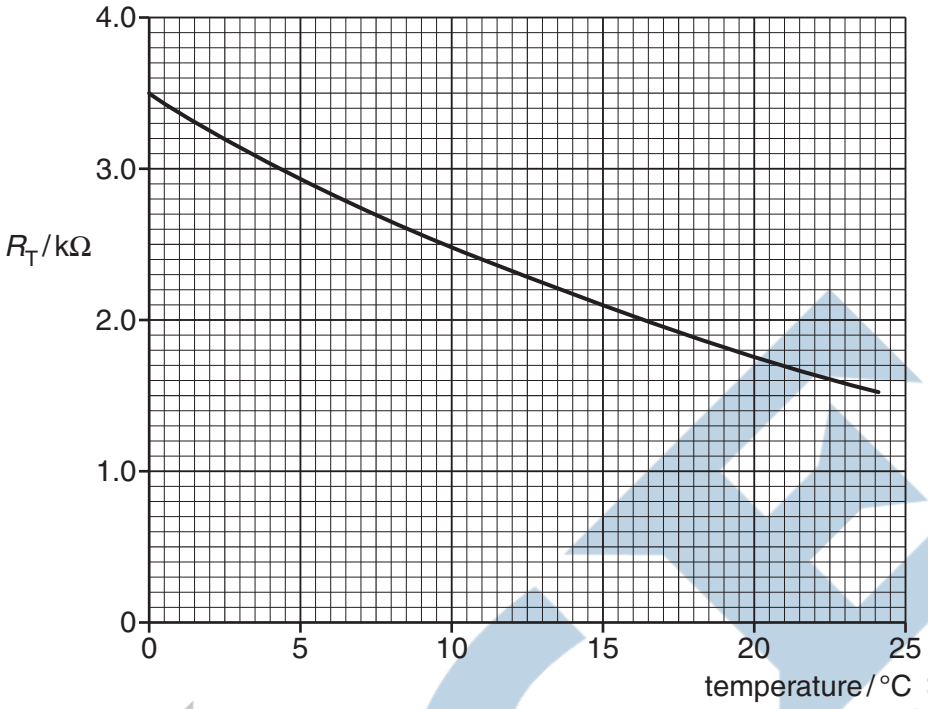


Fig. 6.1

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

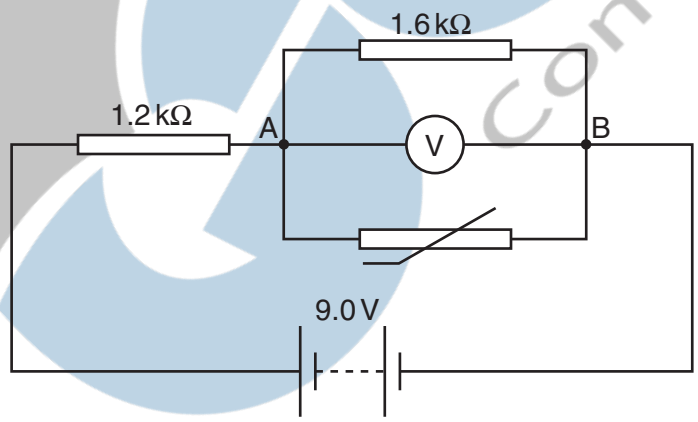


Fig. 6.2

The battery has e.m.f. 9.0 V 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 4.0 V. Determine

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

resistance = ... Ω [2]

[Turn over

(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]

8 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.

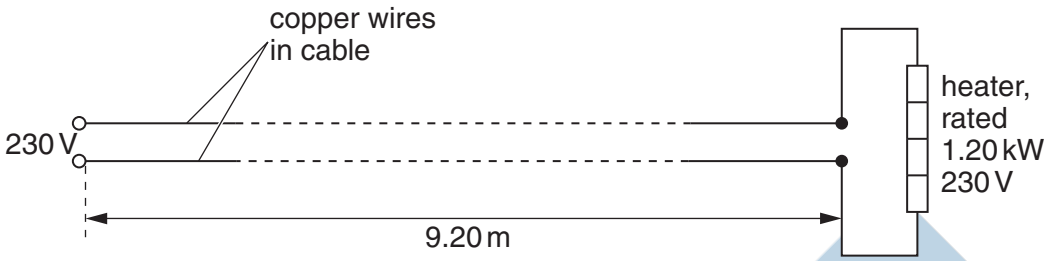


Fig. 8.1

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.

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.

For Examiner's Use

5 **(a)** For a cell, explain the terms

(i) *electromotive force* (e.m.f.),

.....

..... [1]

(ii) *internal resistance*.

.....

..... [1]

(b) The circuit of Fig. 5.1 shows two batteries A and B and a resistor R connected in series.

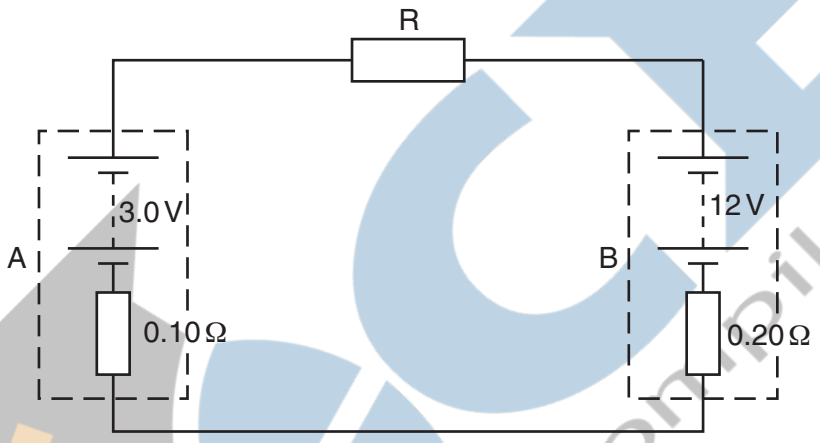


Fig. 5.1

Battery A has an e.m.f. of 3.0 V and an internal resistance of 0.10 Ω. Battery B has an e.m.f. of 12 V and an internal resistance of 0.20 Ω. Resistor R has a resistance of 3.3 Ω.

(i) Apply Kirchhoff's second law to calculate the current in the circuit.

current = ... A [2]

(ii) Calculate the power transformed by battery B.

power = ... W [2]

(iii) Calculate the total energy lost per second in resistor R and the internal resistances.

For Examiner's Use

energy lost per second = ... $J s^{-1}$ [2]

(c) The circuit of Fig. 5.1 may be used to store energy in battery A. Suggest how your answers in **(b)** support this statement.

.....

.....

..... [1]

For Examiner's Use

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

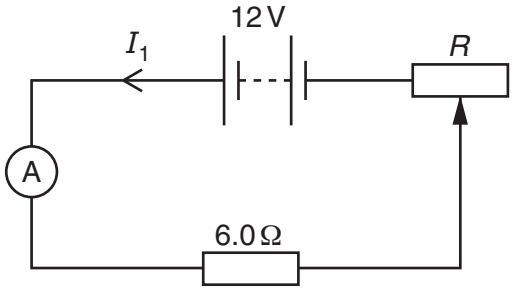


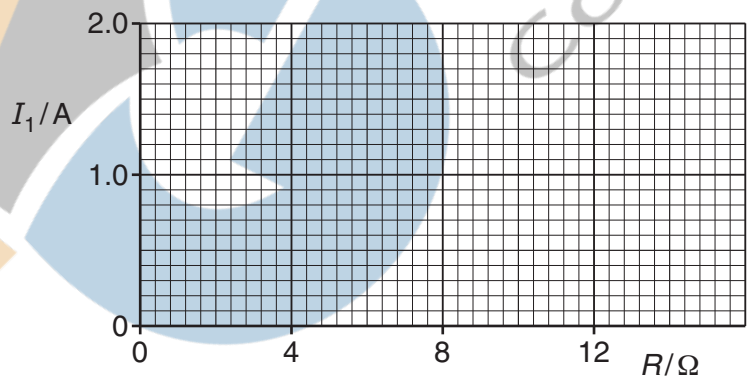
Fig. 5.1

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.

For Examiner's Use

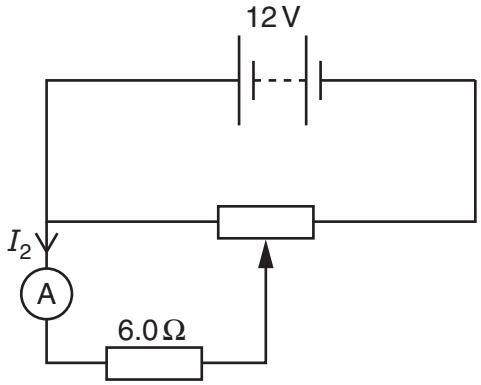


Fig. 5.3

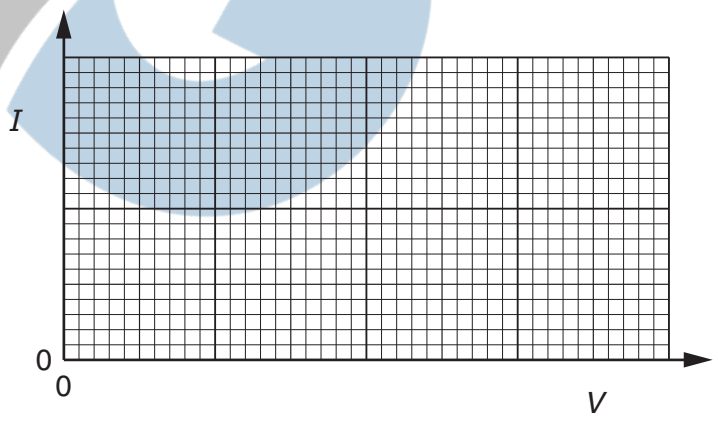
Calculate the maximum possible and minimum possible current I_2 in the ammeter.

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.

For Examiner's Use

.....

.....

..... [1]

For Examiner's Use

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

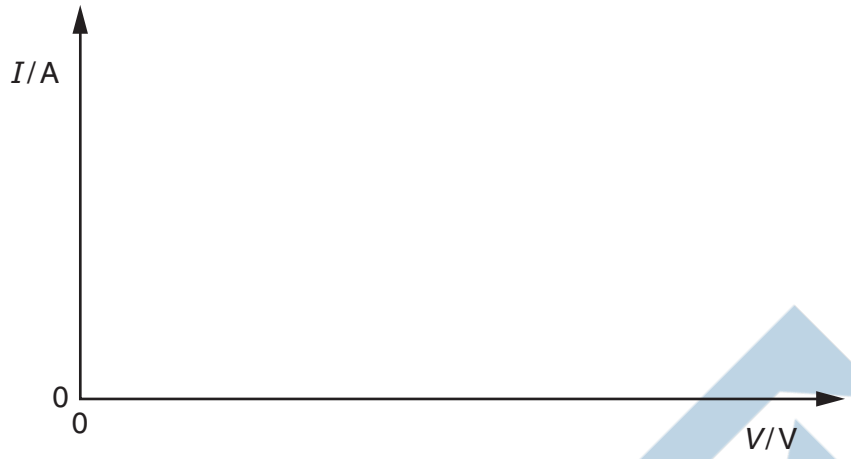


Fig. 5.1

[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 12V power supply that has negligible internal resistance. The circuits are shown in Fig. 5.2 and Fig. 5.3 respectively.

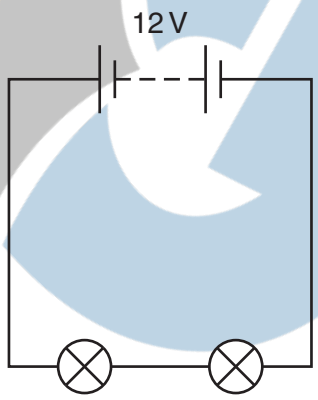


Fig. 5.2

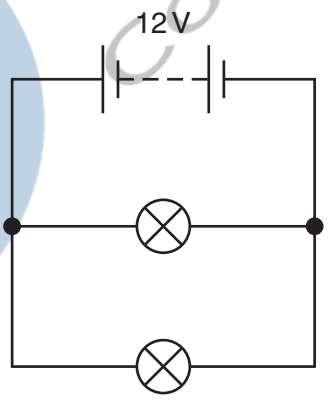


Fig. 5.3

(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.

.....

.....

.....

.....

.....[3]

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

total resistance = ... Ω [3]