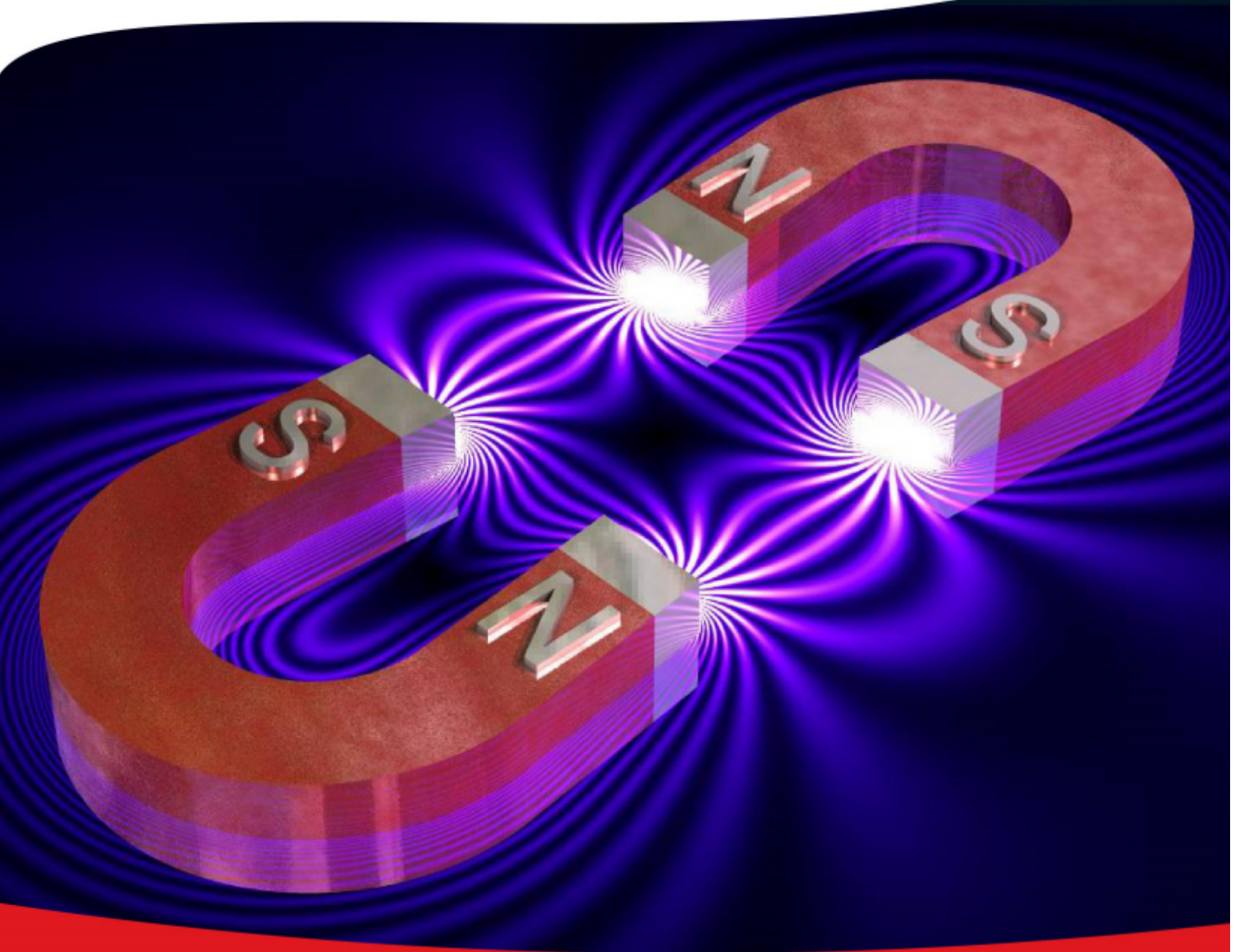
Cambridge International AS & A Level

PHYSICS (9702) P2

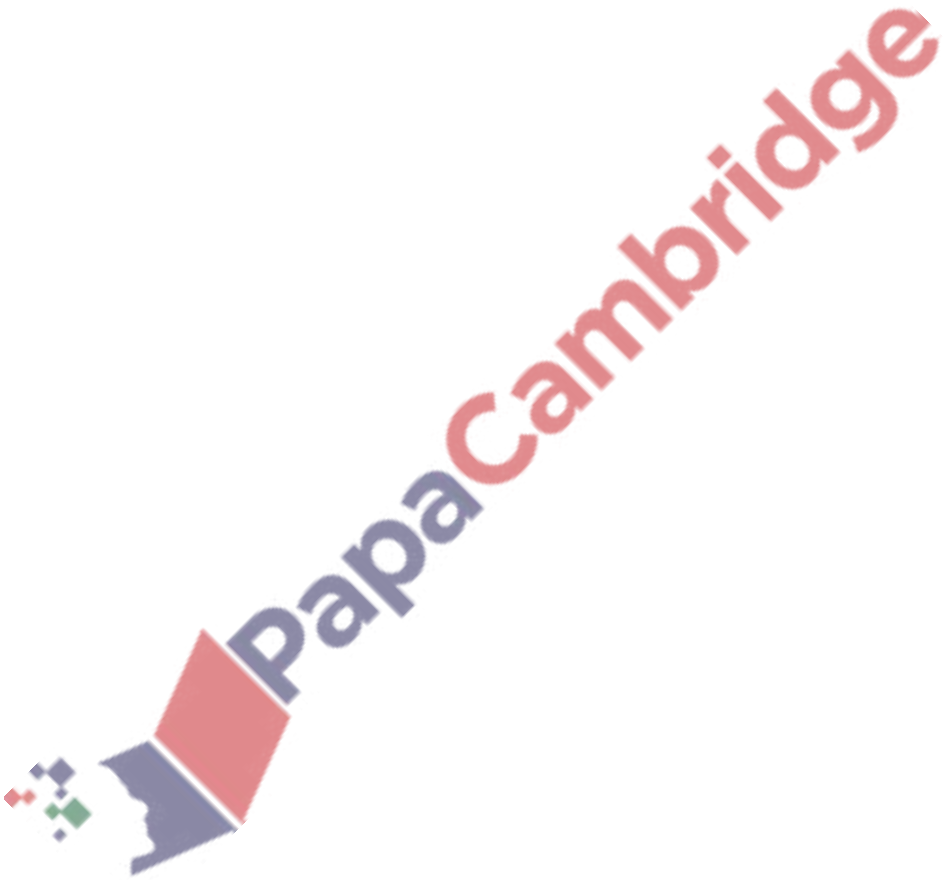
TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS



PapaCambridge

Chapter 11

Current of electricity



11.1 Electric current

199. 9702_s20_qp_23 Q: 6

The current I in a metal wire is given by the expression

$$I = Anve$$

where v is the average drift speed of the free electrons in the wire and e is the elementary charge.

(a) State what is meant by the symbols A and n.

A: .....

n: .....

[2]

(b) Use the above expression to determine the SI base units of e.
Show your working.

base units ..... [2]

(c) Two lamps P and Q are connected in series to a battery, as shown in Fig. 6.1.

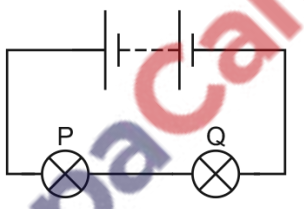


Fig. 6.1

The radius of the filament wire of lamp P is twice the radius of the filament wire of lamp Q. The filament wires are made of metals with the same value of n.

Calculate the ratio

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

ratio = ... [2]

[Total: 6]

200. 9702_w18_qp_22 Q: 7

(a) The current I in a metal wire is given by the expression

$$I = Anve.$$

State what is meant by the symbols A and n.

A: .....

n: .....

[2]

(b) The diameter of a wire XY varies linearly with distance along the wire as shown in Fig. 7.1.

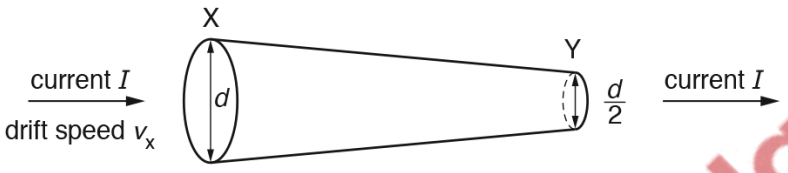


Fig. 7.1

There is a current I in the wire. At end X of the wire, the diameter is d and the average drift speed of the free electrons is v_x. At end Y of the wire, the diameter is $\frac{d}{2}$.

On Fig. 7.2, sketch a graph to show the variation of the average drift speed with position along the wire between X and Y.

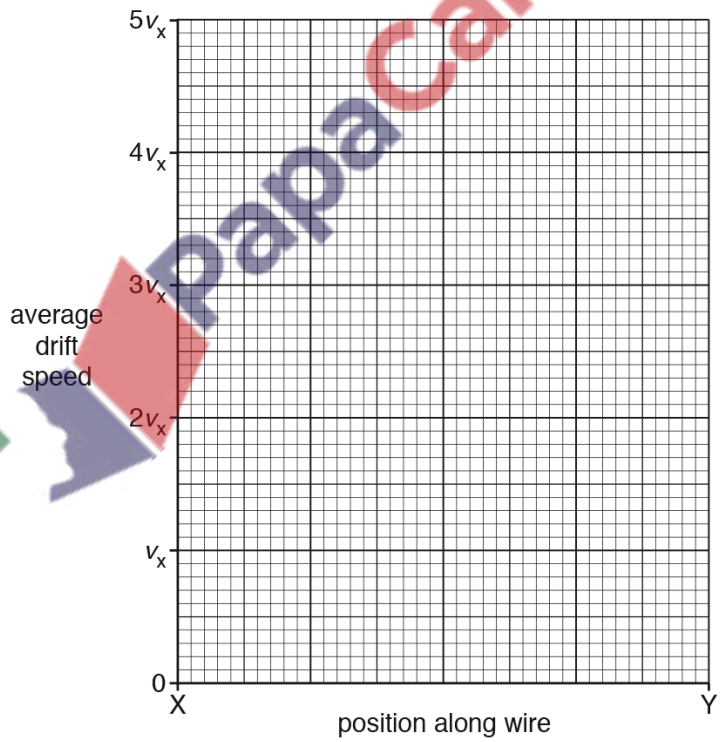


Fig. 7.2

[2]

[Total: 4]

201. 9702_w18_qp_23 Q: 6

(a) Define the *coulomb*.

.....

.....[1]

(b) An electric current is a flow of charge carriers.

In the following list, underline the possible charges for a charge carrier.

8.0×10^{-19} C 4.0×10^{-19} C 1.6×10^{-19} C 1.6×10^{-20} C [1]

(c) The diameter of a wire ST varies linearly with distance along the wire as shown in Fig. 6.1.

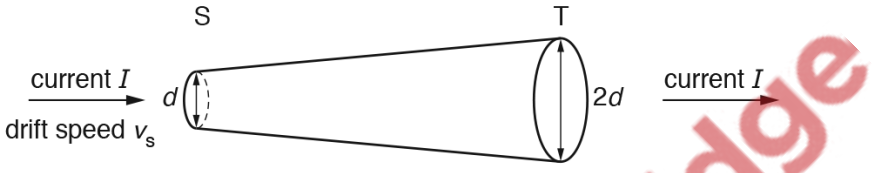


Fig. 6.1

There is a current I in the wire. At end S of the wire, the diameter is d and the average drift speed of the free electrons is v_s. At end T of the wire, the diameter is $2d$.

On Fig. 6.2, sketch a graph to show the variation of the average drift speed with position along the wire between S and T.

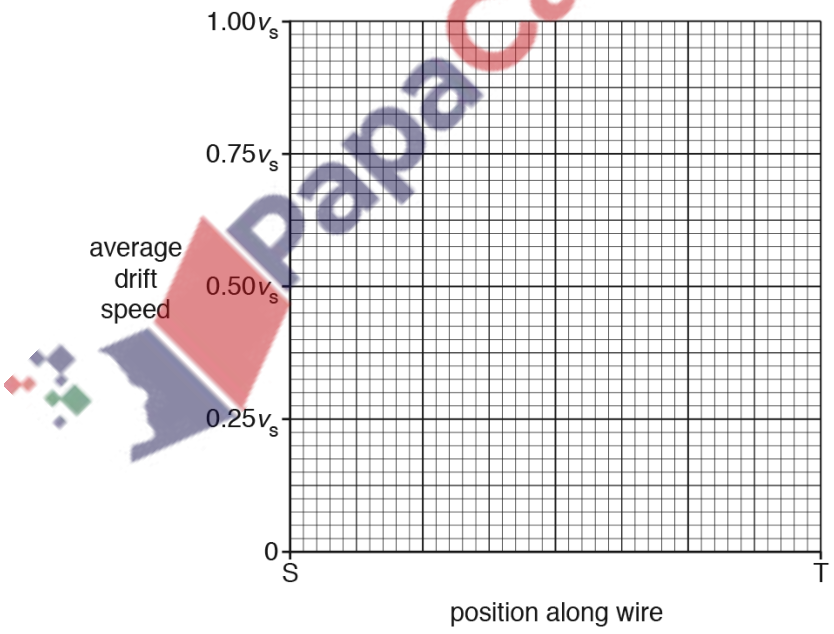


Fig. 6.2

[2]

[Total: 4]

202. 9702_w17_qp_22 Q: 5

(a) Define the *coulomb*.

.....[1]

(b) Two vertical metal plates in a vacuum have a separation of 4.0 cm. A potential difference of 2.0×10^2 V is applied between the plates. Fig. 5.1 shows a side view of this arrangement.

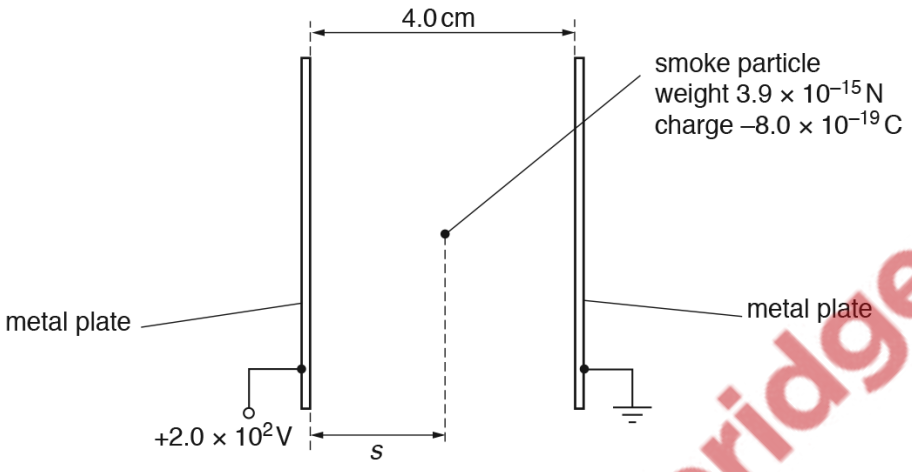


Fig. 5.1

A smoke particle is in the uniform electric field between the plates. The particle has weight 3.9×10^{-15} N and charge -8.0×10^{-19} C.

(i) Show that the electric force acting on the particle is 4.0×10^{-15} N.

[2]

(ii) On Fig. 5.1, draw labelled arrows to show the directions of the two forces acting on the smoke particle. [1]

(iii) The resultant force acting on the particle is F.

Determine

1. the magnitude of F,

magnitude = ... N

2. the angle of F to the horizontal.

angle = ... °

[3]

(c) The electric field in **(b)** is switched on at time $t = 0$ when the particle is at a horizontal displacement $s = 2.0$ cm from the left-hand plate. At time $t = 0$ the horizontal velocity of the particle is zero. The particle is then moved by the electric field until it hits a plate at time $t = T$.

On Fig. 5.2, sketch the variation with time t of the horizontal displacement s of the particle from the left-hand plate.

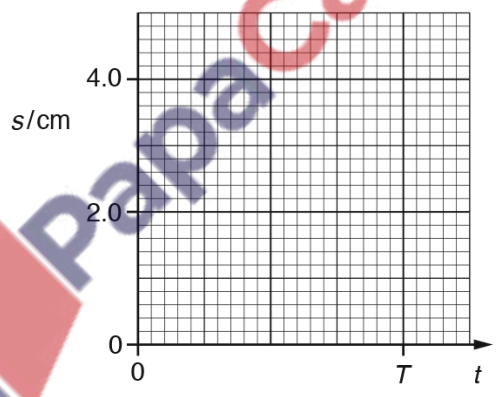


Fig. 5.2

[2]

[Total: 9]

11.2 Potential difference and power

203. 9702_s15_qp_22 Q: 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]

11.3 Resistance and resistivity

204. 9702_s20_qp_22 Q: 5

One end of a wire is attached to a fixed point. A force F is applied to the wire to cause extension x. The variation with F of x is shown in Fig. 5.1.

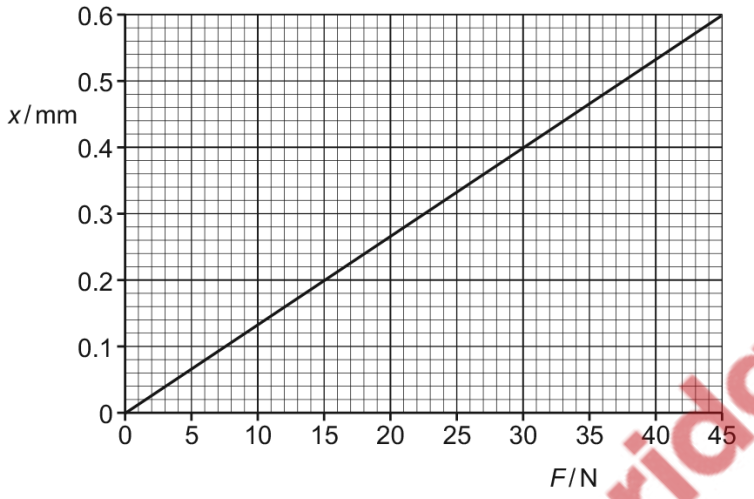


Fig. 5.1

The wire has a cross-sectional area of $4.1 \times 10^{-7}\,m^2$ and is made of metal of Young modulus $1.7 \times 10^{11}\,Pa$. Assume that the cross-sectional area of the wire remains constant as the wire extends.

(a) State the name of the law that describes the relationship between F and x shown in Fig. 5.1.

..... [1]

(b) The wire has an extension of 0.48 mm.

Determine:

(i) the stress

stress = ... Pa [2]

(ii) the strain.

strain = ... [2]

(c) The resistivity of the metal of the wire is $3.7 \times 10^{-7}\,\Omega\,\text{m}$.

Determine the change in resistance of the wire when the extension x of the wire changes from $x = 0.48\,\text{mm}$ to $x = 0.60\,\text{mm}$.

change in resistance = ... Ω [3]

(d) A force of greater than 45 N is now applied to the wire.

Describe how it may be checked that the elastic limit of the wire has not been exceeded.

.....

..... [1]

[Total: 9]

205. 9702_s19_qp_23 Q: 1

(a) **(i)** Define *resistance*.

.....

.....[1]

(ii) A potential difference of 0.60 V is applied across a resistor of resistance 4.0 GΩ.

Calculate the current, in pA, in the resistor.

current = ... pA [2]

(b) The energy E transferred when charge Q moves through an electrical component is given by the equation

$$E = QV$$

where V is the potential difference across the component.

Use the equation to determine the SI base units of potential difference.

SI base units ..... [3]

[Total: 6]

206. 9702_w18_qp_22 Q: 6

(a) Define the *volt*.

.....

.....[1]

(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.

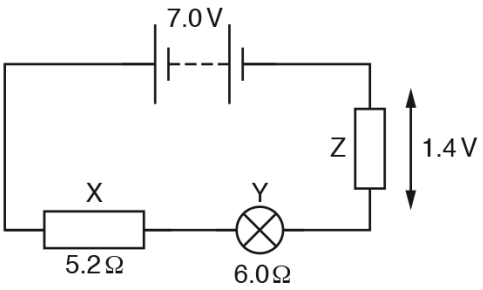


Fig. 6.1

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.

(i) Calculate the current in the circuit.

current = ... A [2]

(ii) Determine the resistance of resistor Z.

resistance = ... Ω [1]

(iii) Calculate the percentage efficiency with which the battery supplies power to the lamp.

efficiency = ... % [3]

(iv) The filament wire of the lamp is made of metal of resistivity $3.7 \times 10^{-7}\,\Omega\,\text{m}$ at its operating temperature in the circuit.

Determine, for the filament wire, the value of α where

$$\alpha = \frac{\text{cross-sectional area}}{\text{length}}.$$

α = ... m [2]

[Total: 9]

207. 9702_w17_qp_21 Q: 7

(a) Define the *ohm*.

.....[1]

(b) Wires are used to connect a battery of negligible internal resistance to a lamp, as shown in Fig. 7.1.

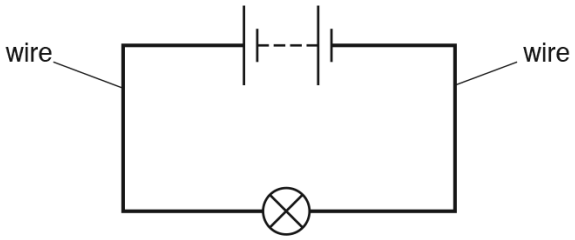


Fig. 7.1

The lamp is at its normal operating temperature. Some data for the filament wire of the lamp and for the connecting wires of the circuit are shown in Fig. 7.2.

	filament wire	connecting wires
diameter	d	$14\,d$
total length	L	$7.0\,L$
resistivity of metal (at normal operating temperature)	ρ	$0.028\,\rho$

Fig. 7.2

(i) Show that

$$\frac{\text{resistance of filament wire}}{\text{total resistance of connecting wires}} = 1000.$$

[2]

(ii) Use the information in **(i)** to explain qualitatively why the power dissipated in the filament wire of the lamp is greater than the total power dissipated in the connecting wires.

.....

.....

.....[1]

(iii) The lamp is rated as 12 V, 6.0 W. Use the information in **(i)** to determine the total resistance of the connecting wires.

total resistance of connecting wires = ... Ω [3]

(iv) The diameter of the connecting wires is decreased. The total length of the connecting wires and the resistivity of the metal of the connecting wires remain the same.

State and explain the change, if any, that occurs to the resistance of the filament wire of the lamp.

.....

.....

.....

.....

.....[3]

[Total: 10]

208. 9702_w17_qp_22 Q: 6

(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. 6.1.

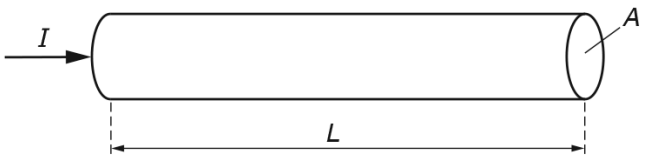


Fig. 6.1

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 and
e is the charge on an electron.

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

.....[1]

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

$$I = nAve.$$

[2]

(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. 6.2.

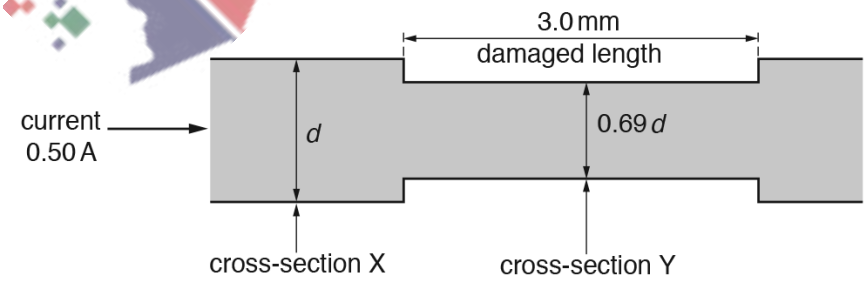


Fig. 6.2

The wire has diameter d at cross-section X and diameter $0.69d$ 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 main part of the wire with cross-section X has a resistance per unit length of $1.7 \times 10^{-2}\,\Omega\,m^{-1}$.

For the damaged length of the wire, calculate

1. the resistance per unit length,

resistance per unit length = ... $\Omega\,m^{-1}$ [2]

2. the power dissipated.

power = ... W [2]

(iii) The diameter of the damaged length of the wire is further decreased. Assume that the current in the wire remains constant.

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

.....

.....

.....[2]

[Total: 12]

209. 9702_w17_qp_23 Q: 6

A filament lamp is rated as 30 W, 120 V. A potential difference of 120 V is applied across the lamp.

(a) For the filament wire of the lamp, calculate

(i) the current,

current = ... A [2]

(ii) the number of electrons passing a point in 3.0 hours.

number = ...[2]

(b) Show that the resistance of the filament wire is 480 Ω.

[2]

(c) The filament wire has an uncoiled length of 580 mm and is made of metal. The metal has resistivity $6.1 \times 10^{-7}\,\Omega\,m$ at the operating temperature of the lamp.

Calculate the diameter of the wire.

diameter = ... m [3]

(d) The potential difference across the lamp is now reduced. State and explain the effect, if any, on the resistance of the filament wire.

.....

.....[1]

[Total: 10]

210. 9702_s16_qp_21 Q: 6

(a) Define the *coulomb*.

.....[1]

(b) A resistor X is connected to a cell as shown in Fig. 6.1.

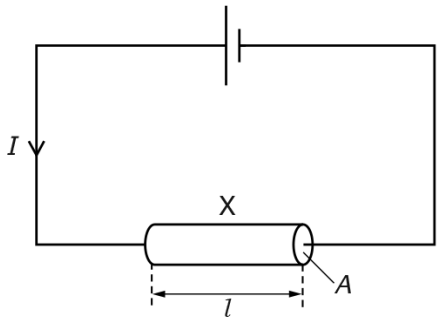


Fig. 6.1

The resistor is a wire of cross-sectional area A and length l. The current in the wire is I.

Show that the average drift speed v of the charge carriers in X is given by the equation

$$v = \frac{I}{nAe}$$

where e is the charge on a charge carrier and n is the number of charge carriers per unit volume in X.

[3]

(c) A 12V battery with negligible internal resistance is connected to two resistors Y and Z, as shown in Fig. 6.2.

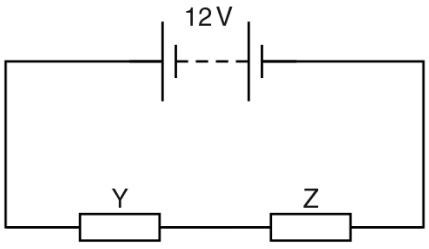


Fig. 6.2

The resistors are made from wires of the same material. The wire of Y has a diameter d and length l. The wire of Z has a diameter $2d$ and length $2l$.

(i) Determine the ratio

$$\frac{\text{average drift speed of the charge carriers in Y}}{\text{average drift speed of the charge carriers in Z}}.$$

ratio = ... [3]

(ii) Show that

$$\frac{\text{resistance of Y}}{\text{resistance of Z}} = 2.$$

[2]

iii) Determine the potential difference across Y.

potential difference = ... V [2]

iv) Determine the ratio

$$\frac{\text{power dissipated in Y}}{\text{power dissipated in Z}}.$$

ratio = ... [1]

[Total: 12]

211. 9702_s16_qp_23 Q: 6

(a) Define the *ohm*.

..... [1]

(b) A 15V battery with negligible internal resistance is connected to two resistors P and Q, as shown in Fig. 6.1.

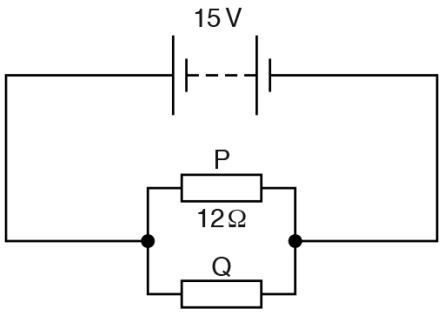


Fig. 6.1

The resistors are made of wires of the same material. The wire of P has diameter d and length $2l$. The wire of Q has diameter $2d$ and length l.

The resistance of P is 12 Ω.

(i) Show that the resistance of Q is 1.5 Ω.

[3]

(ii) Calculate the total power dissipated in the resistors P and Q.

power = ... W [3]

(iii) Determine the ratio

$$\frac{\text{average drift speed of the charge carriers in P}}{\text{average drift speed of the charge carriers in Q}}.$$

ratio = ... [3]

[Total: 10]
