Mark scheme for Extension Worksheet – Topic 5, Worksheet 1

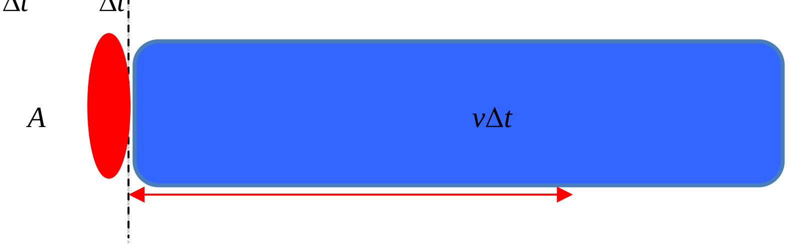
1 From $R=\rho\frac{L}{A}$ we have that $R=\rho\frac{L}{\pi r^2}$. Hence $R'=\rho\frac{2L}{\pi(2r)^2}=\rho\frac{2L}{4\pi r^2}$; i.e.

$R'=\frac{2}{4}\left(\rho\frac{L}{\pi r^2}\right)=\frac{R}{2}$ [2]

2 $R=\rho\frac{L}{\pi r^2}$ and so $L=\frac{R\pi r^2}{\rho}$; $L=\frac{12\times\pi(2.35\times10^{-3})^2}{1.68\times10^{-8}}=1.2\times10^4$ m [2]

3 The electrons that will be able to cross the dotted line in the diagram below are those electrons that are at most a distance $v\Delta t$ from the line; the number of these electrons is equal to the number of electrons per unit volume times the volume i.e. $nV=nAv\Delta t$ and so the charge that will cross the dotted line is $\Delta Q=enAv\Delta t$; the current is then

$I=\frac{\Delta Q}{\Delta t}=\frac{enAv\Delta t}{\Delta t}=enAv$;



[3]

4 In a time of 1 second the number of electrons that will leave the area A is RA; and so the charge that leaves the surface in 1 second, i.e. the current is $I=RAe$. [2]

5 **a** The graph for an ohmic device would a straight line **through the origin**, which is not the case here. [1]

b One way to answer the question is to choose two points say for $V=0.8$ V and $V=1.2$ V and find the resistance in each case: so $R_1=\frac{0.80}{0.85}=0.94\ \Omega$ and $R_2=\frac{1.20}{2.0}=0.60\ \Omega$; so decreases [2]

6 The work per unit charge done to move charge completely around a circuit/the power per unit current generated by a battery in a circuit. [1]

7 **a** εI [1]

b $V_1 I$ and $V_2 I$ [1]

c By energy conservation $\varepsilon I=V_1 I+V_2 I$, hence the result. [1]

d If the total resistance is R_T we expect that $\varepsilon=R_T I$, $V_1=R_1 I$ and $V_2=R_2 I$; and so $R_T I=R_1 I+R_2 I$ giving the result. [2]

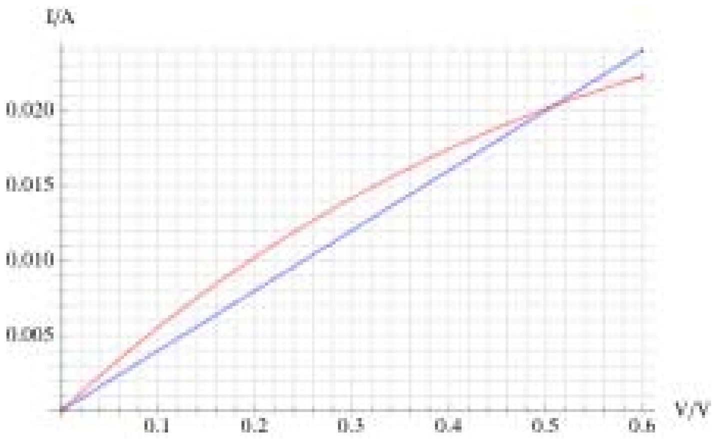
8 **a** $I_1 = \frac{\varepsilon}{R_1}$ and $I_2 = \frac{\varepsilon}{R_2}$ [1]

b If R is the total resistance we expect that $I = \frac{\varepsilon}{R}$ and $I = I_1 + I_2$; so $\frac{\varepsilon}{R} = \frac{\varepsilon}{R_1} + \frac{\varepsilon}{R_2}$ giving the result. [2]

9 **a** A device obeying Ohm's law would give a straight line graph through the origin which is not the case here. [1]

b In a filament lamp the resistance is expected to increase as the voltage across it increases; because at higher voltages there would be higher temperatures inside the wire and so greater chance of collisions of electrons with metal atoms; the graph shows that the resistance increases as the voltage increases. [3]

c See graph below:



[1]

d This requires trial and error to use the graphs and find that current for which the corresponding voltages add up to 0.90 V; the required current is in between 0.018 A and 0.019 A. [2]

10 **a** The work required is $W = QV$ [1]

b The power is $P = \frac{W}{t} = \frac{QV}{t} = IV$ [1]