(a)

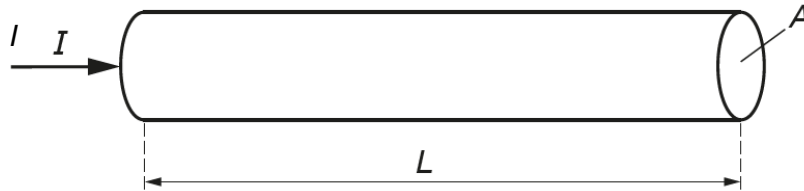A metal wire has length L and cross-sectional area A, as shown in Fig. 5.1.

Fig. 5.1

I is the current in the wire,

n is the number of free electrons per unit volume in the wire,

v is the average drift speed of a free electron and

e is the charge of 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

$$I = nAve$$

[1]

(b)

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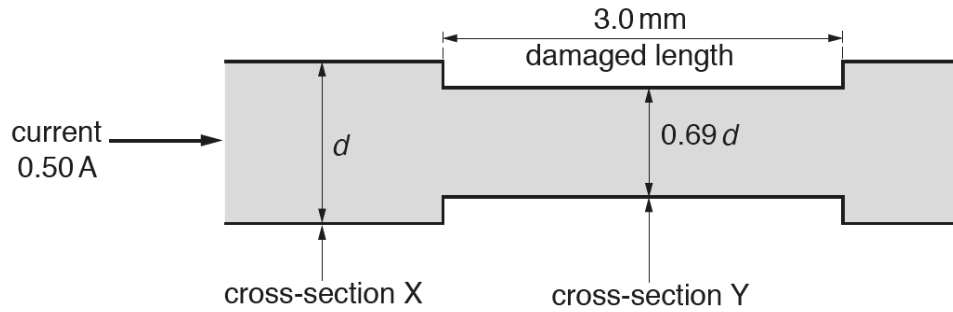

Fig. 5.2

The wire has diameter d at cross-section X and diameter $0.69d$ at cross-section Y.

The current in the wire is 0.50 A.

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]

(c)

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

(i)

Show that the resistance of the wire AB is 2.5 Ω.

[1]

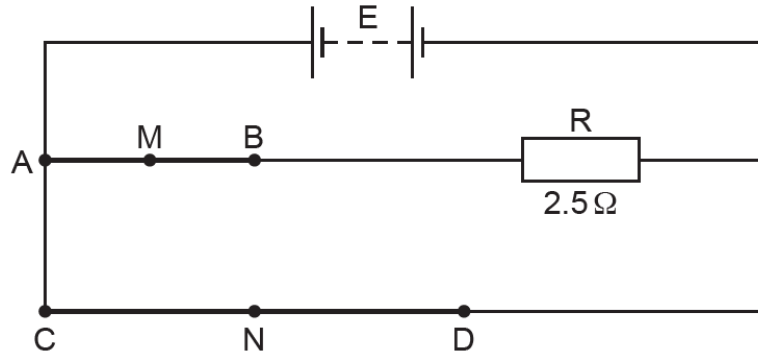The wire AB is connected in series with a power supply E and a resistor R as shown in Fig. 5.3.

Fig. 5.3

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

1.

the current supplied by E,

current = ………………….. A

[3]

2.

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

p.d. = ………………….. V

[2]

[Total: 10]