5 **(a)** A metal wire in a circuit has a damaged part. The resistivity of the metal is unchanged but the cross-sectional area of the wire is reduced over a 4.0 mm length, as shown in Fig. 5.1.

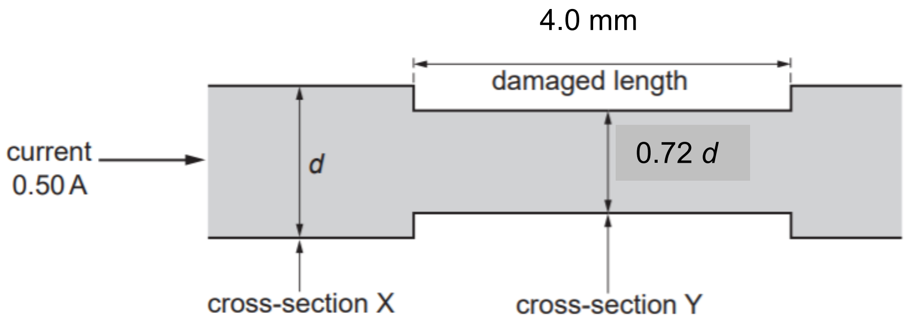

Fig. 5.1

The wire has diameter *d* at cross-section X and diameter 0.72 *d* at cross-section Y. The current in the wire is 0.50 A.

(i) Determine the ratio of $\dfrac{\text{average drift speed of electrons at cross-section Y}}{\text{average drift speed of electrons at cross-section X}}$.

ratio = …………………….. [2]

(ii) If the resistivity of the material of the wire is $1.12 \times 10^{-6}\ \Omega$ m and d = 0.21 mm, determine the resistance of the damaged length.

resistance = …………………….. Ω [2]

(iii) When current flows through the wire, explain why the damaged part of the wire has a higher voltage per unit length as compared to the rest of the wire.

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

………………………………………………………………………………………… [1]

(b) Fig. 5.2 shows a cell of e.m.f. E_1 and internal resistance r_1 connected in series with a resistor of resistance R_1 and a uniform metal wire of resistance R_2 with length 1.000 m placed between points B and F.

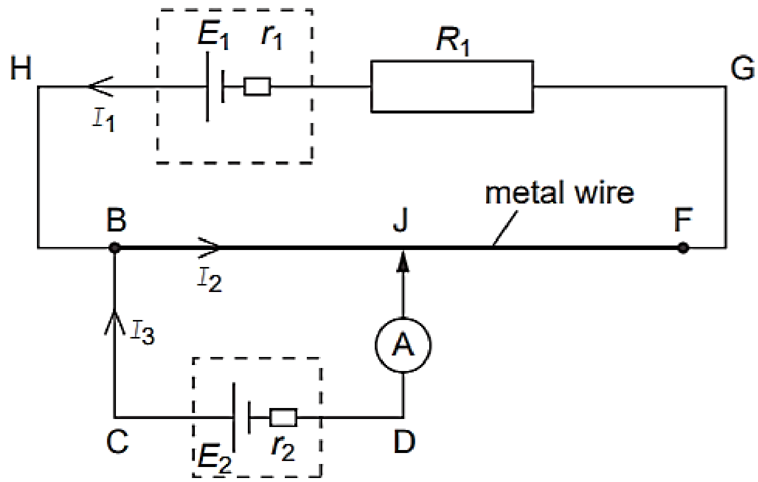

Fig. 5.2

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 points B and J. The current directions are shown on Fig. 5.2.

(i) Write down the relationship between the three currents at B.

[1]

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

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

.... [2]

(iii) The values of the e.m.f.s and resistances are as follows.

$E_1 = 4.5$ V

$E_2 = 1.2$ V

$r_1 = 1.5\ \Omega$

$r_2 = 0.8\ \Omega$

$R_1 = 3.0\ \Omega$

$R_2 = 3.5\ \Omega$

Determine the length of BJ for which the ammeter reads zero.

length = ………………….. m [3]

[Total: 11]