WJEC (Eduqas) Physics A-level

Topic 2.1: Conduction of Electricity

Notes

Charge and Current

The unit used for charge is the **coulomb (C)**. It is a derived SI unit with 1 coulomb = 1 amp-second. Frequently in particle physics we represent charges in terms of the electron charge, *e,* instead.

$$e = 1.6\times10^{-19}\ C$$

Therefore, to produce a charge of 1 coulomb you would need $\frac{1}{1.6\times10^{-19}} = 6.3\times10^{18}\ (2sf)$ electrons.

Charge does not flow through every material. The materials which allow charge to flow are called conductors and ones where charge can't flow (easily) are called insulators. To measure how fast charge is flowing through a material we look at **current – the rate of flow of charge**.

As current is the rate of flow of charge it is given by the equation:

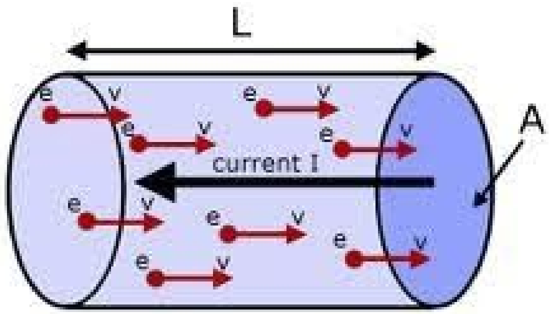
$$I = \frac{\Delta Q}{\Delta t}$$

And as given above, the unit for current is amperes often shortened to amps.

Electrons

Metals contain positive ions and **free** (delocalised electrons) due to metallic bonding. When a potential difference is applied across a conductor (e.g. when you connect a battery) the electrons drift towards one end of the conductor. As electrons are charged particles, this movement forms a **current**. The electrons must be free otherwise they could not drift.

To work out how fast the electrons move in a conductor we will use a simple diagram.



https://simple.wikipedia.org/wiki/Drift_velocity

A few things to define:

- n is the charge carrier density i.e. number of electrons per unit volume
- I is the current in the conductor
- A is the cross-sectional area of the conductor
- L is the length of a section of the conductor
- v is the mean drift velocity of electrons

Note: the mean drift velocity is **not how fast each electron moves**. They move much faster. They are involved in many collisions with positive ions and electrons within the conductor so are frequently changing direction. The mean drift velocity is how far the electrons will move in the conductor over a period of time because their frequently changing directions will average out to give a slight forward motion.

The time taken to travel along this section of conductor is given as:

$$t = \frac{L}{v}$$

The number of free electrons within this section of conductor N is equal to:

$$N = volume \times charge\ carrier\ density = ALn$$

The number of electrons passing through the end of the conductor per second is then equal to:

$$\frac{N}{t} = \frac{ALn}{\frac{L}{v}} = Anv$$

Therefore, the current passing through the end of the conductor is the number of electrons per second times by the charge of each electron:

$$I = Anv \times e$$

$$I = nAve$$

This rearranges to give the equation for the **mean drift velocity of electrons** in a conductor:

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