10. D.C. Circuits

10.2 Kirchhoff's laws

Paper 2

Question Paper

1 **(a)** State Kirchhoff's first law.

.....

..... [1]

(b) A cell with internal resistance r is connected to two resistors of resistances R_1 and R_2 as shown in Fig. 6.1.

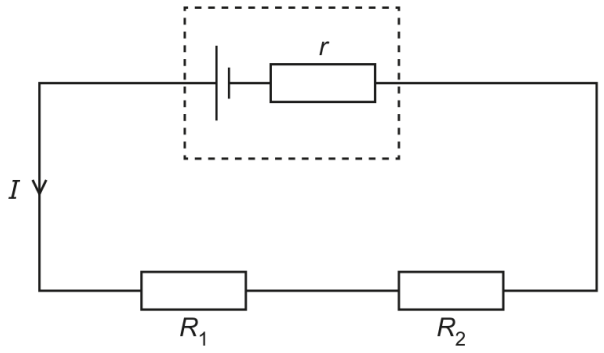


Fig. 6.1

The potential differences (p.d.s) across R_1 and R_2 are V_1 and V_2 respectively.
The terminal p.d. across the cell is V.
The current in the circuit is I.

Use Kirchhoff's laws to show that the total resistance R_T of the external circuit is given by

$$R_T = R_1 + R_2 .$$

[2]

(d) A resistor of resistance R_3 is added to the circuit in Fig. 6.1, so that the circuit is as shown in Fig. 6.2.

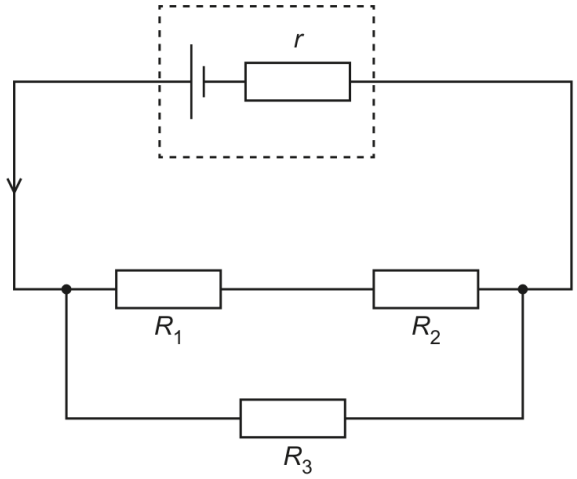


Fig. 6.2

State and explain the effect, if any, of this change on:

(i) the current in the cell

.....

.....

..... [2]

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

.....

..... [1]

3 **(a)** Fig. 7.1 shows two resistors connected in series with a cell of electromotive force (e.m.f.) 1.50 V and internal resistance 0.28 Ω.

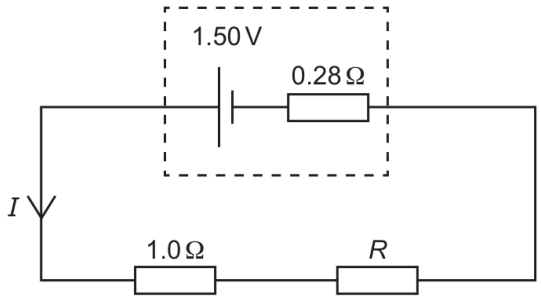


Fig. 7.1

One of the resistors has resistance 1.0 Ω. The other resistor has resistance *R*.
The terminal potential difference (p.d.) across the cell is 1.36 V.

(iii) Use your answer in **(a)(ii)** to determine resistance *R*.

R = ... Ω [1]

(b) The circuit in Fig. 7.1 is disconnected and the two resistors are reconnected to the cell, now in parallel with each other.

4 **(b)** A power supply, three resistors and a component X are connected in the circuit shown in Fig. 5.1.

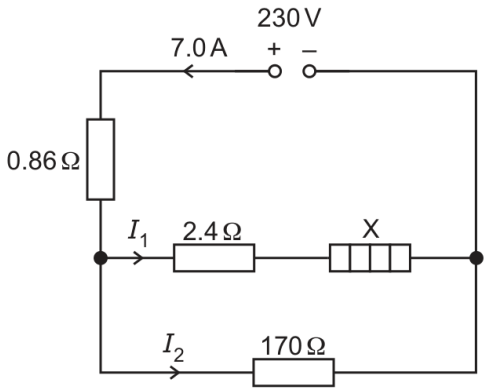


Fig. 5.1

The power supply has an electromotive force (e.m.f.) of 230 V and negligible internal resistance. The current in the power supply is 7.0 A.

(iii) Determine the current I_1.

I_1 = ...A [2]

(iv) Calculate the p.d. across component X.

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

(vii) The resistor of resistance 170 Ω is removed, leaving an open circuit in the lower branch of the circuit. There is no change to the resistance of component X.

State whether the current in the power supply increases, decreases or remains the same.

..... [1]

5 A battery of electromotive force (e.m.f.) 9.6 V and negligible internal resistance is connected in series with two fixed resistors and a thermistor, as shown in Fig. 7.1.

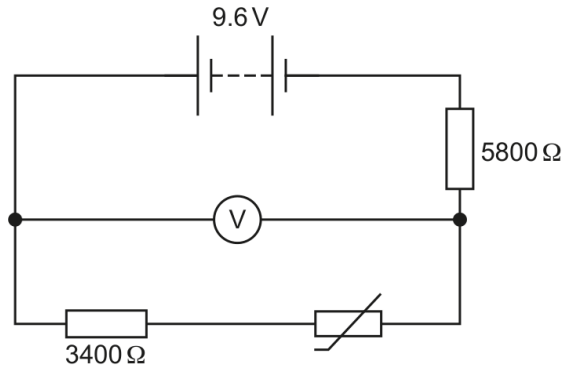


Fig. 7.1

The fixed resistors have resistances of 3400 Ω and 5800 Ω. The reading on the voltmeter in the circuit is 6.0 V.

(b) Calculate the resistance of the thermistor.

resistance = ... Ω [2]

(d) The environmental conditions change causing an increase in the resistance of the thermistor.

State whether there is a decrease, increase or no change to:

(ii) the current in the thermistor

..... [1]

6 A battery is connected in a circuit with a light-dependent resistor (LDR), two fixed resistors and a voltmeter, as shown in Fig. 6.1.

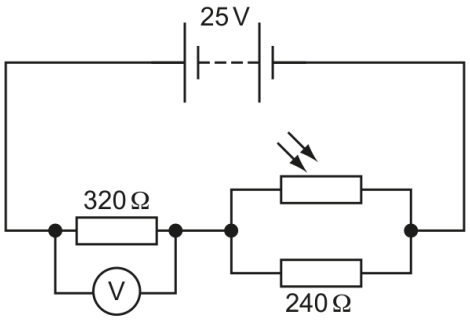


Fig. 6.1

The battery has an electromotive force (e.m.f.) of 25 V and negligible internal resistance.
The resistors have resistances of 320 Ω and 240 Ω.

(a) The voltmeter displays a reading of 16 V.

(ii) Calculate the resistance of the LDR.

resistance = ... Ω [3]

7 **(b)** A battery of electromotive force (e.m.f.) E and negligible internal resistance is connected in series with a fixed resistor and a light-dependent resistor (LDR), as shown in Fig. 6.1.

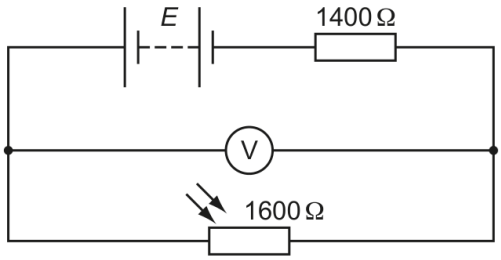


Fig. 6.1

The resistance of the fixed resistor is 1400 Ω. The intensity of the light illuminating the LDR causes it to have a resistance of 1600 Ω. A voltmeter connected across the LDR reads 6.4 V.

(iii) Calculate the e.m.f. E.

E = ... V [2]

(c) The environmental conditions change causing a decrease in the resistance of the LDR in **(b)**. The temperature of the environment does not change.

State whether there is a decrease, increase or no change to:

(ii) the current in the battery

..... [1]

8 **(a)** State Kirchhoff's first law.

.....

..... [1]

9 **(a)** A network of three resistors of resistances R_1, R_2 and R_3 is shown in Fig. 6.1.

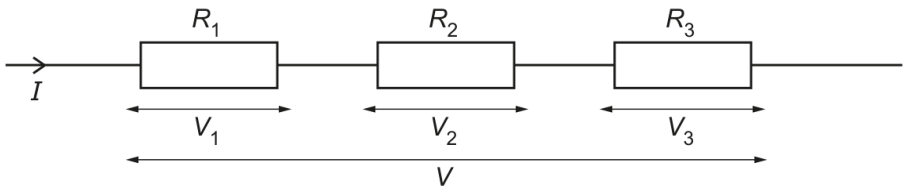


Fig. 6.1

The individual potential differences across the resistors are V_1, V_2 and V_3. The current in the combination of resistors is I and the total potential difference across the combination is V.

Show that the combined resistance R of the network is given by

$$R = R_1 + R_2 + R_3.$$

[2]

(b) A battery of electromotive force (e.m.f.) 8.0 V and negligible internal resistance is connected to a thermistor, a switch X and two fixed resistors, as shown in Fig. 6.2.

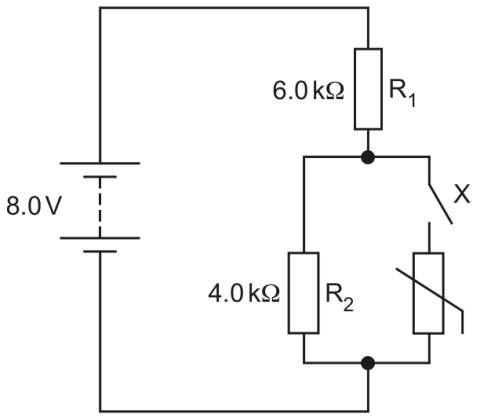


Fig. 6.2

Resistor R_1 has resistance 6.0 kΩ and resistor R_2 has resistance 4.0 kΩ.

(ii) Switch X is now closed. The resistance of the thermistor is 12.0 kΩ.

Calculate the current in the battery.

current = ... A [2]

10 (a) State Kirchhoff's second law.

.....

.....

..... [2]

(b) A battery has electromotive force (e.m.f.) 4.0 V and internal resistance 0.35 Ω. The battery is connected to a uniform resistance wire XY and a fixed resistor of resistance *R*, as shown in Fig. 5.1.

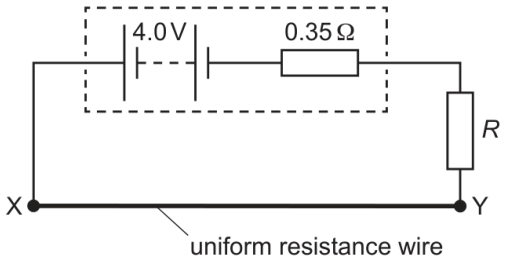


Fig. 5.1

Wire XY has resistance 0.90 Ω. The potential difference across wire XY is 1.8 V.

Calculate:

(iii) resistance *R*.

R = ... Ω [2]

11 (a) State Kirchhoff's first law.

.....

.....

..... [2]

(b) The circuit shown in Fig. 5.1 contains a battery of electromotive force (e.m.f.) *E* and negligible internal resistance connected to four resistors R_1, R_2, R_3 and R_4, each of resistance *R*.

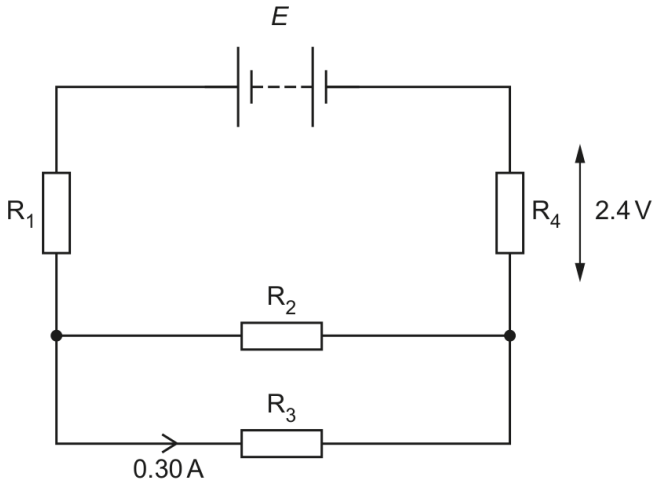


Fig. 5.1

The current in R_3 is 0.30 A and the potential difference (p.d.) across R_4 is 2.4 V.

(ii) Determine the e.m.f. *E* of the battery.

E = ... V [2]

12 (c) Three resistors have resistances of 180 Ω, 90 Ω and 30 Ω.

(i) Sketch a diagram showing how **two** of these three resistors may be connected together to give a combined resistance of 60 Ω between the terminals shown.
Ensure you label the values of the resistances in your diagram.

[1]

13 (b) A student is provided with three resistors of resistances 90 Ω, 45 Ω and 20 Ω.

(i) Sketch a circuit diagram showing how **two** of these three resistors may be connected together to give a combined resistance of 30 Ω between the terminals shown. Label the values of the resistances on your diagram.

[1]

14 (a) A network of three resistors of resistances R_1, R_2 and R_3 is shown in Fig. 6.1.

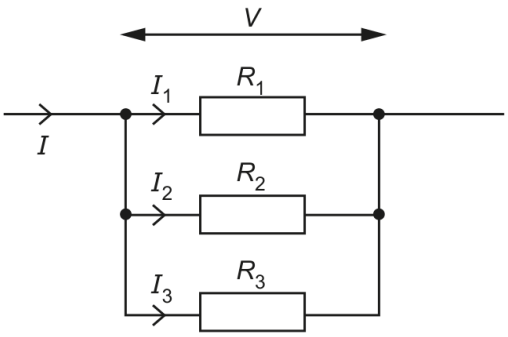


Fig. 6.1

The individual currents in the resistors are I_1, I_2 and I_3. The total current in the combination of resistors is I and the potential difference across the combination is V.

Show that the combined resistance R of the network is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

[2]

(b) A battery of electromotive force (e.m.f.) 8.0 V and internal resistance *r* is connected to three resistors X, Y and Z, as shown in Fig. 6.2.

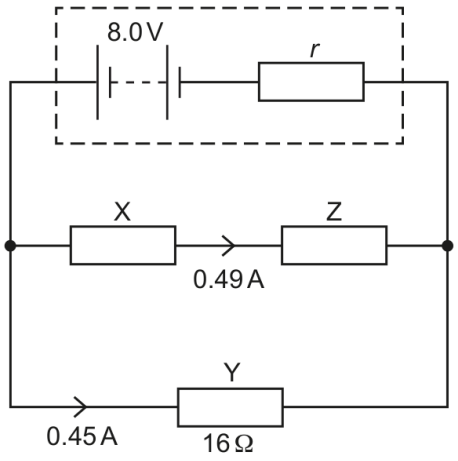


Fig. 6.2

Resistor Y has a resistance of 16 Ω. The current in resistor X is 0.49 A and the current in resistor Y is 0.45 A.

Calculate:

(i) the current in the battery

current = ... A [1]

15 (a) State Kirchhoff's second law.

.....

.....[2]

(b) A battery of electromotive force (e.m.f.) 5.6 V and internal resistance *r* is connected to two external resistors, as shown in Fig. 5.1.

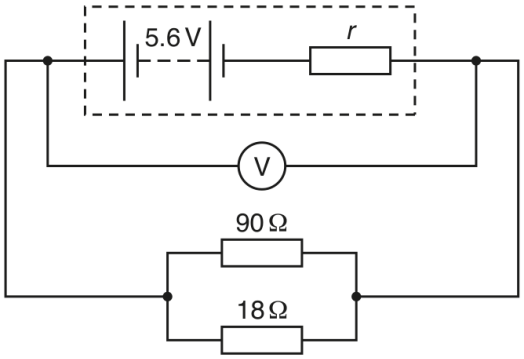


Fig. 5.1

The reading on the voltmeter is 4.8 V.

(i) Calculate:

1. the combined resistance of the two resistors connected in parallel

combined resistance = ... Ω [2]

2. the current in the battery.

current = ... A [2]

(c) The battery in **(b)** is now connected to a battery of e.m.f. 7.2 V and internal resistance 3.5 Ω. The new circuit is shown in Fig. 5.2.

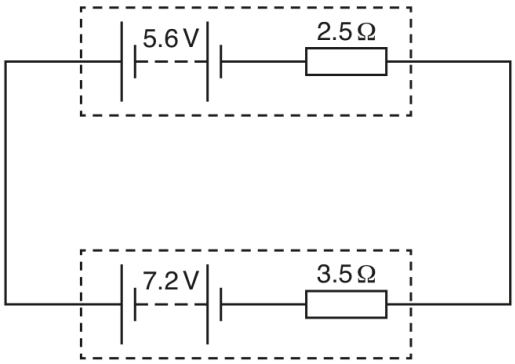


Fig. 5.2

Determine the current in the circuit.

current = ... A [2]

16 (c) The diode in **(b)** is part of the circuit shown in Fig. 6.2.

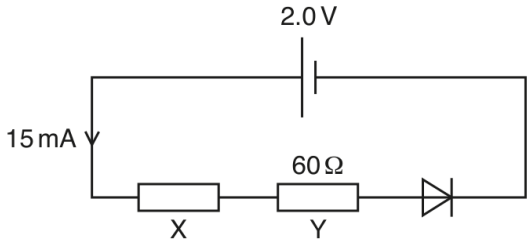


Fig. 6.2

The cell of electromotive force (e.m.f.) 2.0 V and negligible internal resistance is connected in series with the diode and resistors X and Y. The resistance of Y is 60 Ω. The current in the cell is 15 mA.

(ii) Calculate:

1. the resistance of X

resistance = ... Ω [3]

2. the ratio

$$\frac{\text{power dissipated in resistor Y}}{\text{total power produced by the cell}}.$$

ratio = ... [2]

17 **(a)** State Kirchhoff's first law.

.....

..... [1]

(c) The diode and the resistor X in **(b)** are connected into the circuit shown in Fig. 6.2.

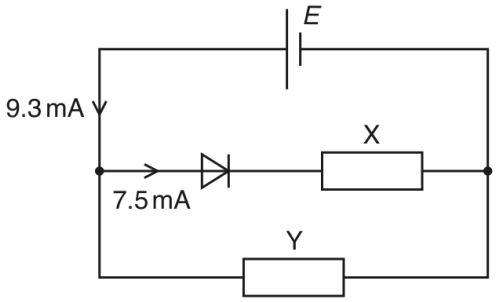


Fig. 6.2

The cell has electromotive force (e.m.f.) *E* and negligible internal resistance. Resistor Y is connected in parallel with resistor X and the diode. The current in the cell is 9.3 mA and the current in the diode is 7.5 mA.

(ii) Determine the resistance of resistor Y.

resistance = ... Ω [2]

18 (a) (i) State Kirchhoff's first law.

.....

.....[1]

(ii) Kirchhoff's first law is linked to the conservation of a certain quantity. State this quantity.

.....[1]

(b) A battery of electromotive force (e.m.f.) 8.0 V and internal resistance 2.0 Ω is connected to a resistor X and a wire Y, as shown in Fig. 6.1.

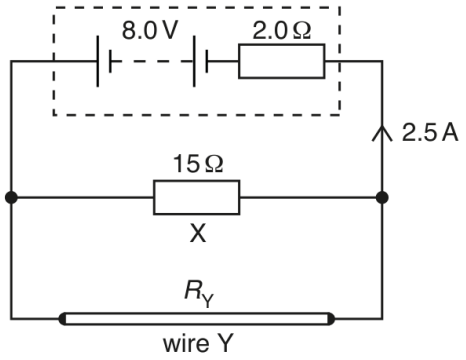


Fig. 6.1

The resistance of X is 15 Ω. The resistance of Y is R_Y. The current in the battery is 2.5 A.

(ii) Determine the resistance R_Y.

R_Y = ... Ω [3]

19 (a) State Kirchhoff's second law.

.....

.....

..... [2]

(b) An electric heater containing two heating wires X and Y is connected to a power supply of electromotive force (e.m.f.) 9.0 V and negligible internal resistance, as shown in Fig. 6.1.

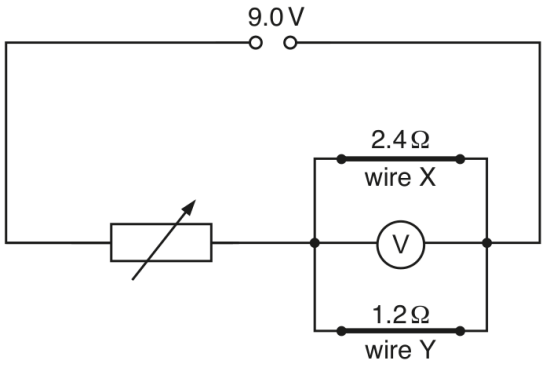


Fig. 6.1

Wire X has a resistance of 2.4 Ω and wire Y has a resistance of 1.2 Ω. A voltmeter is connected in parallel with the wires. A variable resistor is used to adjust the power dissipated in wires X and Y.

The variable resistor is adjusted so that the voltmeter reads 6.0 V.

(i) Calculate the resistance of the variable resistor.

resistance = ... Ω [3]

20 (b) A battery of electromotive force (e.m.f.) 7.0 V and negligible internal resistance is connected in series with three components, as shown in Fig. 6.1.

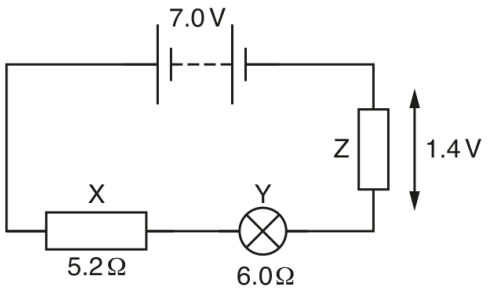


Fig. 6.1

Resistor X has a resistance of 5.2 Ω. The resistance of the filament wire of lamp Y is 6.0 Ω. The potential difference across resistor Z is 1.4 V.

(ii) Determine the resistance of resistor Z.

resistance = ... Ω [1]