Effects of Electric Current Notes

Introduction to Electric Current

- Electric current (I) is the flow of electric charge through a conductor.
- It is measured in Amperes (A).

Example Numerical: Calculating Current

1. Calculate the current when a charge of 4 C flows through a conductor in 2 seconds.

$$I = \frac{Q}{t} = \frac{4 \text{ C}}{2 \text{ s}} = 2 \text{ A}$$

Solution

$$I = \frac{4 \text{ C}}{2 \text{ s}} = 2 \text{ A}$$

2. Calculate the current if 6 C of charge flows through a conductor in 3 seconds.

$$I = \frac{Q}{t} = \frac{6 \text{ C}}{3 \text{ s}} = 2 \text{ A}$$

Solution

$$I = \frac{6 \text{ C}}{3 \text{ s}} = 2 \text{ A}$$

3. Determine the charge flowing through a conductor in 5 seconds if the current is 3 A.

$$Q = I \cdot t = 3 \text{ A} \times 5 \text{ s} = 15 \text{ C}$$

Solution

$$Q = 3 \text{ A} \times 5 \text{ s} = 15 \text{ C}$$

Potential Difference

- Potential difference (V) is the work done per unit charge to move it between two points.
- It is measured in Volts (V).

Example Numerical: Calculating Potential Difference

1. Calculate the potential difference when 6 J of work is done in moving 3 C of charge.

$$V = \frac{W}{Q} = \frac{6 \text{ J}}{3 \text{ C}} = 2 \text{ V}$$

Solution

$$V = \frac{6 \text{ J}}{3 \text{ C}} = 2 \text{ V}$$

2. Determine the work done in moving 10 C of charge across a potential difference of 5 V.

$$W = V \cdot Q = 5 \text{ V} \times 10 \text{ C} = 50 \text{ J}$$

Solution

$$W = 5 \text{ V} \times 10 \text{ C} = 50 \text{ J}$$

3. Calculate the charge moved when the potential difference is 4 V and the work done is 12 J.

$$Q = \frac{W}{V} = \frac{12 \text{ J}}{4 \text{ V}} = 3 \text{ C}$$

Solution

$$Q = \frac{12 \text{ J}}{4 \text{ V}} = 3 \text{ C}$$

Ohm's Law

- Ohm's Law relates the potential difference (V), current (I), and resistance (R) of a conductor:

$$V = IR$$

Where:

  - V is the potential difference across the conductor (Volts, V).
  - I is the current flowing through the conductor (Amperes, A).
  - R is the resistance of the conductor (Ohms, Ω).

Example Numerical: Using Ohm's Law

1. Calculate the current flowing through a resistor of 5 Ω when a potential difference of 10 V is applied across it.

$$I = \frac{V}{R} = \frac{10 \text{ V}}{5\Omega} = 2 \text{ A}$$

Solution

$$I = \frac{10 \text{ V}}{5\Omega} = 2 \text{ A}$$

2. Determine the resistance of a conductor if a current of 4 A flows through it and the potential difference is 12 V.

$$R = \frac{V}{I} = \frac{12 \text{ V}}{4 \text{ A}} = 3\Omega$$

Solution

$$R = \frac{12 \text{ V}}{4 \text{ A}} = 3\Omega$$

3. Calculate the potential difference across a resistor of 8 Ω when a current of 2 A flows through it.

$$V = I \cdot R = 2 \text{ A} \times 8\Omega = 16 \text{ V}$$

Solution

$$V = 2 \text{ A} \times 8\Omega = 16 \text{ V}$$

Resistance and Nichrome

- Resistance is a measure of the opposition to the flow of electric current in a conductor. It quantifies how much a material resists the movement of electrons through it.
- The unit of resistance is the ohm ().
- Resistance is denoted by the symbol R
- Resistance (R) in a conductor depends on its material, length, and cross-sectional area.
- Nichrome wire becomes red hot due to its high resistance, which causes it to dissipate a significant amount of electrical energy as heat.

Example Experiment: Nichrome Wire Becoming Red Hot

An experiment demonstrates why nichrome wire becomes red hot:

- **Materials**: Nichrome wire, power source (battery or power supply), ammeter, voltmeter.
- **Procedure**:
  1. Connect the nichrome wire to the circuit with the power source.
  2. Measure the current (I) flowing through the wire using an ammeter and the potential difference (V) across it using a voltmeter.
  3. Record the values of I, V, and calculate the resistance $R = \frac{V}{I}$.
  4. Increase the voltage gradually.
  5. Observe that as the voltage increases, the nichrome wire begins to heat up and eventually becomes red hot due to the increased current flowing through it.
- **Explanation**: Nichrome wire has a relatively high resistivity, so when a high current flows through it (due to a higher applied voltage), it dissipates a significant amount of energy as heat, causing it to become red hot.

Joule's Heating Law

- Joule's Heating Law states that the heat produced in a conductor is directly proportional to the square of the current (I^2), the resistance (R), and the time (t) for which the current flows:

$$H = I^2 Rt$$

Example Numerical: Joule's Heating Law

1. Calculate the heat produced in a resistor of 4 Ω when a current of 3 A flows through it for 5 seconds.

$$H = I^2 Rt = (3\text{ A})^2 \times 4\Omega \times 5\text{ s} = 180\text{ J}$$

Solution

$$H = (3\text{ A})^2 \times 4\Omega \times 5\text{ s} = 180\text{ J}$$

2. Determine the time required to produce 150 J of heat in a resistor of 6 Ω when a current of 2 A flows through it.

$$t = \frac{H}{I^2 R} = \frac{150\text{ J}}{(2\text{ A})^2 \times 6\Omega} = 6.25\text{ s}$$

Solution

$$t = \frac{150\text{ J}}{(2\text{ A})^2 \times 6\Omega} = 6.25\text{ s}$$

3. Calculate the resistance of a conductor if 240 J of heat is produced in 10 seconds with a current of 4 A.

$$R = \frac{H}{I^2 t} = \frac{240 \text{ J}}{(4 \text{ A})^2 \times 10 \text{ s}} = 1.5\Omega$$

Solution

$$R = \frac{240 \text{ J}}{(4 \text{ A})^2 \times 10 \text{ s}} = 1.5\Omega$$

Energy Conversion in Electrical Appliances

Electrical energy can be converted into various forms in different appliances:

Appliance	**Energy Input**	**Energy Output**
Electric Heater	Electrical Energy	Heat Energy
Electric Bulb	Electrical Energy	Light and Heat Energy
Electric Motor	Electrical Energy	Mechanical Energy
Loudspeaker	Electrical Energy	Sound Energy

Summary

- Electric current is the flow of charge and is measured in Amperes (A).
- Potential difference is the work done per unit charge and is measured in Volts (V).
- Ohm's Law relates voltage, current, and resistance: $V = IR$.
- Resistance depends on the material, length, and cross-sectional area of the conductor.
- Joule's Heating Law states that heat produced in a conductor is $H = I^2 Rt$.
- Electrical energy can be converted into various forms such as heat, light, mechanical, and sound energy in different appliances.