1 Fig. 3.1 shows the current-voltage (I-V) characteristics of two resistors R and X.

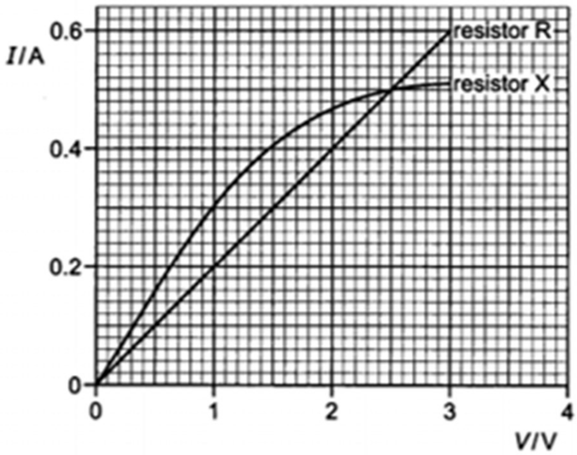

Fig. 3.1

The two resistors are connected in series with a cell of negligible internal resistance as shown in Fig. 3.2. The e.m.f. of the cell is 2.5 V.

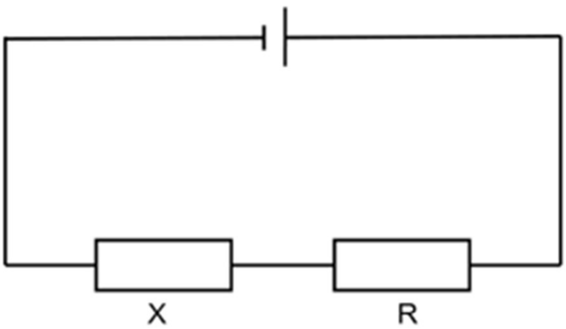

Fig. 3.2

(a) What is meant by the term *e.m.f.* of a cell?

....

....

....[2]

(b) Describe and explain how the resistance of resistor X varies with increasing potential difference with reference to the motion of the electrons.

....

....

....

....

....[3]

1 **(c)** **(i)** Using Fig. 3.1, determine the current passing through resistor X.
Show your working clearly.

current = ... A [3]

(ii) State

1. the resistance of X

resistance of X = ... Ω [1]

2. the resistance of R

resistance of R =................................... Ω [1]

[Total: 10]

2 **(a)** Explain what is meant by the *potential difference* across an electrical component.

....

....

....

....[2]

(b) Fig. 5.1 shows the voltage-current variation of two components X and Y.

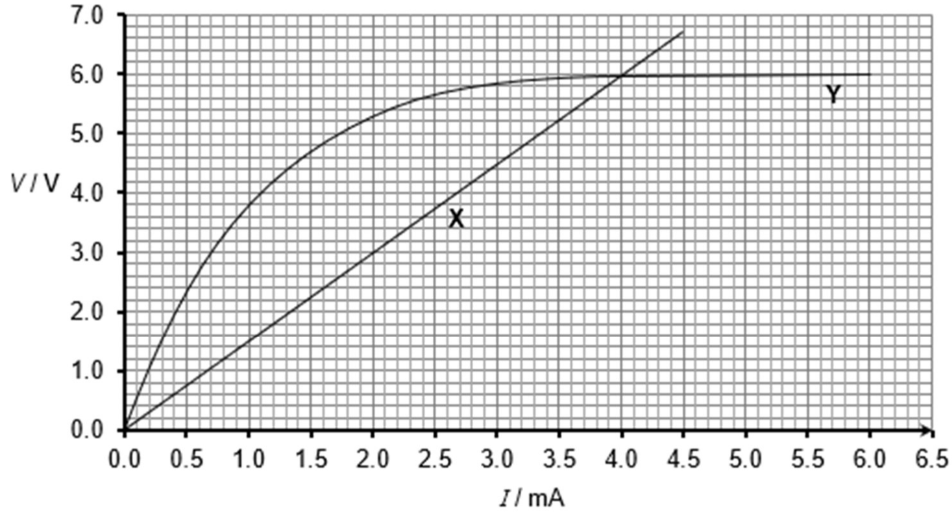

Fig. 5.1

State the maximum and minimum resistance of component Y between $V = 0.0$ V and $V = 6.0$ V.

minimum resistance = ... kΩ

maximum resistance = ... kΩ

[2]

2

(c) Components X and Y are connected in parallel as shown in Fig. 5.2. The parallel combination is connected in series with a variable resistor *R* and a cell of e.m.f. 8.0 V and negligible internal resistance.

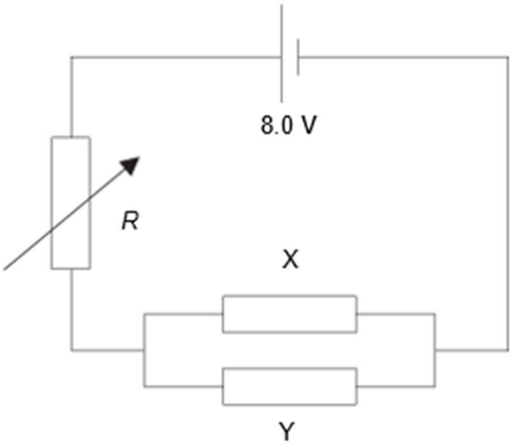

Fig. 5.2

(i) The resistance of the variable resistor *R* is adjusted until both X and Y are operating at the same resistance. With reference to Fig. 5.1, deduce the voltage across X and Y.

voltage = ... V [1]

(ii) Hence, determine the resistance of the variable resistor *R*.

R = ... Ω [2]

3 **(a)** Fig. 6.1 shows a battery of negligible internal resistance connected with a thermistor in parallel with an ohmic resistor of resistance 1200 Ω.

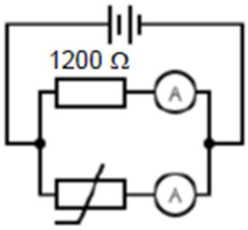

Fig. 6.1

The current in the 1200 Ω resistor is measured to be 5.0 mA.

(i) The thermistor has a resistance of 4700 Ω at room temperature.

Determine the current in the thermistor.

current = ... mA [2]

(ii) The temperature increases.
State how the currents in the resistor and the thermistor change.

resistor: ....

thermistor: .... [1]

(b) Fig. 6.2 shows an illumination level sensor circuit used to send a voltage signal V_{out} to another processing circuit.

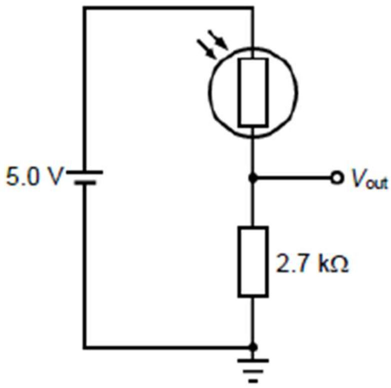

Fig. 6.2

3

The minimum and maximum resistances of the light-dependent resistor is 0.7 kΩ and 4.5 kΩ over the range of illumination level it is expected to operate in.

(i) Determine the minimum and maximum V_{out} the processing circuit is expected to receive.

minimum V_{out} = ... V

maximum V_{out} = ... V [3]

(ii) The processing circuit processes the V_{out} signal to calculate the relative illumination levels measured by the illumination level sensor circuit.

It is recommended that the resistance of the resistor be comparable to the range of resistances of the light-dependent resistor.

Explain the limitation if the resistance of the resistor is very small compared to the range of resistances of the light-dependent resistor.

....

....

....

....

.... [3]

[Total: 9]

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

....

.... [1]

(b) A metal wire has length L and cross-sectional area A, as shown in Fig. 5.1.

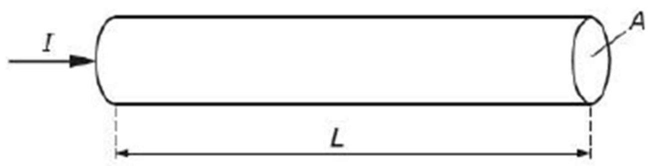

Fig. 5.1

I is the current in the wire,
n is the number of free electrons per unit volume in the wire,
v is the average drift speed of a free electron,
e is the charge on an electron.

(i) State, in terms of A, L, n and e, an expression for the total charge of free electrons in the wire.

.... [1]

(ii) Use your answer in **(b) (i)** to show that the current I is given by the equation

$$I = nAve$$

[2]

4 **(c)** A metal wire in a circuit is damaged. The resistivity of the metal is unchanged but the cross-sectional area of the wire is reduced over a length of 3.0 mm, as shown in Fig. 5.2.

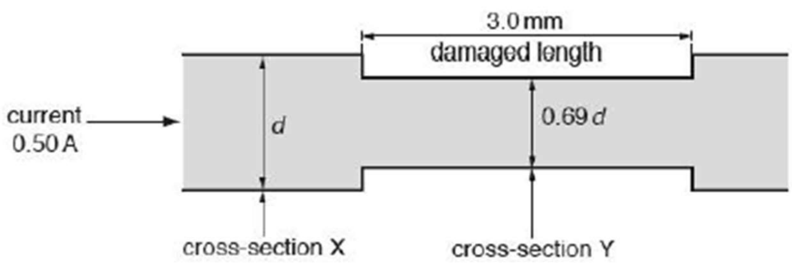

Fig. 5.2

The wire has a diameter *d* at cross-section X and diameter 0.69 *d* at cross-section Y. The current in the wire is 0.50 A.

(i) Determine the ratio

$$\frac{\text{average drift speed of free electrons at cross-section Y}}{\text{average drift speed of free electrons at cross-section X}}$$

ratio = ... [2]

(ii) The diameter of the damaged length of wire is further decreased. Assume that the current in the wire stays constant at 0.50 A.

State and explain qualitatively the change, if any, to the power dissipated in the damaged length of the wire.

....

....

....

.... [2]

[Total: 8]

5 **(a)** Two cylindrical resistors M and N of the same material are connected parallel in Fig. 6.1. The mass of M is twice the mass of N and the radius of M is half the radius of N.

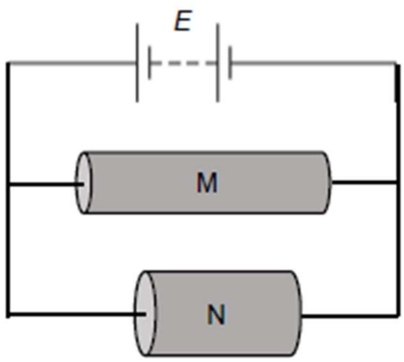

Fig. 6.1 (not to scale)

Determine the ratio

(i) $\dfrac{\text{resistance of M}}{\text{resistance of N}}$,

ratio = ... [2]

(ii) $\dfrac{\text{average drift speed of electrons in M}}{\text{average drift speed of electrons in N}}$.

ratio = ... [2]

5 **(b)** A cell of electromotive force (e.m.f.) 1.5 V and internal resistance 1.0 Ω is connected to a resistor X and resistor Y as shown in Fig. 6.2.

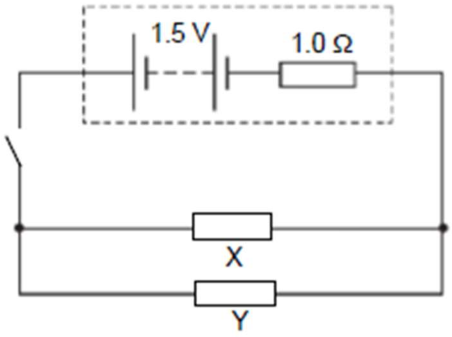

Fig. 6.2

Resistor X has resistance 2.0 Ω while resistor Y has a resistance of 6.0 Ω.

(i) Show that the current in the cell is 0.60 A when the switch is closed.

[2]

(ii) Determine the energy dissipated in the cell when the switch is closed for 8.0 minutes.

energy dissipated = ... J [1]

(iii) Resistor Y is replaced with a component Z with similar resistance value. When the temperature increases, the resistance of component Z decreases. State and explain the change to the power dissipated in the cell when temperature increases.

....

....

....[1]

5

(iv) The *I*-*V* characteristic of X and Z are given in Fig. 6.3.

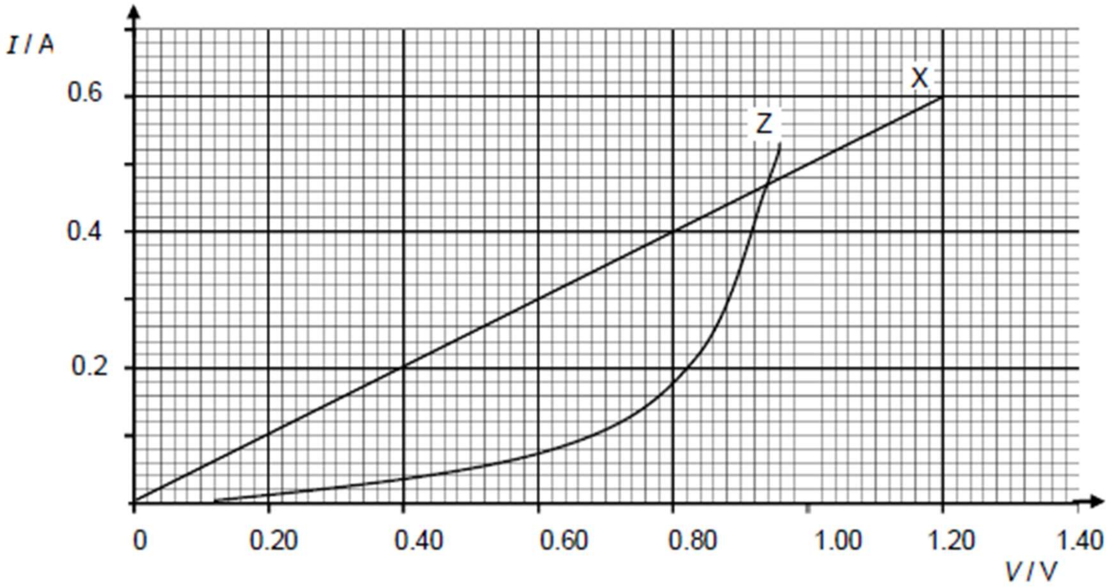

Fig. 6.3

The circuit is now reconnected such that resistor X and component Z are in series with the same cell. Using the Fig. 6.3, or otherwise, determine the potential difference across component Z.

potential difference = ... V [2]

[Total: 10]

6 Fig. 5.1 shows a circuit that consists of a lamp, an ammeter, a voltmeter and a battery of unknown electromotive force (e.m.f.).

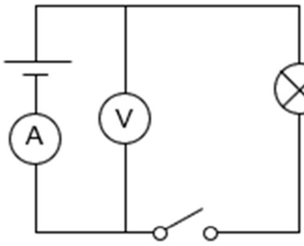

Fig. 5.1

When the switch is open, the ammeter and the voltmeter read 0 A and 3.00 V, respectively. When the switch is closed, the meters read 1.60 A and 2.20 V.

(a) State the e.m.f. of the battery.

e.m.f. = ... V [1]

(b) Determine the internal resistance of the battery.

internal resistance = ... Ω [2]

(c) **(i)** Calculate the power delivered to the lamp.

power = ... W [1]

(ii) Determine the efficiency of the power transfer of the battery.

efficiency = ... % [2]

7 **(a)** Using energy considerations, distinguish between *electromotive force* and *potential difference*.

....

....

....

....

....

.... [2]

(b) An electric hotplate is designed to operate on a power supply of 240 V and has two coils of wire of resistivity of 9.8×10^{-7} Ω m. Each coil of wire has a length of 16 m and cross-sectional area 0.20 mm^2.

(i) For one of the coils, calculate

1. its resistance,

resistance = ... Ω [2]

2. the power dissipation when a 240 V supply is connected across it.

power = ... W [2]

7

(ii) Fig. 6.1 shows how the two coils can be connected for the hotplate to operate at different powers.

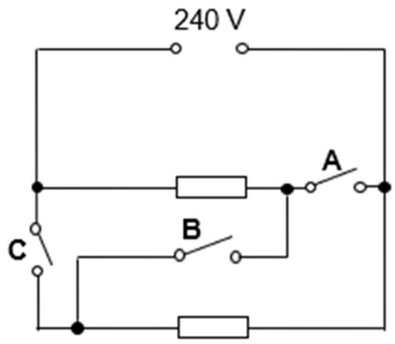

Fig. 6.1

On Fig. 6.2, fill up the table with "ON" or "OFF" to obtain the lowest and highest levels of operating power.

	switch A	switch B	switch C
Lowest			
Highest			

[2]

Fig. 6.2

8 **(a)** A battery of electromotive force (e.m.f.) 12.0 V and internal resistance *r* is connected to a filament lamp and a resistor, as shown in Fig. 5.1.

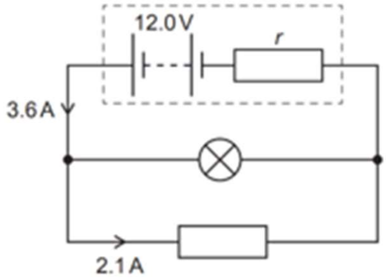

Fig. 5.1

The current in the battery is 3.6 A and the current in the resistor is 2.1 A. The *I*-*V* characteristic for the lamp is shown in Fig. 5.2.

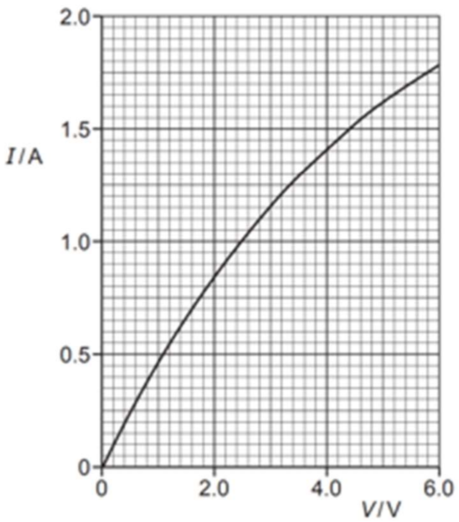

Fig. 5.2

(i) Explain, with reference to the graph, whether the resistance of filament lamp increases or decreases with increasing potential difference.

....

....

....

.... [2]

8 **(ii)** Determine the internal resistance r of the cell in Fig. 5.1.

internal resistance = ... Ω [3]

(iii) The filament wire of the lamp is connected in series with the adjacent copper connecting wire of the circuit, as illustrated in Fig. 5.3.

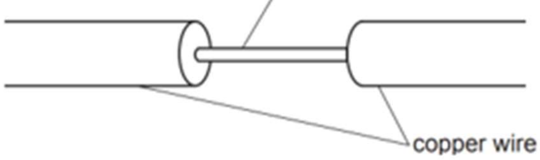

Fig. 5.3

Some data for the filament wire and the adjacent copper connecting wire are given in the table below.

	filament wire	copper wire
cross-sectional area	A	$360A$
number density of free electrons	n	$2.5n$

Calculate the ratio

$$\frac{\text{average drift speed of free electrons in filament wire}}{\text{average drift speed of free electrons in copper wire}}.$$

ratio = ... [1]

8 **(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. 5.4 & Fig. 5.5 respectively.

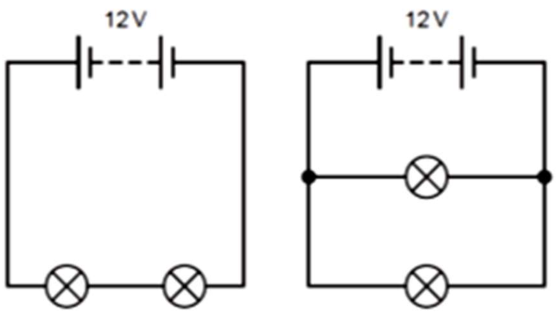

Fig. 5.4 **Fig. 5.5**

Explain why, after some time, 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]

(c) A potentiometer is setup as shown in Fig. 5.5. A resistive wire of 1.0 m is connected between point B and point D.

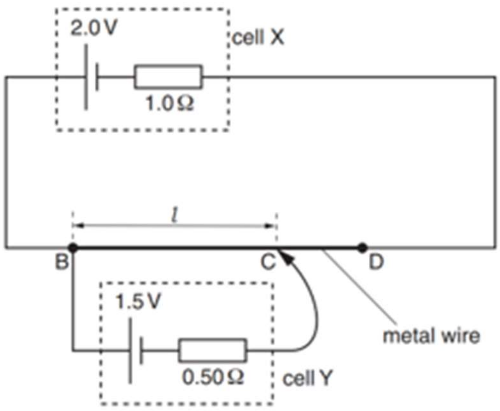

Fig. 5.5

When the length l is set at 93.75 cm, the current in cell Y is zero.

8 Two resistors are added to the potentiometer circuit, as shown in Fig. 5.6.

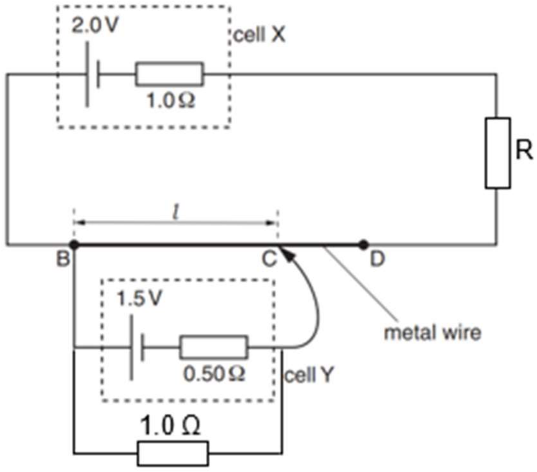

Fig. 5.6

Calculate the value of R such that the balance point of the circuit will be at point D.

R = ... Ω [4]