Chapter 9 Electricity

9.1 Electric current

Candidates should be able to:

1 understand that an electric current is a flow of charge carriers

2 understand that the charge on charge carriers is quantised

3 recall and use $Q = It$

4 use, for a current-carrying conductor, the expression $I = Anvq$, where n is the number density of charge carriers

- **Electrical charge**, Q consist of either '+' or '-' charge.
- The SI unit for charge is in **coulomb**.
- Like charges repel each other while opposite charges attract.
- Electrons and protons are the cause of the charge. Remember that electrons are negatively charged while protons are positively charged.
- Each electron has a charge of $\mathbf{-1.6 \times 10^{-19}}$ ***C*** while each proton has a charge of $\mathbf{1.6 \times 10^{-19}}$ ***C***.
- In a conductor, current is due to the movement of charge carriers.
- Current, I is defined as the **rate of charge flow** in a conductor

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

- Where I is the electric current measured in ampere (A), Q is the charge (C) and t is the time is seconds.
- Note: The current always flows in the **opposite direction** of the electron.
- The drift speed (v) is the average speed the charge carriers are travelling through the conductor.
- Current can also be expressed in terms of the drift speed (v), the number of density (number of charge carriers per unit volume, n) and the charge of the carriers (q)

$$I = Anvq$$

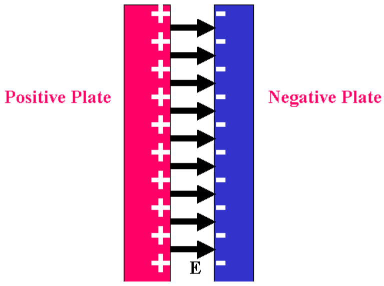
9.2 Potential difference and power

Candidates should be able to:

1 define the potential difference across a component as the energy transferred per unit charge

2 recall and use $V = W / Q$

3 recall and use $P = VI$, $P = I^2R$ and $P = V^2 / R$



- **Potential difference** is defined as the work done to transfer one unit of charge across two points of different potential (charge).

$$V = \frac{W}{Q}$$

- Here V is the potential difference in volts (V), W is the work done in joules and Q is the charge in coulombs.
- Recall that power is the rate of work done or rate of energy transferred i.e.

$$P = \frac{W}{t}$$

- Depending on the info given in the question, the above equation can be written in many forms e.g.

$$P = \frac{QV}{t}$$

$$P = VI$$

$$P = I^2R$$

9.3 Resistance and resistivity

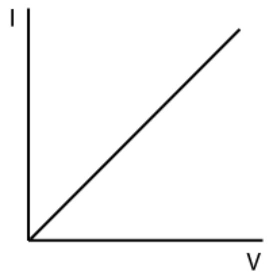
Candidates should be able to:

1. define resistance
2. recall and use $V = IR$
3. sketch the I–V characteristics of a metallic conductor at constant temperature, a semiconductor diode and a filament lamp
4. explain that the resistance of a filament lamp increases as current increases because its temperature increases
5. state Ohm's law
6. recall and use $R = \rho L / A$
7. understand that the resistance of a light-dependent resistor (LDR) decreases as the light intensity increases
8. understand that the resistance of a thermistor decreases as the temperature increases (it will be assumed that thermistors have a negative temperature coefficient)

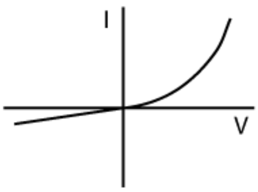
- **Resistance**, R of a conductor is the opposition to an electrical current.
- The higher the resistance of a conductor the more work needs to be applied to push the same amount of current through a conductor (Think friction when pushing a box).
- Resistance is measured in ohms, Ω.
- **Ohm's Law** states that the **potential difference (V)** is directly proportional to the **Current (I)** that flows through a conductor.

$$R = \frac{V}{I}$$

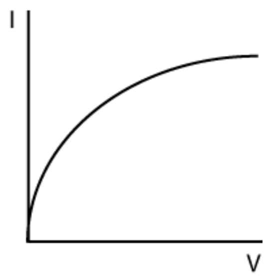
- This law is only obeyed provided that the temperature and other physical properties remain constant and that the conductor is ohmic.
- Below are several I-V plots



Metallic conductor



Semiconductor diode



Filament lamp

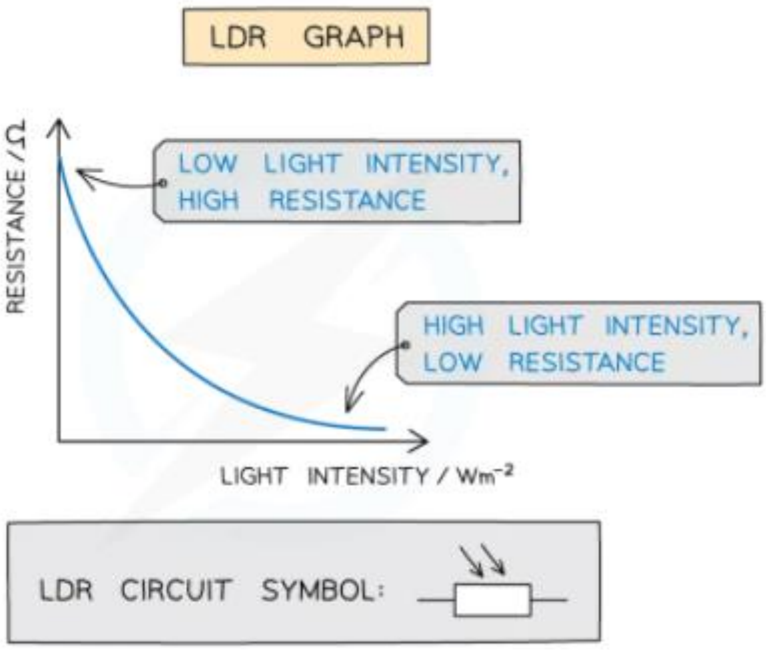
- Several factors affect the resistance of a conductor:

1) The length of the conductor (L): The longer the length of the conductor, the higher its resistance.
2) Area of the conductor (A): The bigger the area of the conductor, the higher its resistance.
3) Temperature of the conductor: The higher the temperature of the conductor, the higher its resistance.
4) The type of material of a conductor (ρ): depends on material type (conductive or insulative type).

- Combining the factors above and assuming the temperature of the conductor is constant, the resistance of a conductor can be found from

$$R = \frac{\rho L}{A}$$

- A **light-dependent resistor (LDR)** is a non-ohmic conductor and sensory resistor.
- As light intensity on the LDR **increases**, the resistance **decreases**.



- Another non-ohmic resistor is a **thermistor.**
- As the temperature **increases** the resistance of a thermistor **decreases**.