Practical Circuits & Kirchoff's Law

Question paper 4

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	D.C. Circuits
Sub Topic	Practical Circuits & Kirchoff's Law
Paper Type	Theory
Booklet	Question paper 4

Time Allowed: **87 minutes**

Score: **/72**

Percentage: **/100**

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

1 **(a)** Use the definition of work done to show that the SI base units of energy are $kg\,m^2\,s^{-2}$.

[2]

(b) Define potential difference.

.....

..... [1]

(c) Determine the SI base units of resistance. Show your working.

units ..... [3]

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

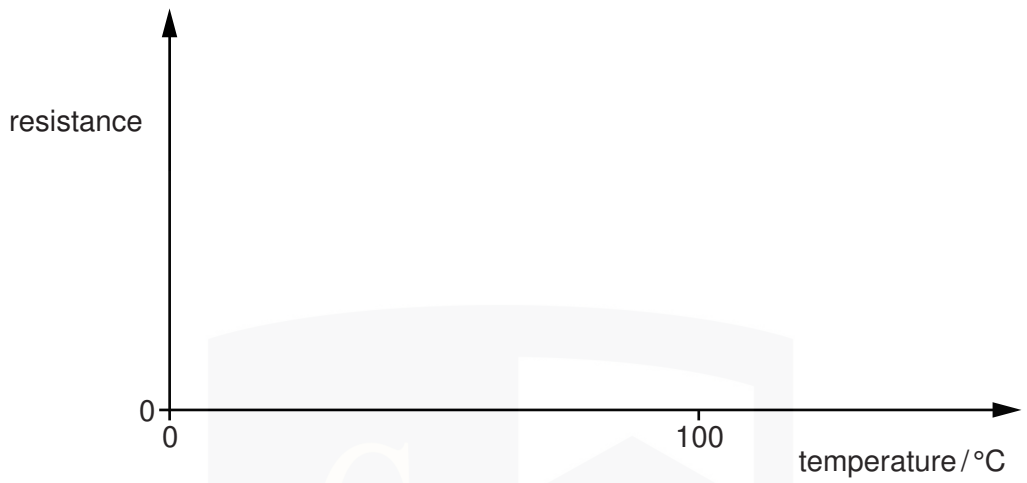

Fig. 5.1

[2]

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

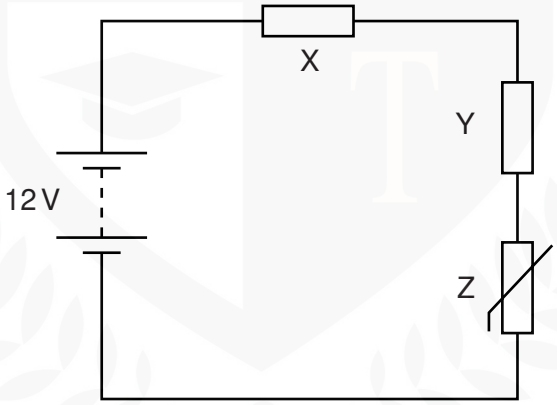

Fig. 5.2

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]

3 **(a)** A wire has length 100 cm and diameter 0.38 mm. The metal of the wire has resistivity $4.5 \times 10^{-7}\,\Omega\,\text{m}$.

Show that the resistance of the wire is 4.0 Ω.

[3]

(b) The ends B and D of the wire in **(a)** are connected to a cell X, as shown in Fig. 6.1.

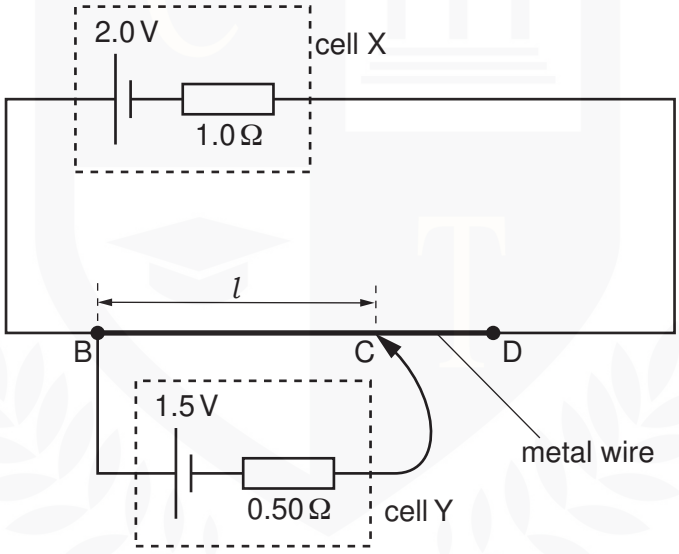

Fig. 6.1

The cell X has electromotive force (e.m.f.) 2.0 V and internal resistance 1.0 Ω.

A cell Y of e.m.f. 1.5 V and internal resistance 0.50 Ω is connected to the wire at points B and C, as shown in Fig. 6.1.

The point C is distance l from point B. The current in cell Y is zero.

Calculate

(i) the current in cell X,

current = ... A [2]

(ii) the potential difference (p.d.) across the wire BD,

p.d. = ... V [1]

(iii) the distance l.

l = ... cm [2]

(c) The connection at C is moved so that l is increased. Explain why the e.m.f. of cell Y is less than its terminal p.d.

.....

.....

.....[2]

4 **(a)** Distinguish between *electromotive force* (e.m.f.) and *potential difference* (p.d.).

.....

.....

..... [2]

(b) A battery of e.m.f. 12V and internal resistance 0.50Ω is connected to two identical lamps, as shown in Fig. 6.1.

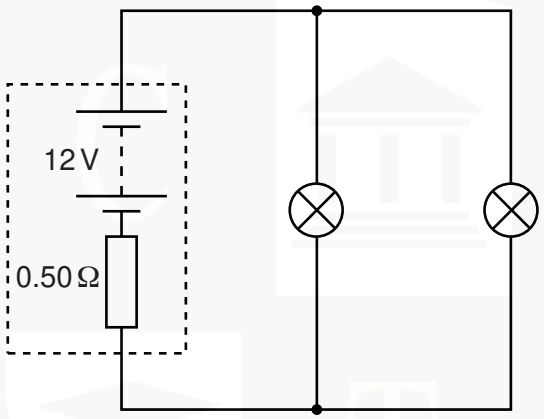

Fig. 6.1

Each lamp has constant resistance. The power rating of each lamp is 48W when connected across a p.d. of 12V.

(i) Explain why the power dissipated in each lamp is not 48W when connected as shown in Fig. 6.1.

.....

.....

..... [1]

(ii) Calculate the resistance of one lamp.

resistance = ... Ω [2]

(iii) Calculate the current in the battery.

current = ... A [2]

(iv) Calculate the power dissipated in one lamp.

power = ... W [2]

(c) A third identical lamp is placed in parallel with the battery in the circuit of Fig. 6.1. Describe and explain the effect on the terminal p.d. of the battery.

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.....

.....

..... [2]

5 A potentiometer circuit that is used as a means of comparing potential differences is shown in Fig. 5.1.

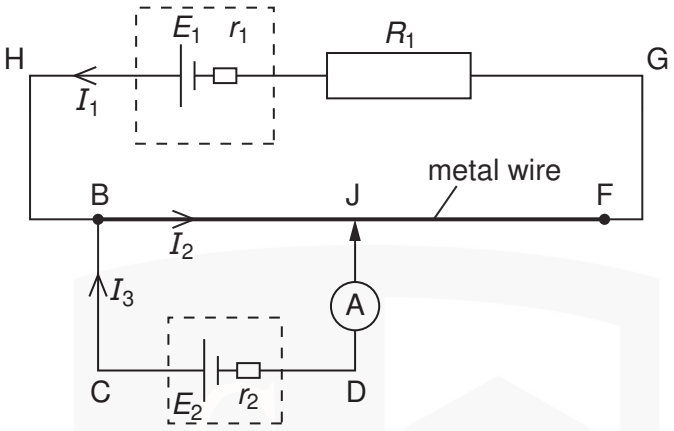

Fig. 5.1

A cell of e.m.f. E_1 and internal resistance r_1 is connected in series with a resistor of resistance R_1 and a uniform metal wire of total resistance R_2.
A second cell of e.m.f. E_2 and internal resistance r_2 is connected in series with a sensitive ammeter and is then connected across the wire at BJ. The connection at J is halfway along the wire. The current directions are shown on Fig. 5.1.

(a) Use Kirchhoff's laws to obtain the relation

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

.....[1]

(ii) between E_1, R_1, R_2, r_1, I_1 and I_2 in loop HBJFGH,

.....[1]

(iii) between E_1, E_2, r_1, r_2, R_1, R_2, I_1 and I_3 in the loop HBCDJFGH.

.....[2]

(b) The connection at J is moved along the wire. Explain why the reading on the ammeter changes.

.....

.....

.....

.....[2]

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.

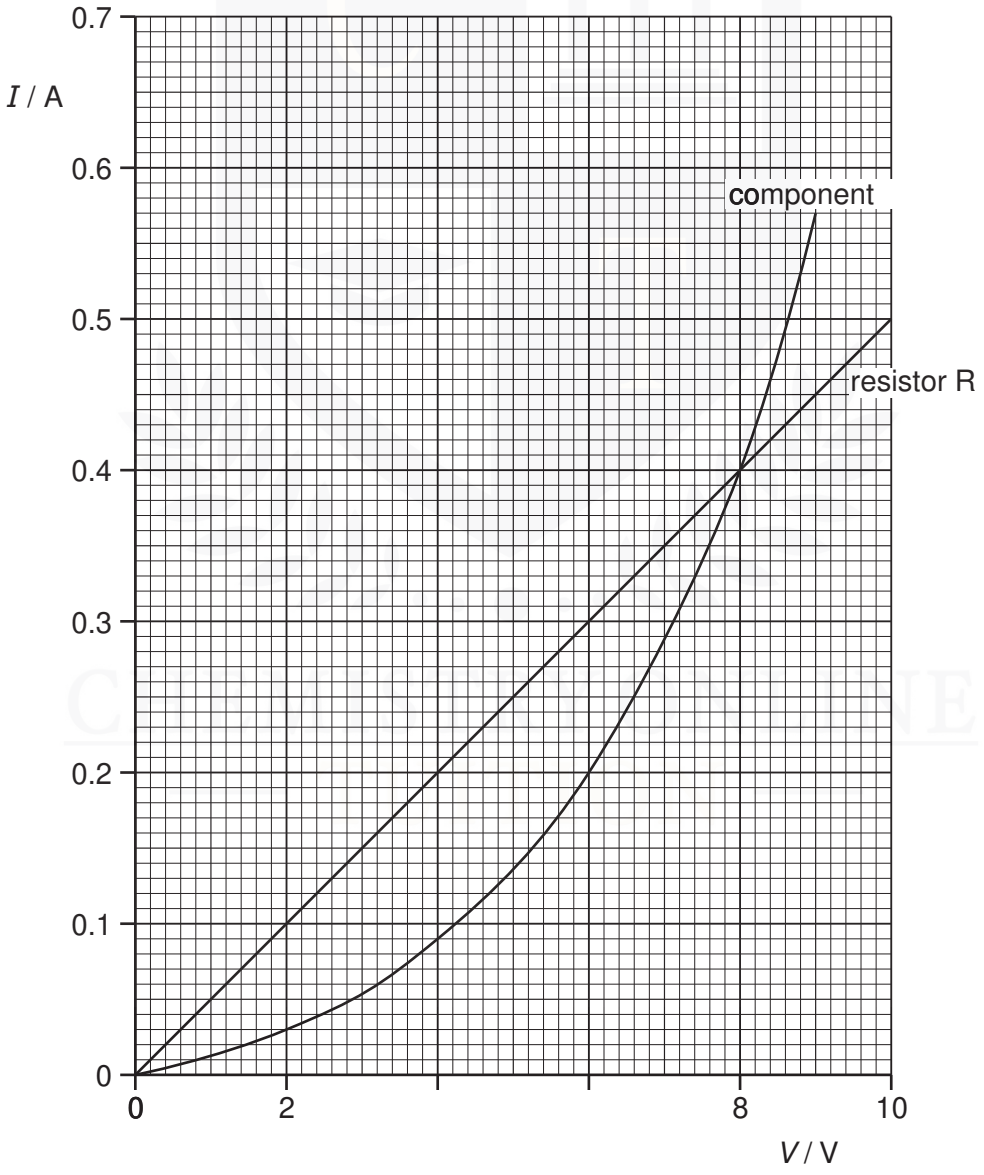

Fig. 6.1

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

.....

.....

.....[2]

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

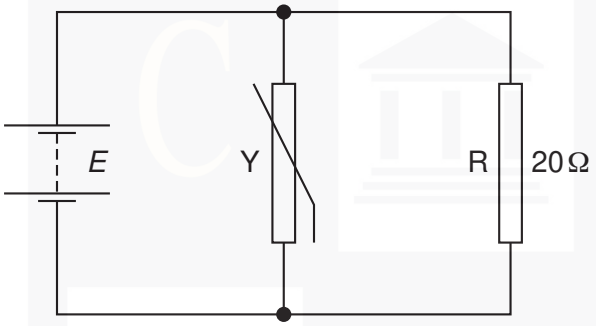

Fig. 6.2

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.

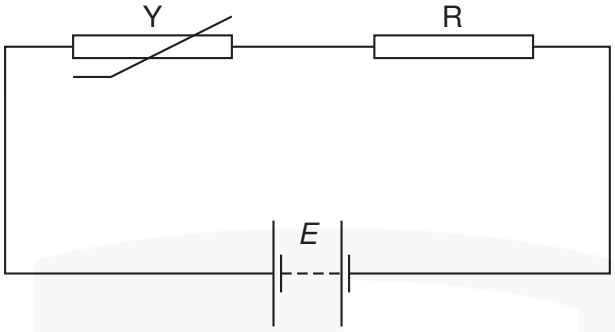

Fig. 6.3

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]

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

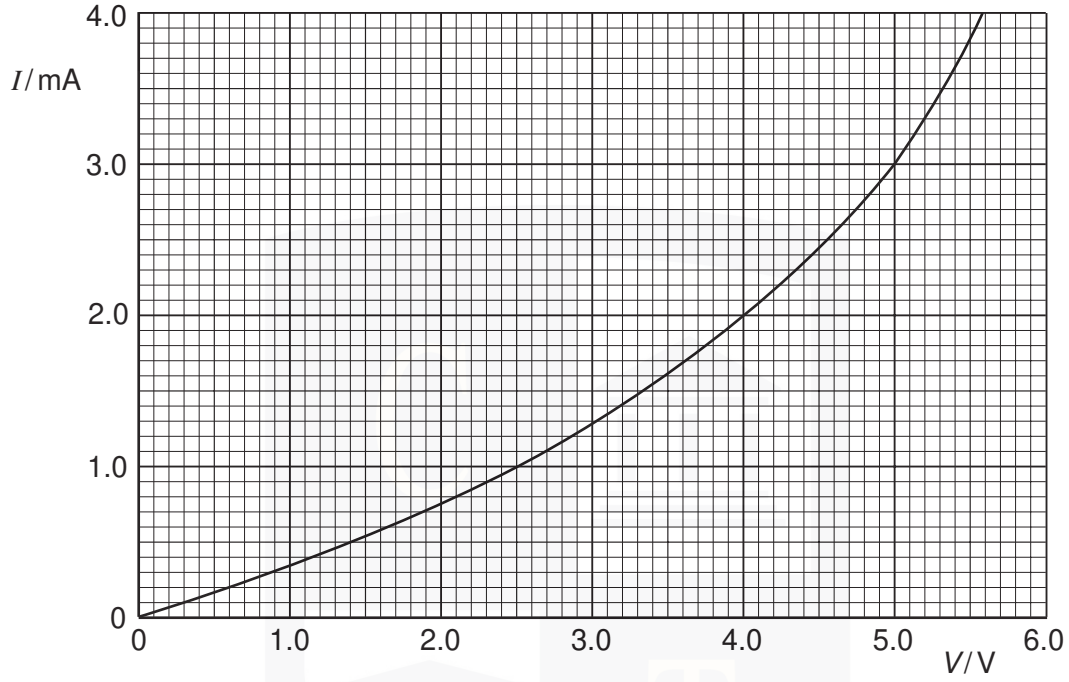

Fig. 6.1

(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.

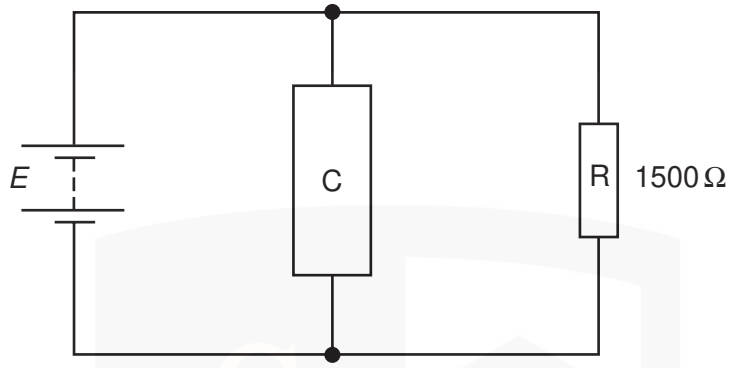

Fig. 6.2

(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]

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

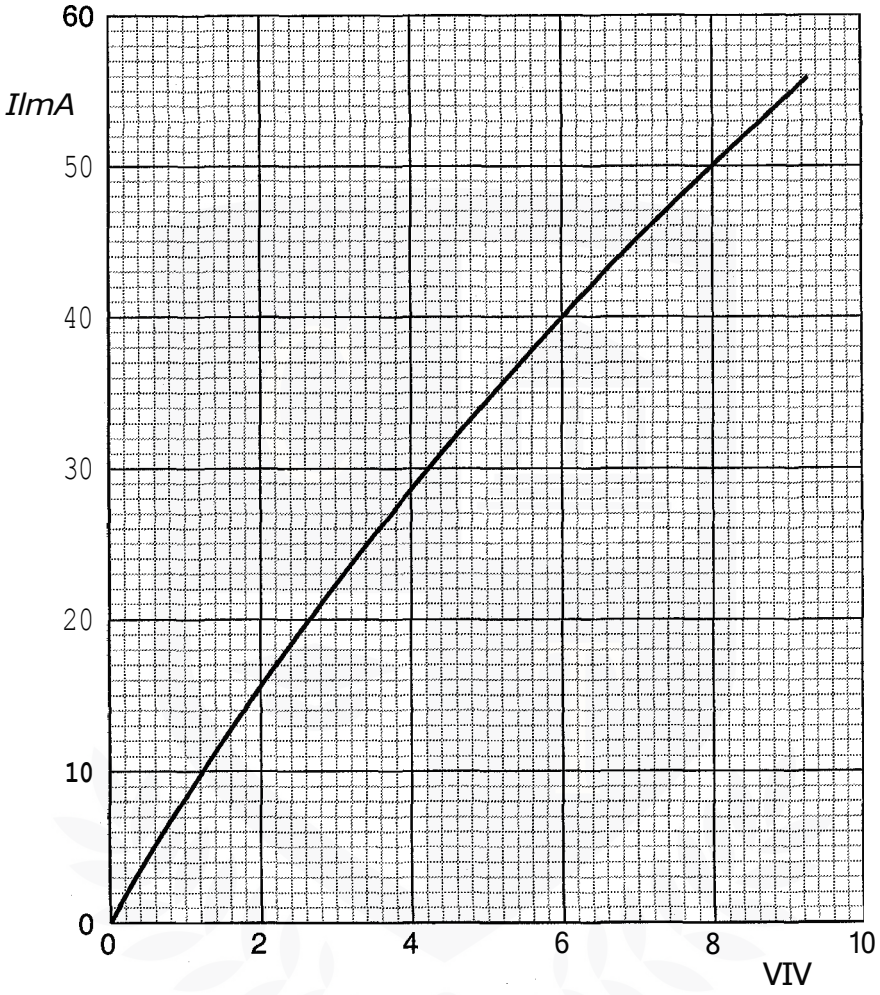

Fig.5.1

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

(i) 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.

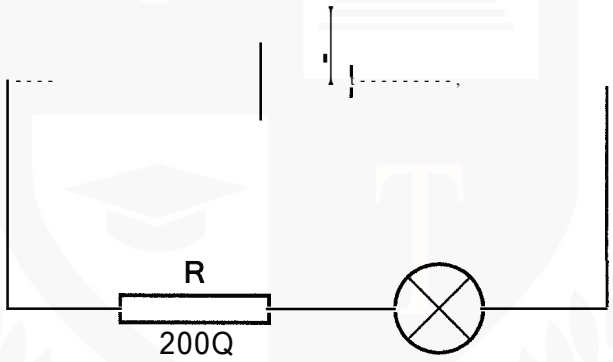

Fig.5.2

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]