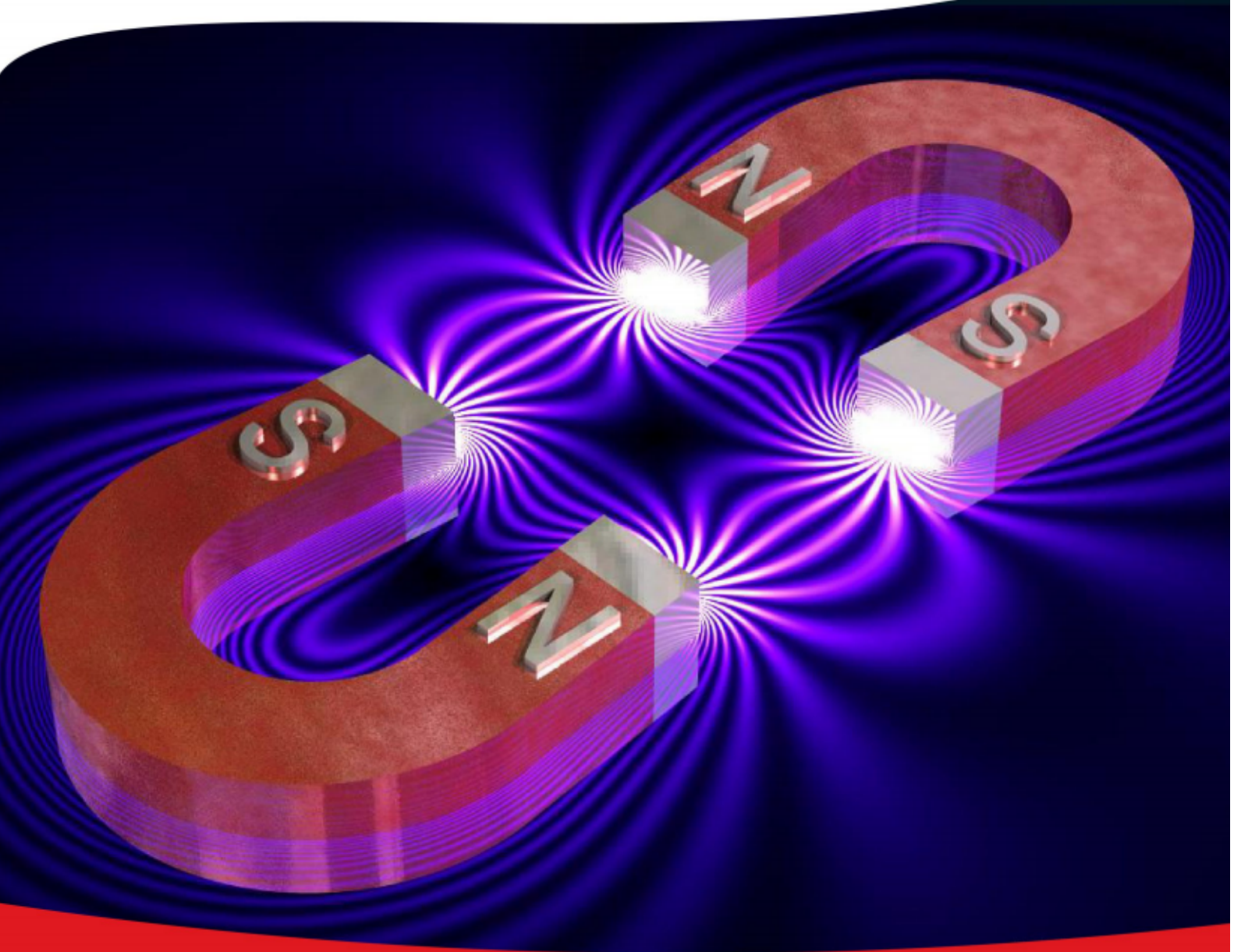
Cambridge International AS & A Level

PHYSICS (9702) P2

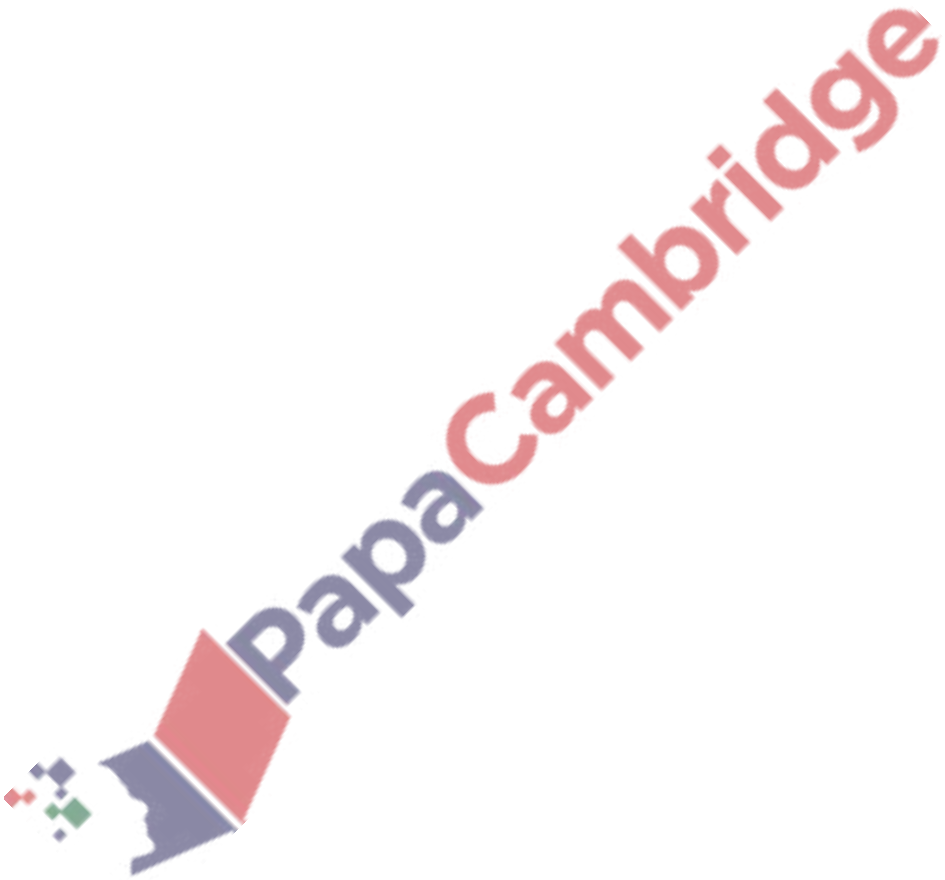
TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS



PapaCambridge

Chapter 12

D.C. circuits



12.1 Practical circuits

212. 9702_m20_qp_22 Q: 6

A uniform electric field is produced between two parallel metal plates. The electric field strength is $1.4 \times 10^4\,\text{N C}^{-1}$. The potential difference between the plates is 350 V.

(a) Calculate the separation of the plates.

separation = ... m [2]

(b) A nucleus of mass 8.3×10^{-27} kg is now placed in the electric field. The electric force acting on the nucleus is 6.7×10^{-15} N.

(i) Calculate the charge on the nucleus in terms of *e*, where *e* is the elementary charge.

charge = ... *e* [3]

(ii) Calculate the mass, in u, of the nucleus.

mass = ... u [1]

(iii) Use your answers in **(b)(i)** and **(b)(ii)** to determine the number of neutrons in the nucleus.

number = ... [1]

[Total: 7]

213. 9702_s15_qp_21 Q: 5

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

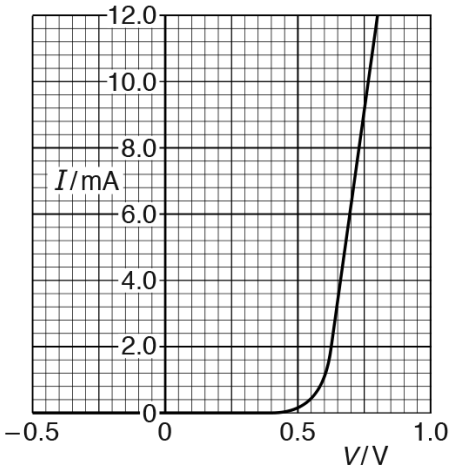


Fig. 5.1

(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.

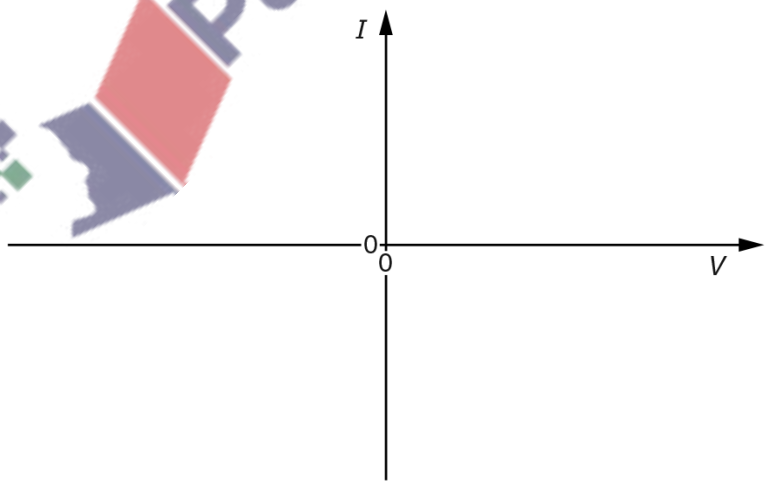


Fig. 5.2

[2]

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

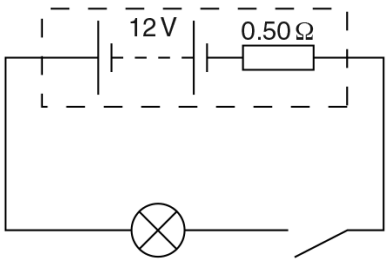


Fig. 5.3

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]

12.2 Kirchhoff's laws

214. 9702_m20_qp_22 Q: 5

(a) Define the *ohm*.

.....

.....

..... [1]

(b) A wire has a resistance of 1.8 Ω. The wire has a uniform cross-sectional area of 0.38 mm^2 and is made of metal of resistivity 9.6×10^{-7} Ω m.

Calculate the length of the wire.

length = ... m [3]

(c) A resistor X of resistance 1.8 Ω is connected to a resistor Y of resistance 0.60 Ω and a battery P, as shown in Fig. 5.1.

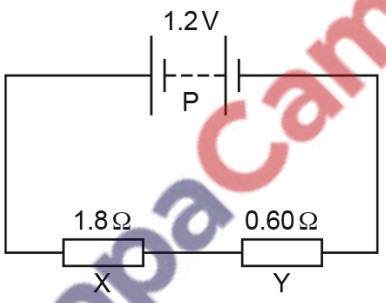


Fig. 5.1

The battery P has an electromotive force (e.m.f.) of 1.2 V and negligible internal resistance.

(i) Explain, in terms of energy, why the potential difference (p.d.) across resistor X is less than the e.m.f. of the battery.

.....

.....

..... [1]

(ii) Calculate the potential difference across resistor X.

potential difference = ... V [2]

(d) Another battery Q of e.m.f. 1.2 V and negligible internal resistance is now connected into the circuit of Fig. 5.1 to produce the new circuit shown in Fig. 5.2.

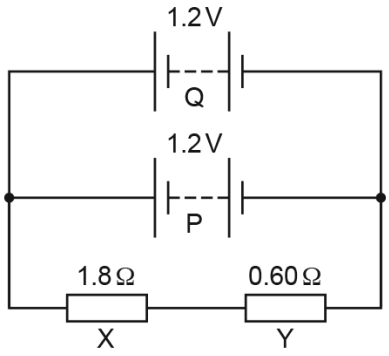


Fig. 5.2

State whether the addition of battery Q causes the current to decrease, increase or remain the same in:

(i) resistor X ..... [1]

(ii) battery P. ..... [1]

(e) The circuit shown in Fig. 5.2 is modified to produce the new circuit shown in Fig. 5.3.

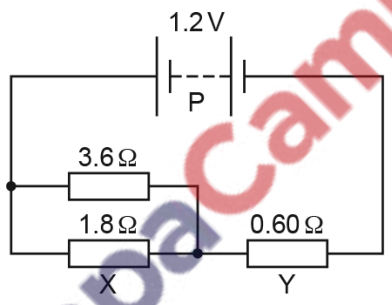


Fig. 5.3

Calculate:

(i) the total resistance of the two resistors connected in parallel

resistance = ... Ω [1]

(ii) the current in resistor Y.

current = ... A [2]

[Total: 12]

215. 9702_s20_qp_22 Q: 6

(a) A battery of electromotive force (e.m.f.) 7.8 V and internal resistance r is connected to a filament lamp, as shown in Fig. 6.1.

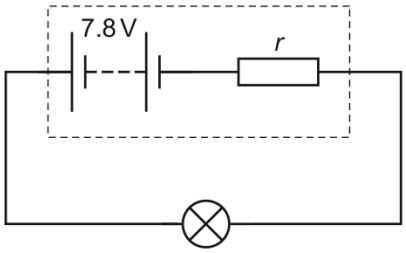


Fig. 6.1

A total charge of 750 C moves through the battery in a time interval of 1500 s. During this time the filament lamp dissipates 5.7 kJ of energy. The e.m.f. of the battery remains constant.

(i) Explain, in terms of energy and without a calculation, why the potential difference across the lamp must be less than the e.m.f. of the battery.

.....

..... [1]

(ii) Calculate:

1. the current in the circuit

current = ... A [2]

2. the potential difference across the lamp

potential difference = ... V [2]

3. the internal resistance of the battery.

internal resistance = ... Ω [2]

(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]

(ii) A potential divider circuit is produced by connecting the three resistors to a battery of e.m.f. 9.0 V and negligible internal resistance. The potential divider circuit provides an output potential difference V_{OUT} of 3.6 V. The circuit diagram is shown in Fig. 6.2.

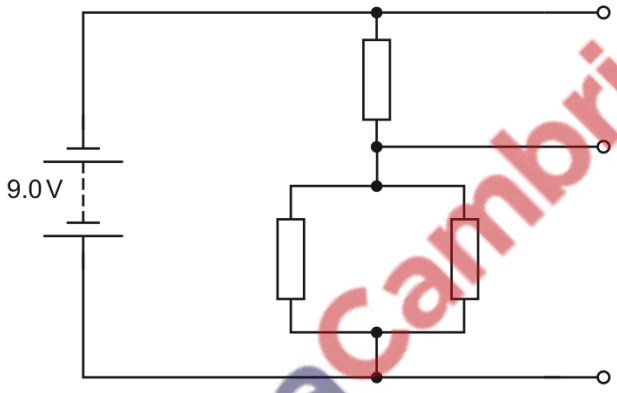


Fig. 6.2

On Fig. 6.2, label the resistances of all three resistors and the potential difference V_{OUT}. [2]

[Total: 10]

216. 9702_s20_qp_23 Q: 5

(a) Define the *volt*.

.....

..... [1]

(b) Fig. 5.1 shows a network of three resistors.

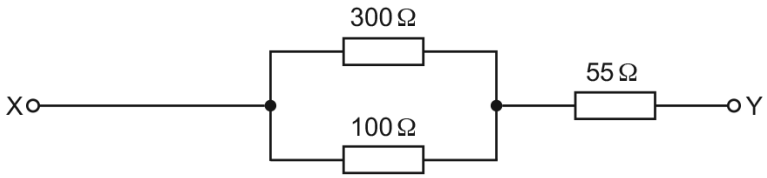


Fig. 5.1

Calculate:

(i) the combined resistance of the two resistors connected in parallel

combined resistance = ... Ω [1]

(ii) the total resistance between terminals X and Y.

total resistance = ... Ω [1]

(c) The network in **(b)** is connected to a power supply so that there is a potential difference between terminals X and Y. The power dissipated in the resistor of resistance 55 Ω is 0.20 W.

(i) Calculate the current in the resistor of resistance:

1. 55 Ω

current = ... A

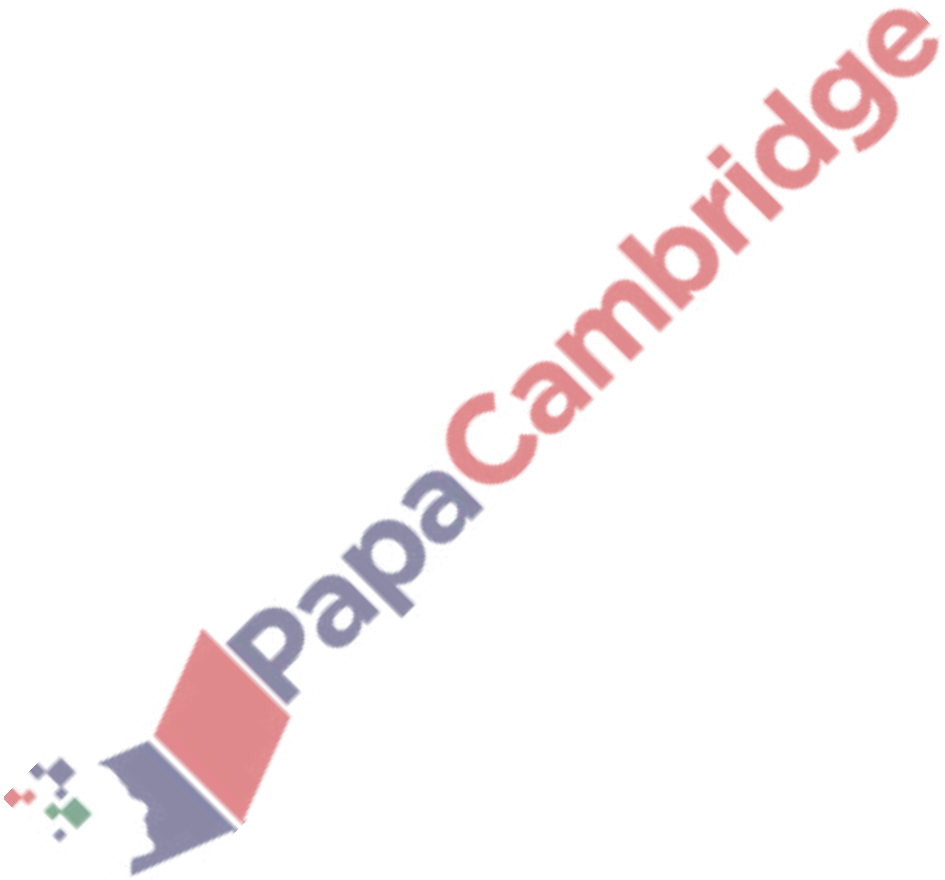
2. 300 Ω.

current = ... A
[3]

(ii) Calculate the potential difference between X and Y.

potential difference = ... V [1]

[Total: 7]



217. 9702_w20_qp_21 Q: 7

(a) Define the *ohm*.

.....

..... [1]

(b) A uniform wire has resistance 3.2 Ω. The wire has length 2.5 m and is made from metal of resistivity 460 nΩ m.

Calculate the cross-sectional area of the wire.

cross-sectional area = ... m^2 [3]

(c) A cell of electromotive force (e.m.f.) E and internal resistance r is connected to a variable resistor of resistance R, as shown in Fig. 7.1.

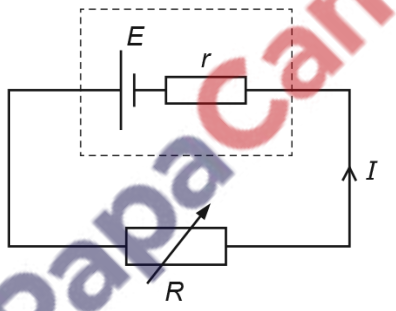


Fig. 7.1

The current in the circuit is I.

(i) State, in terms of energy, why the potential difference across the variable resistor is less than the e.m.f. of the cell.

.....

..... [1]

(ii) State an expression for E in terms of I, R and r.

E = ... [1]

(iii) The resistance R of the variable resistor is changed so that it is equal to r.

Determine an expression, in terms of only E and r, for the power P dissipated in the variable resistor.

P = ... [2]

[Total: 8]

218. 9702_w20_qp_22 Q: 6

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

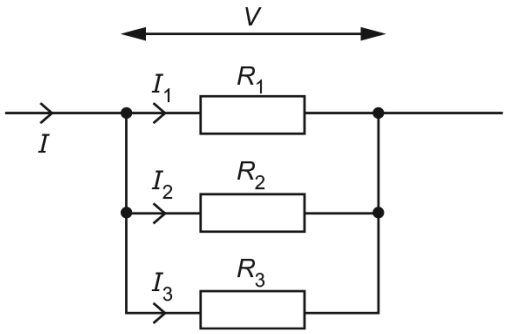


Fig. 6.1

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.

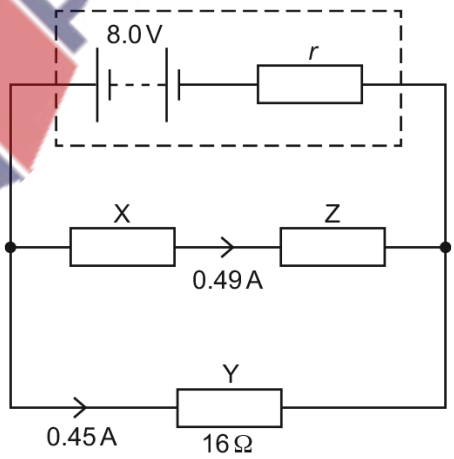


Fig. 6.2

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

Calculate:

(i) the current in the battery

current = ... A [1]

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

r = ... Ω [2]

(c) Resistors X and Y in Fig. 6.2 are made from wires of the same material and cross-sectional area. The average drift speed of the free electrons in X is $2.1 \times 10^{-4}\,m\,s^{-1}$.

Calculate the average drift speed *v* of the free electrons in Y.

v = ... $m\,s^{-1}$ [2]

(d) Resistor Z in Fig. 6.2 is replaced by a new resistor of smaller resistance.

State and explain the effect, if any, on the terminal potential difference of the battery.

.....

.....

..... [2]

[Total: 9]

219. 9702_w20_qp_23 Q: 6

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

.....

..... [1]

(b) A wire of cross-sectional area A is made from metal of resistivity ρ. The wire is extended. Assume that the volume V of the wire remains constant as it extends.

Show that the resistance R of the extending wire is inversely proportional to A^2.

[2]

(c) A battery of electromotive force (e.m.f.) E and internal resistance r is connected to a variable resistor of resistance R, as shown in Fig. 6.1.

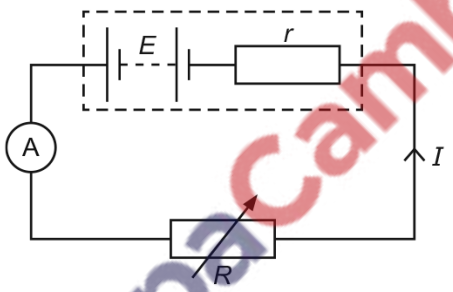


Fig. 6.1

The current in the circuit is I.

Use Kirchhoff's second law to show that

$$R = \left(\frac{E}{I}\right) - r.$$

(d) An ammeter is used in the circuit in **(c)** to measure the current I as resistance R is varied. Fig. 6.2 is a graph of R against $\frac{1}{I}$.

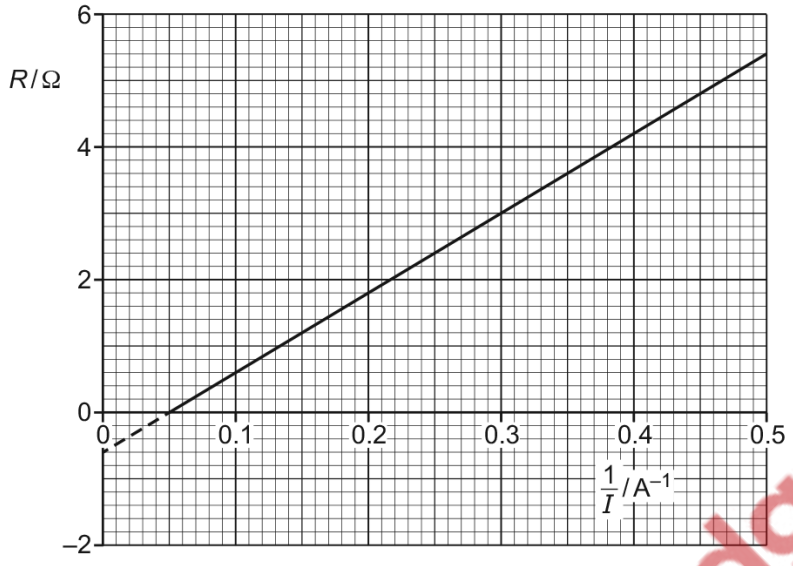


Fig. 6.2

(i) Use Fig. 6.2 to determine the power dissipated in the variable resistor when there is a current of 2.0 A in the circuit.

power = ... W [3]

(ii) Use Fig. 6.2 and the equation in **(c)** to:

1. state the internal resistance r of the battery

r = ... Ω

2. determine the e.m.f. E of the battery.

E = ... V
[3]

[Total: 10]

220. 9702_m19_qp_22 Q: 6

(a) Using energy transformations, describe the *electromotive force* (*e.m.f.*) of a battery and the *potential difference* (*p.d.*) across a resistor.

e.m.f.: .....

.....

p.d.: .....

.....[2]

(b) A battery of e.m.f. 6.0 V and negligible internal resistance is connected to a network of resistors and a voltmeter, as shown in Fig. 6.1.

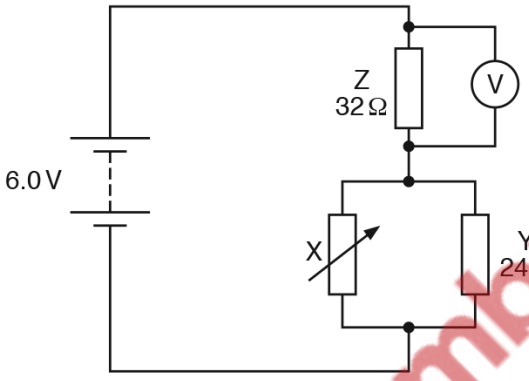


Fig. 6.1

Resistor Y has a resistance of 24 Ω and resistor Z has a resistance of 32 Ω.

(i) The resistance R_X of the variable resistor X is adjusted until the voltmeter reads 4.8 V.

Calculate:

1. the current in resistor Z

current = ... A [1]

2. the total power provided by the battery

power = ... W [2]

3. the number of conduction electrons that move through the battery in a time interval of 25 s

number = ... [2]

4. the total resistance of X and Y connected in parallel

total resistance = ... Ω [2]

5. the resistance R_X.

R_X = ... Ω [2]

(ii) The resistance R_X is now decreased.

State and explain the change, if any, to the reading on the voltmeter.

.....

.....

.....[2]

[Total: 13]

221. 9702_s19_qp_21 Q: 6

A battery of electromotive force (e.m.f.) E and internal resistance r is connected to a variable resistor of resistance R, as shown in Fig. 6.1.

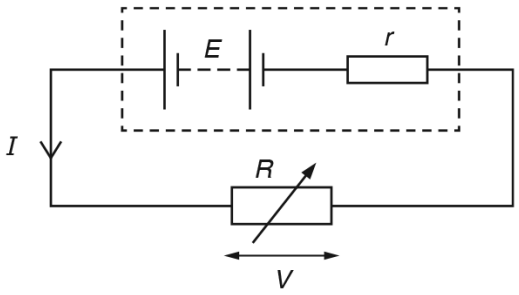


Fig. 6.1

The current in the circuit is I and the potential difference across the variable resistor is V.

(a) Explain, in terms of energy, why V is less than E.

.....

.....[1]

(b) State an equation relating E, I, r and V.

.....[1]

(c) The resistance R of the variable resistor is varied. The variation with I of V is shown in Fig. 6.2.

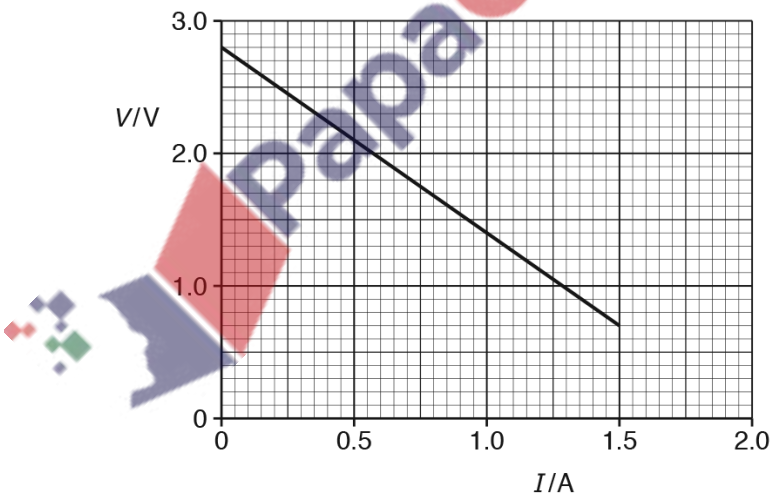


Fig. 6.2

Use Fig. 6.2 to:

(i) explain how it may be deduced that the e.m.f. of the battery is 2.8 V

.....

.....[1]

(ii) calculate the internal resistance *r*.

r = ... Ω [2]

(d) The battery stores 9.2 kJ of energy. The variable resistor is adjusted so that *V* = 2.1 V. Use Fig. 6.2 to:

(i) calculate resistance *R*

R = ... Ω [1]

(ii) calculate the number of conduction electrons moving through the battery in a time of 1.0 s

number = ... [1]

(iii) determine the time taken for the energy in the battery to become equal to 1.6 kJ. (Assume that the e.m.f. of the battery and the current in the battery remain constant.)

time taken = ... s [3]

[Total: 10]

222. 9702_s19_qp_22 Q: 5

(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.

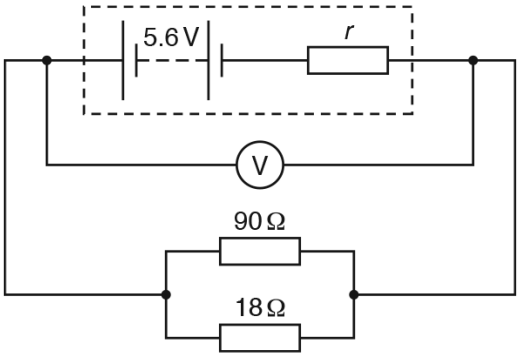


Fig. 5.1

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]

(ii) Show that the internal resistance r is 2.5 Ω.

[2]

(iii) Determine the ratio

$$\frac{\text{power dissipated by internal resistance } r}{\text{total power produced by battery}}.$$

ratio = ... [3]

(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.

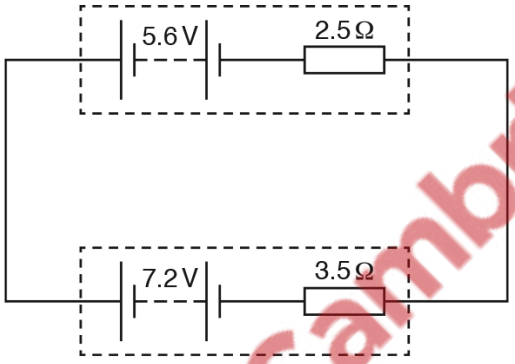


Fig. 5.2

Determine the current in the circuit.

current = ... A [2]

[Total: 13]

223. 9702_s19_qp_23 Q: 6

(a) Define the *ohm*.

.....[1]

(b) A battery of electromotive force (e.m.f.) E and internal resistance 1.5 Ω is connected to a network of resistors, as shown in Fig. 6.1.

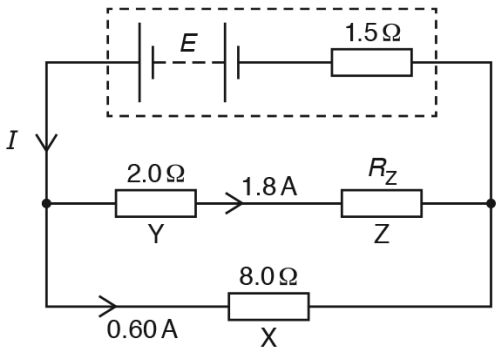


Fig. 6.1

Resistor X has a resistance of 8.0 Ω. Resistor Y has a resistance of 2.0 Ω. Resistor Z has a resistance of R_Z. The current in X is 0.60 A and the current in Y is 1.8 A.

(i) Calculate:

1. the current I in the battery

I = ... A [1]

2. resistance R_Z

R_Z = ... Ω [2]

3. e.m.f. E.

E = ... V [2]

(ii) Resistors X and Y are each made of wire. The two wires have the same length and are made of the same metal.

Determine the ratio:

1. $\frac{\text{cross-sectional area of wire X}}{\text{cross-sectional area of wire Y}}$

ratio = ... [2]

2. $\frac{\text{average drift speed of free electrons in X}}{\text{average drift speed of free electrons in Y}}$.

ratio = ... [2]

[Total: 10]

224. 9702_w19_qp_21 Q: 6

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

.....

..... [1]

(b) The variation with potential difference V of the current I in a semiconductor diode is shown in Fig. 6.1.

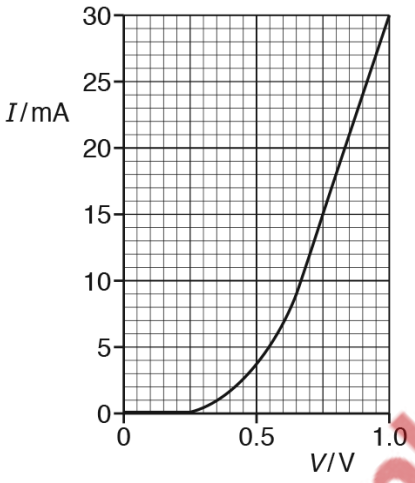


Fig. 6.1

Use Fig. 6.1 to describe qualitatively the variation of the resistance of the diode as V increases from 0 to 1.0 V.

.....

.....

.....

..... [2]

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

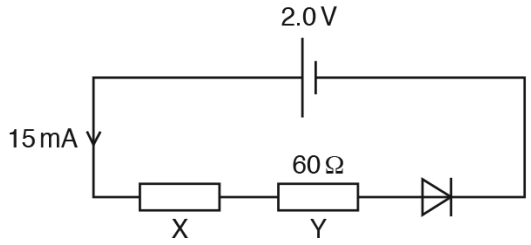


Fig. 6.2

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.

(i) Use Fig. 6.1 to determine the resistance of the diode.

resistance = ... Ω [3]

(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]

[Total: 11]

225. 9702_w19_qp_22 Q: 6

(a) State Kirchhoff's first law.

.....

..... [1]

(b) The variations with potential difference V of the current I for a resistor X and for a semiconductor diode are shown in Fig. 6.1.

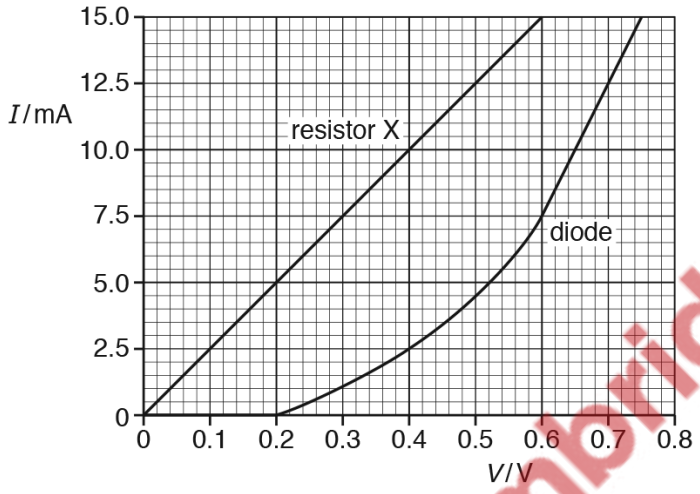


Fig. 6.1

(i) Determine the resistance of the diode for a potential difference V of 0.60 V.

resistance = ... Ω [3]

(ii) Describe, qualitatively, the variation of the resistance of the diode as V increases from 0.60 V to 0.75 V.

..... [1]

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

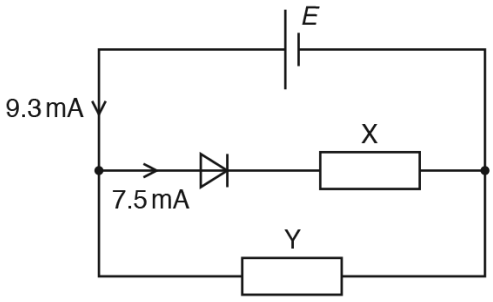


Fig. 6.2

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.

(i) Use Fig. 6.1 to determine E.

E = ...V [1]

(ii) Determine the resistance of resistor Y.

resistance = ... Ω [2]

(iii) Calculate the power dissipated in the diode.

power = ...W [2]

(iv) The cell is now replaced by a new cell of e.m.f. 0.50 V and negligible internal resistance. Use Fig. 6.1 to determine the new current in the diode.

current = ...mA [1]

[Total: 11]

226. 9702_w19_qp_23 Q: 6

A battery of electromotive force (e.m.f.) 12 V and negligible internal resistance is connected to a network of two lamps and two resistors, as shown in Fig. 6.1.

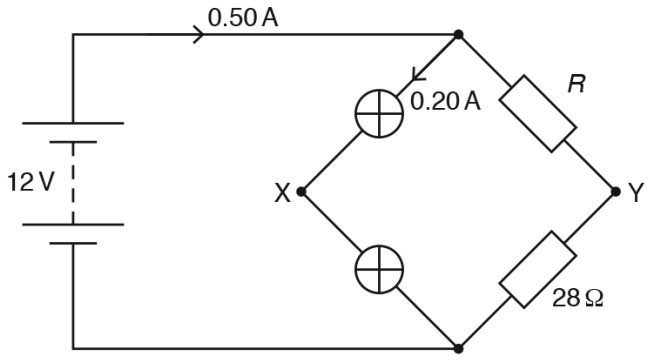


Fig. 6.1

The two lamps in the circuit have equal resistances. The two resistors have resistances R and 28 Ω. The lamps are connected at junction X and the resistors are connected at junction Y. The current in the battery is 0.50 A and the current in the lamps is 0.20 A.

(a) Calculate:

(i) the resistance of each lamp

resistance = ... Ω [2]

(ii) resistance R.

R = ... Ω [2]

(b) Determine the potential difference V_{XY} between points X and Y.

V_{XY} = ... V [3]

(c) Calculate the ratio

$$\frac{\text{total power dissipated by the lamps}}{\text{total power produced by the battery}}.$$

ratio = ... [2]

(d) The resistor of resistance R is now replaced by another resistor of lower resistance.

State and explain the effect, if any, of this change on the ratio in **(c)**.

.....

.....

.....

.....

..... [2]

[Total: 11]

227. 9702_m18_qp_22 Q: 5

(a) State Kirchhoff's second law.

.....

.....[2]

(b) Two batteries, each of electromotive force (e.m.f.) 6.0 V and negligible internal resistance, are connected in series with three resistors, as shown in Fig. 5.1.

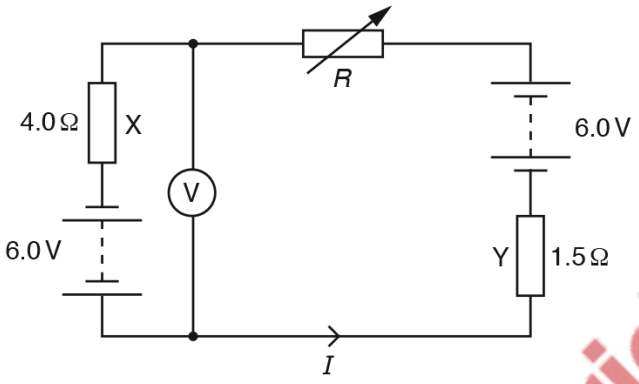


Fig. 5.1

Resistor X has resistance 4.0 Ω and resistor Y has resistance 1.5 Ω.

(i) The resistance *R* of the variable resistor is changed until the voltmeter in the circuit reads zero.

Calculate

1. the current *I* in the circuit,

I = ... A [1]

2. the resistance *R*.

R = ... Ω [2]

(ii) Resistors X and Y are wires made from the same material. The diameter of the wire of X is twice the diameter of the wire of Y.

Determine the ratio

$$\frac{\text{average drift speed of free electrons in X}}{\text{average drift speed of free electrons in Y}}.$$

ratio = ... [2]

(iii) The resistance R of the variable resistor is now increased.

State and explain the effect of the increase in R on the power transformed by each of the batteries.

.....

.....

.....

.....[3]

[Total: 10]

228. 9702_s18_qp_21 Q: 6

(a) Define the *volt*.

.....[1]

(b) A battery of electromotive force (e.m.f.) 4.5 V and negligible internal resistance is connected to two filament lamps P and Q and a resistor R, as shown in Fig. 6.1.

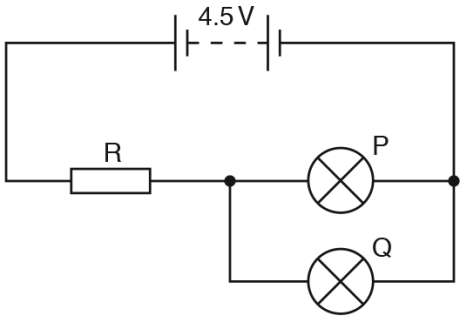


Fig. 6.1

The current in lamp P is 0.15 A.
The I–V characteristics of the filament lamps are shown in Fig. 6.2.

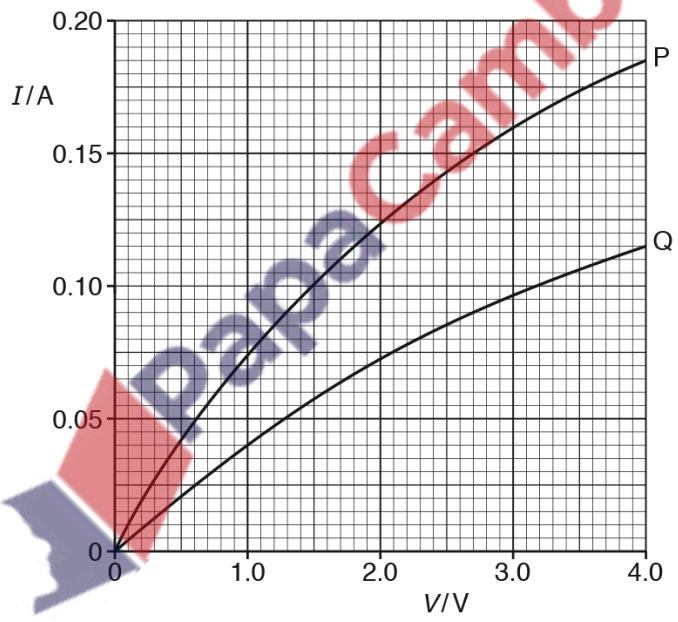


Fig. 6.2

(i) Use Fig. 6.2 to determine the current in the battery. Explain your working.

current = ... A [2]

(ii) Calculate the resistance of resistor R.

resistance = ... Ω [2]

(iii) The filament wires of the two lamps are made from material with the same resistivity at their operating temperature in the circuit. The diameter of the wire of lamp P is twice the diameter of the wire of lamp Q.

Determine the ratio

$$\frac{\text{length of filament wire of lamp P}}{\text{length of filament wire of lamp Q}}.$$

ratio = ... [3]

(iv) The filament wire of lamp Q breaks and stops conducting.

State and explain, qualitatively, the effect on the resistance of lamp P.

.....

.....

.....

.....[2]

[Total: 10]

229. 9702_s18_qp_22 Q: 6

(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.

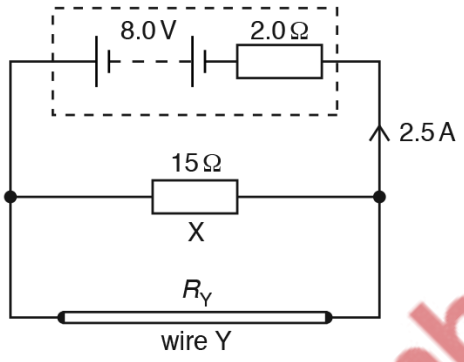


Fig. 6.1

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

(i) Calculate

1. the thermal energy dissipated in the battery in a time of 5.0 minutes,

energy = ...J [2]

2. the terminal potential difference of the battery.

terminal potential difference = ... V [1]

(ii) Determine the resistance R_Y.

R_Y = ...Ω [3]

(iii) A new wire Z has the same length but less resistance than wire Y.

1. State two possible differences between wire Z and wire Y that would separately cause wire Z to have less resistance than wire Y.

first difference: .....

.....

second difference: .....

.....

[2]

2. Wire Y is replaced in the circuit by wire Z. By considering the current in the battery, state and explain the effect of changing the wires on the total power produced by the battery.

.....

.....

.....[2]

[Total: 12]

230. 9702_s18_qp_23 Q: 6

A wire X has a constant resistance per unit length of $3.0\,\Omega\,m^{-1}$ and a diameter of 0.48 mm.

(a) Calculate the resistivity of the metal of wire X.

resistivity = ... Ω m [3]

(b) The wire X is connected into the circuit shown in Fig. 6.1.

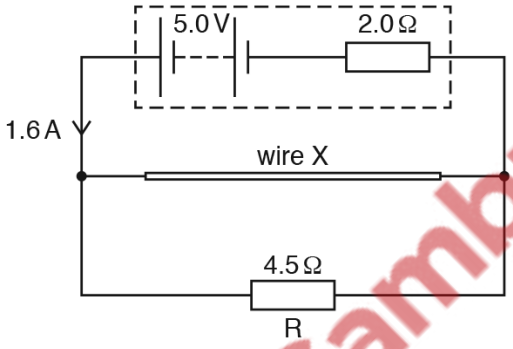


Fig. 6.1

The battery has an electromotive force (e.m.f.) of 5.0 V and an internal resistance of 2.0 Ω. The wire X and a resistor R of resistance 4.5 Ω are connected in parallel. The current in the battery is 1.6 A.

(i) Calculate the potential difference across resistor R.

potential difference = ... V [1]

(ii) Determine, for wire X,

1. its resistance,

resistance = ... Ω [3]

2. its length.

length = ... m [1]

[Total: 8]

---

231. 9702_w18_qp_21 Q: 6

(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.

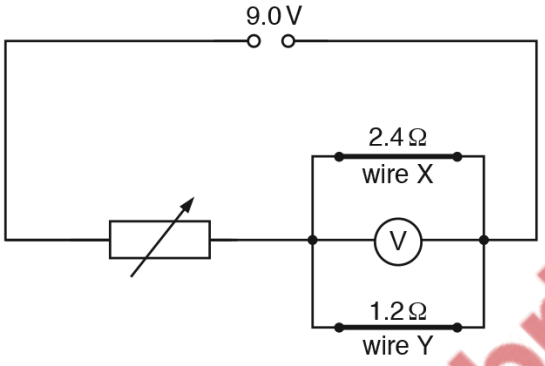


Fig. 6.1

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]

(ii) Calculate the power dissipated in wire X.

power = ... W [2]

(iii) The cross-sectional area of wire X is three times the cross-sectional area of wire Y. Assume that the resistivity and the number density of free electrons for the metal of both wires are the same.

Determine the ratio

1. $\frac{\text{length of wire X}}{\text{length of wire Y}}$,

ratio = ... [2]

2. $\frac{\text{average drift velocity of free electrons in wire X}}{\text{average drift velocity of free electrons in wire Y}}$.

ratio = ... [2]

[Total: 11]

232. 9702_w18_qp_23 Q: 7

(a) State Kirchhoff's first law.

.....

.....[1]

(b) A potentiometer is connected to a battery of electromotive force (e.m.f.) 9.6 V and negligible internal resistance, as shown in Fig. 7.1.

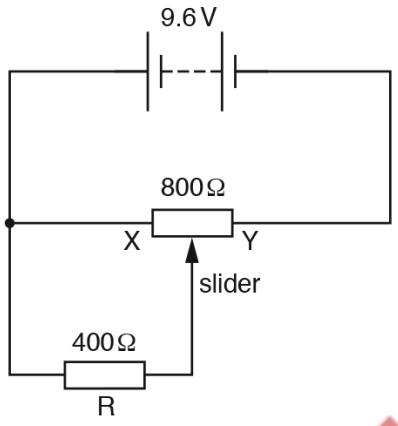


Fig. 7.1

The maximum resistance of the potentiometer is 800 Ω. A resistor R of resistance 400 Ω is connected between the slider and end X of the potentiometer.

(i) State the potential difference across resistor R when the slider is positioned

1. at end X of the potentiometer,

potential difference = ... V

2. at end Y of the potentiometer.

potential difference = ... V
[2]

(ii) Calculate the potential difference across resistor R when the slider is positioned half-way between X and Y.

potential difference = ... V [3]

[Total: 6]

---

233. 9702_m17_qp_22 Q: 6

(a) Three resistors of resistances R_1, R_2 and R_3 are connected as shown in Fig. 6.1.

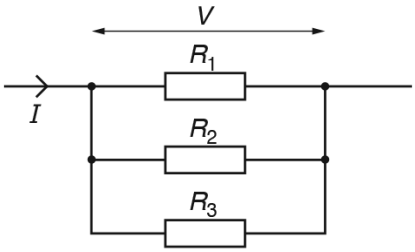


Fig. 6.1

The total current in the combination of resistors is I and the potential difference across the combination is V.

Show that the total resistance R of the combination is given by the equation

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

[2]

(b) A battery of electromotive force (e.m.f.) 6.0 V and internal resistance r is connected to a resistor of resistance 12 Ω and a variable resistor X, as shown in Fig. 6.2.

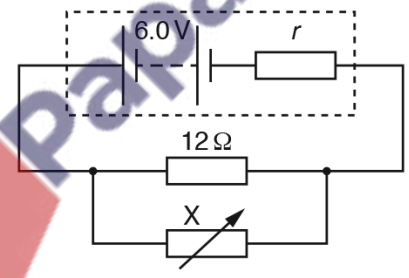


Fig. 6.2

(i) By considering energy, explain why the potential difference across the battery's terminals is less than the e.m.f. of the battery.

.....

.....

.....

.....[2]

(ii) A charge of 2.5 kC passes through the battery.

Calculate

1. the total energy transformed by the battery,

energy = ...J [2]

2. the number of electrons that pass through the battery.

number = ...[1]

(iii) The combined resistance of the two resistors connected in parallel is 4.8 Ω.

Calculate the resistance of X.

resistance of X = ...Ω [1]

(iv) Use your answer in **(b)(iii)** to determine the ratio

$$\frac{\text{power dissipated in X}}{\text{power dissipated in 12}\,\Omega\text{ resistor}}.$$

ratio = ...[2]

(v) The resistance of X is now decreased. Explain why the power produced by the battery is increased.

.....

.....

.....[1]

[Total: 11]

234. 9702_s17_qp_21 Q: 6

(a) Define the *ohm*.

.....

.....[1]

(b) A cell X of electromotive force (e.m.f.) 1.5 V and negligible internal resistance is connected in series to three resistors A, B and C, as shown in Fig. 6.1.

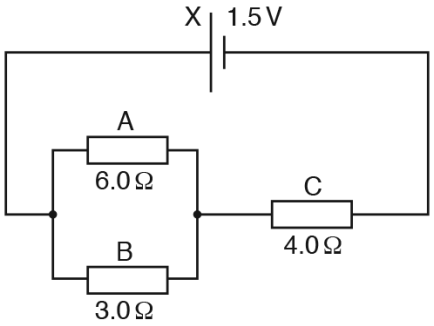


Fig. 6.1

Resistors A and B have resistances 6.0 Ω and 3.0 Ω respectively and are connected in parallel. Resistor C has resistance 4.0 Ω and is connected in series with the parallel combination.

Calculate

(i) the current in the circuit,

current = ...A [3]

(ii) the current in resistor B,

current = ...A [1]

(iii) the ratio

$$\frac{\text{power dissipated in resistor B}}{\text{power dissipated in resistor C}}.$$

ratio = ...[2]

(c) The resistors A, B and C in **(b)** are wires of the same material and have the same length.

(i) Explain how the resistors may be made with different resistance values.

.....[1]

(ii) Calculate the ratio

$$\frac{\text{average drift speed of the charge carriers in resistor B}}{\text{average drift speed of the charge carriers in resistor C}}.$$

ratio = ...[2]

(d) A cell of e.m.f. 1.5 V and negligible internal resistance is connected in parallel with cell X in Fig. 6.1 with their positive terminals together.

State the change, if any, to the current in

(i) cell X,

.....[1]

(ii) resistor C.

.....[1]

[Total: 12]

235. 9702_s17_qp_22 Q: 7

(a) Define *electromotive force* (e.m.f.) of a cell.

.....

.....[1]

(b) A cell C of e.m.f. 1.50 V and internal resistance 0.200 Ω is connected in series with resistors X and Y, as shown in Fig. 7.1.

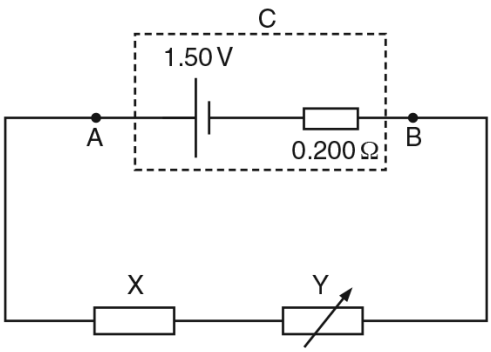


Fig. 7.1

The resistance of X is constant and the resistance of Y can be varied.

(i) The resistance of Y is varied from 0 to 8.00 Ω.

State and explain the variation in the potential difference (p.d.) between points A and B (terminal p.d. across C). Numerical values are not required.

.....

.....

.....

.....[3]

(ii) The resistance of Y is set at 6.00 Ω. The current in the circuit is 0.180 A.

Calculate

1. the resistance of X,

resistance = ...Ω [2]

2. the p.d. between points A and B,

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

3. the efficiency of the cell.

efficiency = ...[2]

[Total: 10]

---

236. 9702_s17_qp_23 Q: 6

(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.

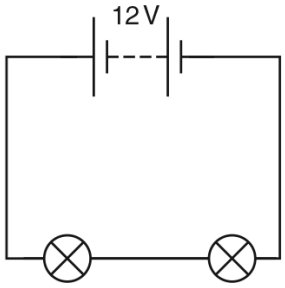


Fig. 6.1a

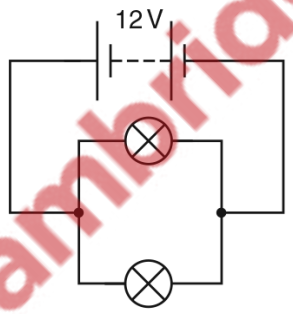


Fig. 6.1b

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

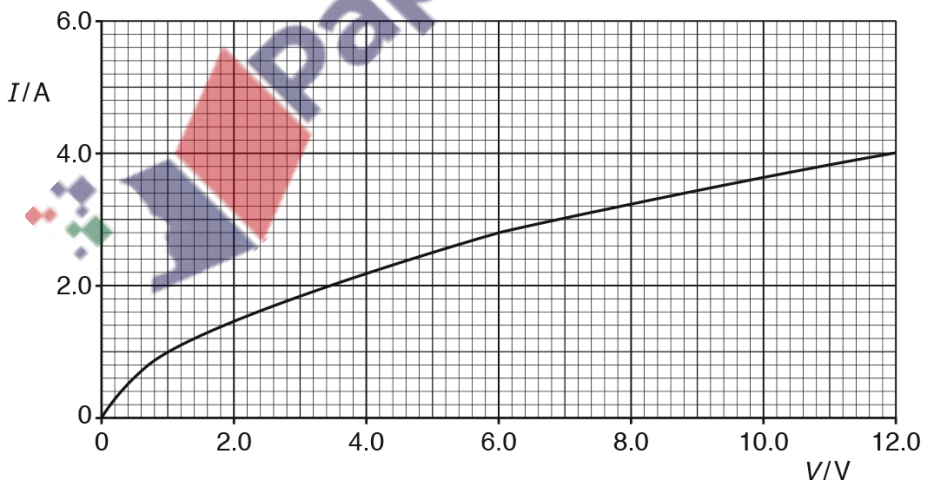


Fig. 6.2

(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]

237. 9702_w17_qp_21 Q: 5

Three cells of electromotive forces (e.m.f.) E_1, E_2 and E_3 are connected into a circuit, as shown in Fig. 5.1.

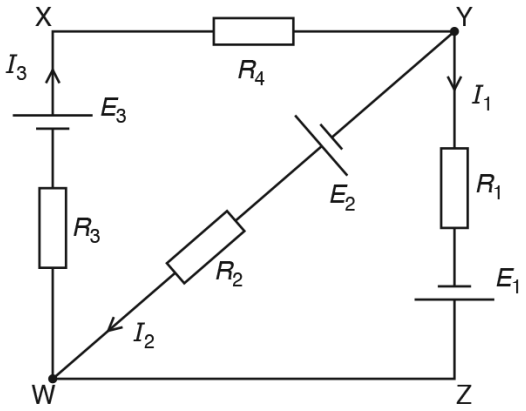


Fig. 5.1

The circuit contains resistors of resistances R_1, R_2, R_3 and R_4.
The currents in the different parts of the circuit are I_1, I_2 and I_3.
The cells have negligible internal resistance.

Use Kirchhoff's laws to state an equation relating

(a) I_1, I_2 and I_3,

.....[1]

(b) E_1, E_3, R_1, R_3, R_4, I_1 and I_3 in loop WXYZW,

.....

.....[1]

(c) E_1, E_2, R_1, R_2, I_1 and I_2 in loop YZWY.

.....

.....[1]

[Total: 3]

238. 9702_m16_qp_22 Q: 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.

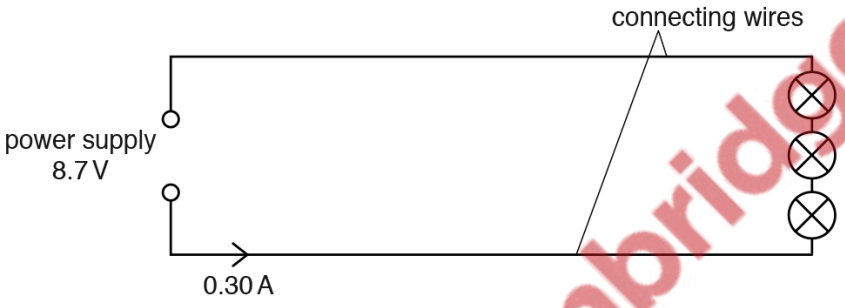


Fig. 5.1 (not to scale)

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.

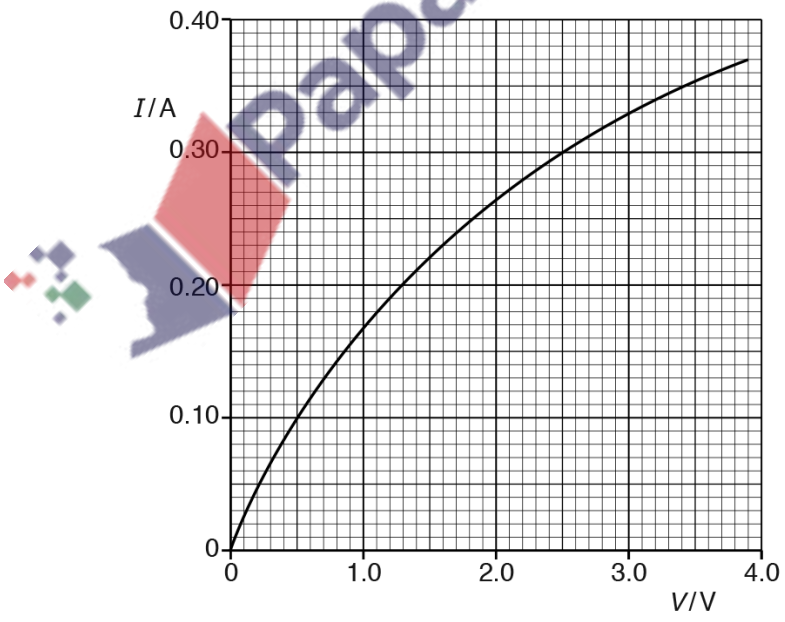


Fig. 5.2

(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]

239. 9702_s16_qp_22 Q: 7

(a) Electric current is a flow of charge carriers. The charge on the carriers is quantised. Explain what is meant by *quantised*.

.....[1]

(b) A battery of electromotive force (e.m.f.) 9.0 V and internal resistance 0.25 Ω is connected in series with two identical resistors X and a resistor Y, as shown in Fig. 7.1.

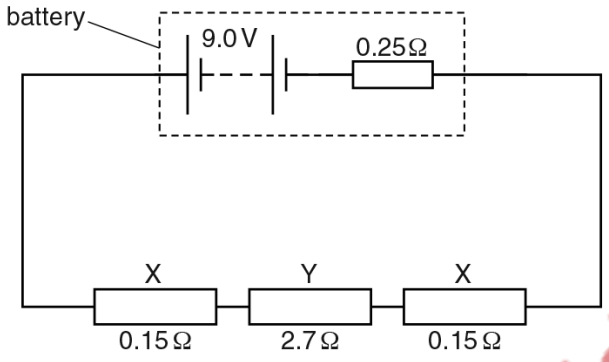


Fig. 7.1

The resistance of each resistor X is 0.15 Ω and the resistance of resistor Y is 2.7 Ω.

(i) Show that the current in the circuit is 2.8 A.

[3]

(ii) Calculate the potential difference across the battery.

potential difference = ... V [2]

(c) Each resistor X connected in the circuit in **(b)** is made from a wire with a cross-sectional area of 2.5 mm^2. The number of free electrons per unit volume in the wire is $8.5 \times 10^{29} m^{-3}$.

(i) Calculate the average drift speed of the electrons in X.

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

(ii) The two resistors X are replaced by two resistors Z made of the same material and length but with half the diameter.

Describe and explain the difference between the average drift speed in Z and that in X.

.....

.....

.....

.....[2]

[Total: 10]

240. 9702_w16_qp_21 Q: 6

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

.....

.....[1]

(b) A battery of electromotive force (e.m.f.) 14V and negligible internal resistance is connected to a resistor network, as shown in Fig. 6.1.

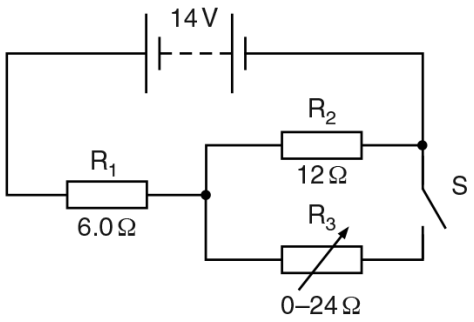


Fig. 6.1

R_1 and R_2 are fixed resistors of resistances 6.0Ω and 12Ω respectively. R_3 is a variable resistor.

Switch S is **closed**.

(i) Calculate the current in the battery when the resistance of R_3 is set

1. at zero,

current = ... A [2]

2. at 24Ω.

current = ... A [2]

(ii) Use your answers in **(b)(i)** to calculate the change in the total power produced by the battery when the resistance of R_3 is changed from zero to 24 Ω.

change in power = ... W [2]

(c) Switch S in Fig. 6.1 is now **opened**.

Resistors R_1 and R_2 are made from metal wires. Some data for these resistors are shown in Fig. 6.2.

	R_1	R_2
cross-sectional area of wire	A	$1.8A$
number of free electrons per unit volume in metal	n	$0.50n$

Fig. 6.2

Determine the ratio

$$\frac{\text{average drift speed of free electrons in } R_1}{\text{average drift speed of free electrons in } R_2}.$$

ratio = ... [2]

[Total: 9]

241. 9702_w16_qp_22 Q: 5

(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.

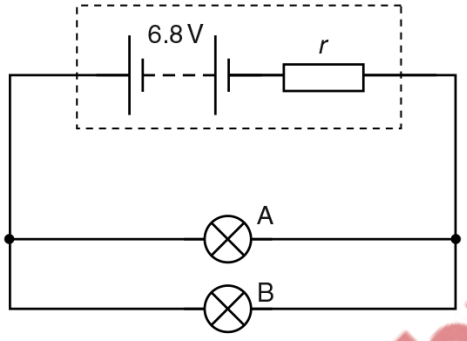


Fig. 5.1

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

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

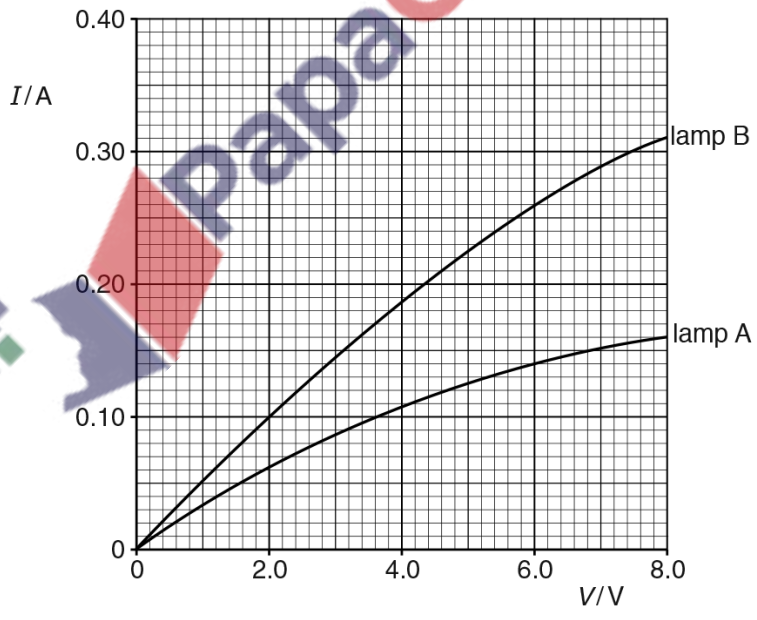


Fig. 5.2

The potential difference across the battery terminals is 6.0 V.

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

[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]

---

242. 9702_w16_qp_23 Q: 6

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

.....

.....[1]

(b) A battery of electromotive force (e.m.f.) 14V and negligible internal resistance is connected to a resistor network, as shown in Fig. 6.1.

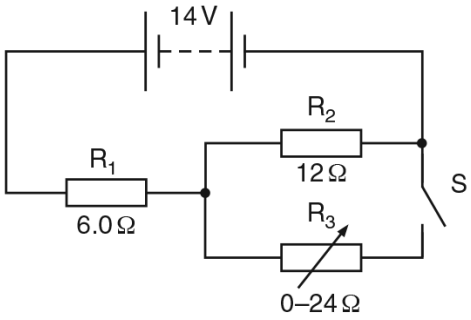


Fig. 6.1

R_1 and R_2 are fixed resistors of resistances 6.0 Ω and 12 Ω respectively. R_3 is a variable resistor.

Switch S is **closed**.

(i) Calculate the current in the battery when the resistance of R_3 is set

1. at zero,

current = ... A [2]

2. at 24 Ω.

current = ... A [2]

(ii) Use your answers in **(b)(i)** to calculate the change in the total power produced by the battery when the resistance of R_3 is changed from zero to 24 Ω.

change in power = ... W [2]

(c) Switch S in Fig. 6.1 is now **opened**.

Resistors R_1 and R_2 are made from metal wires. Some data for these resistors are shown in Fig. 6.2.

	R_1	R_2
cross-sectional area of wire	A	$1.8A$
number of free electrons per unit volume in metal	n	$0.50n$

Fig. 6.2

Determine the ratio

$$\frac{\text{average drift speed of free electrons in } R_1}{\text{average drift speed of free electrons in } R_2}.$$

ratio = ... [2]

[Total: 9]

243. 9702_s15_qp_22 Q: 5

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

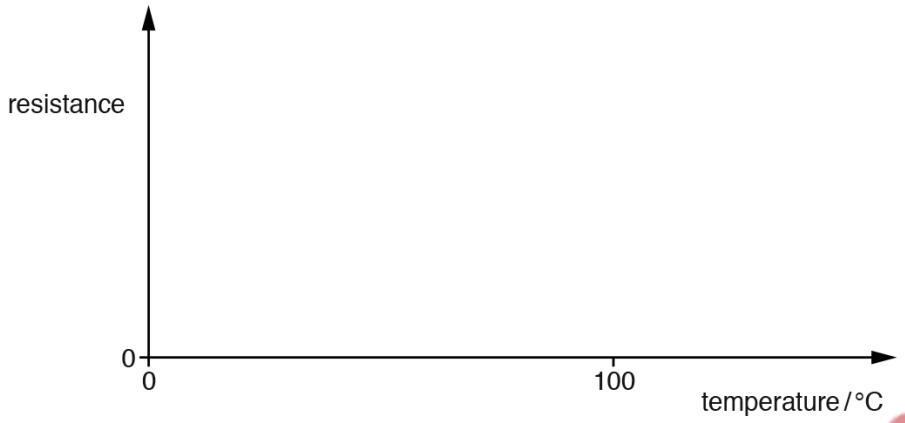


Fig. 5.1

[2]

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

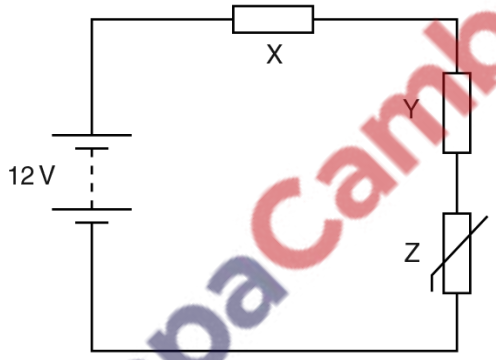


Fig. 5.2

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]

244. 9702_w15_qp_21 Q: 6

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

.....

..... [1]

(b) A battery of e.m.f. 6.0 V and internal resistance 0.50 Ω is connected in series with two resistors X and Y, as shown in Fig. 6.1.

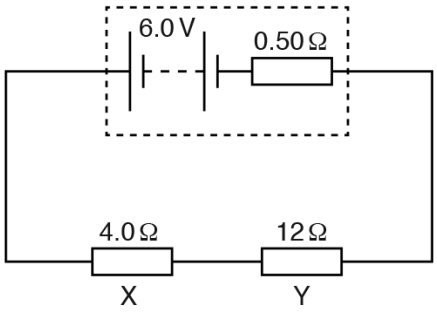


Fig. 6.1

The resistance of X is 4.0 Ω and the resistance of Y is 12 Ω.

Calculate

(i) the current in the circuit,

current = ... A [2]

(ii) the terminal potential difference (p.d.) across the battery.

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

(c) A resistor Z is now connected in parallel with resistor Y in the circuit in **(b)**. The new arrangement is shown in Fig. 6.2.

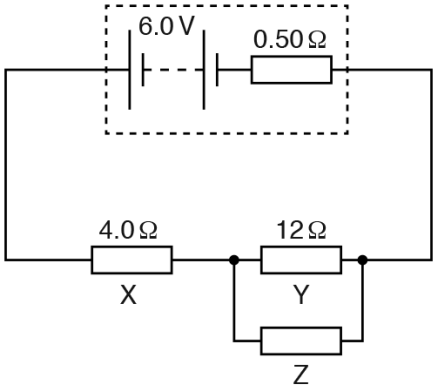


Fig. 6.2

Resistor Y is made from a wire of length l and diameter d. Resistor Z is a wire made from the same material as Y. The length of the wire for Z is $l/2$ and the diameter is $d/2$.

(i) Calculate the resistance R of the combination of resistors Y and Z.

R = ... Ω [3]

(ii) State and explain the effect on the terminal p.d. across the battery.

A numerical value is not required.

.....

.....

.....

..... [2]

(d) For the circuits given in **(b)** and **(c)**, show that the ratio

$$\frac{\text{power developed in the external circuit in Fig. 6.1}}{\text{power developed in the external circuit in Fig. 6.2}}$$

is approximately 0.8.

[3]

245. 9702_w15_qp_22 Q: 6

A 12V battery with internal resistance 0.50Ω is connected to two identical filament lamps L_1 and L_2 as shown in Fig. 6.1.

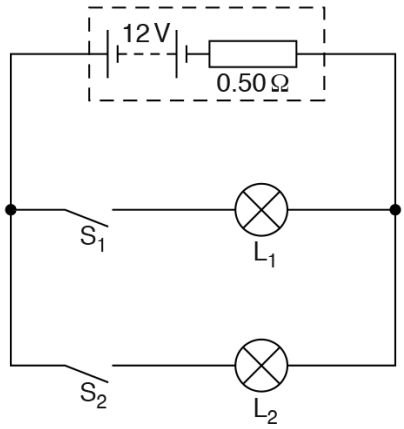


Fig. 6.1

The lamps are connected to the battery via switches S_1 and S_2. The power rating of each lamp is 48W for a potential difference of 12V.

(a) S_1 is closed and S_2 open.

State and explain whether the power transformed in L_1 is 48W.

.....

.....

.....[2]

(b) S_2 is now also closed.

(i) State and explain the effect on the current in L_1.

.....

.....

.....[1]

(ii) State and explain the effect on the resistance of L_1.

.....

.....

.....[1]

246. 9702_w15_qp_23 Q: 5

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

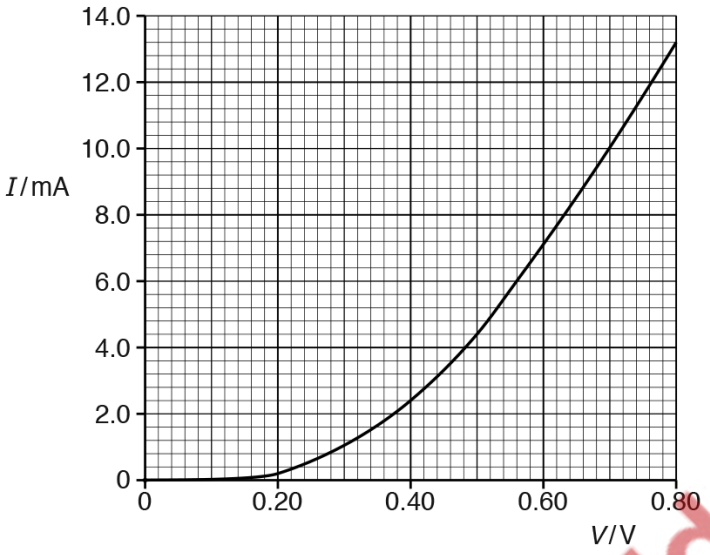


Fig. 5.1

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

.....

.....

.....

.....

.....

.....[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. 1.2V and negligible internal resistance is connected in series to a semiconductor diode and a resistor R_1, as shown in Fig. 5.2.

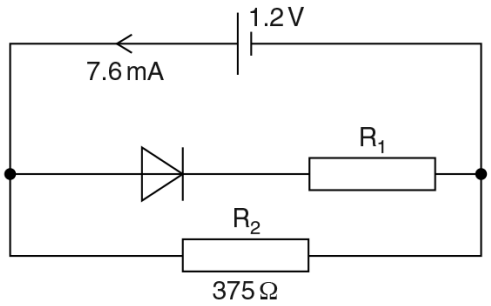


Fig. 5.2

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]

12.3 Potential dividers

247. 9702_s20_qp_21 Q: 5

(a) Metal wire is used to connect a power supply to a lamp. The wire has a total resistance of 3.4 Ω and the metal has a resistivity of 2.6×10^{-8} Ωm. The total length of the wire is 59 m.

(i) Show that the wire has a cross-sectional area of 4.5×10^{-7} m^2.

[2]

(ii) The potential difference across the total length of wire is 1.8 V.

Calculate the current in the wire.

current = ... A [1]

(iii) The number density of the free electrons in the wire is 6.1×10^{28} m^{-3}.

Calculate the average drift speed of the free electrons in the wire.

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

(b) A different wire carries a current. This wire has a part that is thinner than the rest of the wire, as shown in Fig. 5.1.

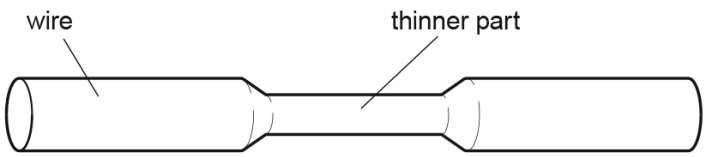


Fig. 5.1

(i) State and explain qualitatively how the average drift speed of the free electrons in the thinner part compares with that in the rest of the wire.

.....

.....

..... [2]

(ii) State and explain whether the power dissipated in the thinner part is the same, less or more than the power dissipated in an equal length of the rest of the wire.

.....

.....

..... [2]

(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]

(ii) A potential divider circuit is produced by connecting the three resistors to a battery of electromotive force (e.m.f.) 12 V and negligible internal resistance. The potential divider circuit provides an output potential difference V_{OUT} of 8.0 V.
Fig. 5.2 shows the circuit diagram.

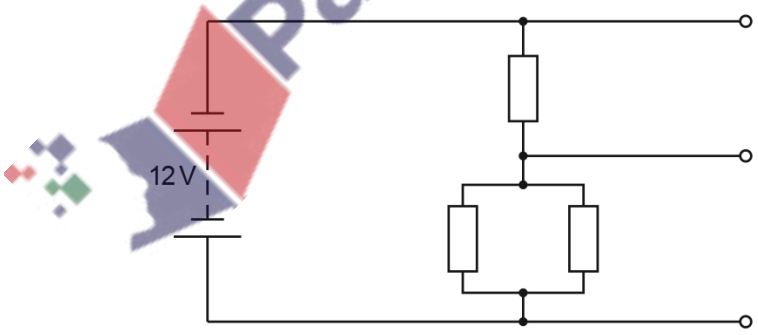


Fig. 5.2

On Fig. 5.2, label the resistances of all three resistors and the potential difference V_{OUT}. [2]

[Total: 12]

248. 9702_s15_qp_23 Q: 5

A uniform resistance wire AB has length 50 cm and diameter 0.36 mm. The resistivity of the metal of the wire is $5.1 \times 10^{-7}\,\Omega\,m$.

(a) Show that the resistance of the wire AB is 2.5 Ω.

[2]

(b) The wire AB is connected in series with a power supply E and a resistor R as shown in Fig. 5.1.

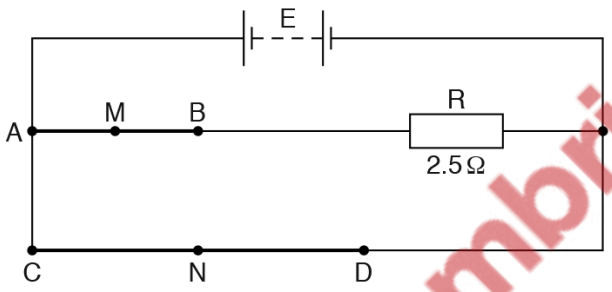


Fig. 5.1

The electromotive force (e.m.f.) of E is 6.0 V and its internal resistance is negligible. The resistance of R is 2.5 Ω. A second uniform wire CD is connected across the terminals of E. The wire CD has length 100 cm, diameter 0.18 mm and is made of the same metal as wire AB.

Calculate

(i) the current supplied by E,

current = ... A [4]

(ii) the power transformed in wire AB,

power = ... W [2]

(iii) the potential difference (p.d.) between the midpoint M of wire AB and the midpoint N of wire CD.

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

249. 9702_w15_qp_22 Q: 5

A 240 V power supply S with negligible internal resistance is connected to four resistors, as shown in Fig. 5.1.

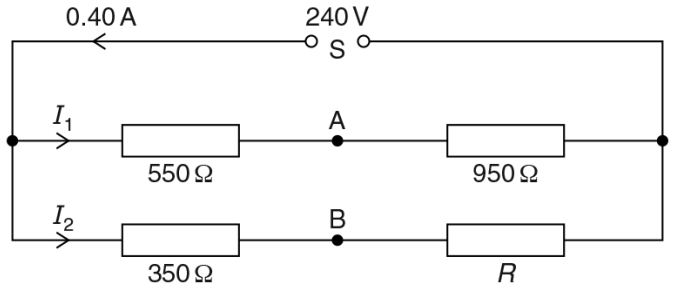


Fig. 5.1

Two resistors of resistance 550 Ω and 950 Ω are connected in series across S. Two resistors of resistance 350 Ω and R are also connected in series across S.

The current supplied by S is 0.40 A.
Currents I_1 and I_2 in the circuit are shown in Fig. 5.1.

(a) Calculate

(i) current I_1,

I_1 = ... A [2]

(ii) resistance R,

R = ...Ω [2]

(iii) the ratio

$$\frac{\text{power transformed in resistor of resistance 350 Ω}}{\text{power transformed in resistor of resistance 550 Ω}}.$$

ratio = ... [2]

(b) Two points are labelled A and B, as shown in Fig. 5.1.

(i) Calculate the potential difference V_{AB} between A and B.

V_{AB} = ... V [2]

(ii) The resistance R is increased.

State and explain the effect on V_{AB}.

.....

.....

.....[1]