Chap 11: Electricity

1. What is electric current? Write its formula and SI unit.

Electric current is the rate of flow of electric charge through a conductor.

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

The unit of electric current (I) is Ampere (A)

The unit of electric charge (Q) is Coulomb (C)

The unit of time (t) is Second (s)

1 Ampere = 1 Coulomb of charge flowing through a conductor per second

2. What is the direction of conventional current flow in a circuit connected to a battery?

Conventional current flows from positive to negative terminal of the battery, in an electric circuit. It is in the opposite direction to the actual flow of electrons.

3. Why are electrons considered negatively charged?

Electric current was discovered much before the discovery of electrons. Electric current is conventionally considered as flow of positive charges from positive to negative terminal. Since electrons move in the opposite direction of conventional current, electrons are considered negatively charged.

4. What is electric potential difference? Write its formula and unit.

The potential difference between two points is the work done to move a unit positive charge from one point to the other.

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

The unit of potential difference (voltage) is Volt (V).

The unit of work done (W) is Joule (J).

The unit of Charge (Q) is Coulomb (C).

1 Volt = 1 Joule per Coulomb

A battery maintains a potential difference between its terminals, which drives current through a circuit.

5. State Ohm's Law. Write the mathematical form and state when it applies.

At constant temperature, the electric current (I) flowing through a conductor is directly proportional to the potential difference (V) across it. V = IR

where R is the resistance of the conductor. It is constant for a given conductor at constant temperature.

Ohm's law is applicable when the temperature and physical conditions of the conductor are constant.

For non-ohmic components like diodes, transistors, and LEDs — current is not linearly proportional to voltage. So, Ohm's law is not applicable to them.

6. What is electrical resistance? What is its SI unit and what factors does it depend on?

Resistance is the opposition to the flow of electric current in a conductor. $R = \frac{V}{I}$

SI unit of Resistance is Ohm (Ω)

Resistance is directly proportional to the length (L) of the conductor, and inversely proportional to its cross sectional area (A).

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

ρ is the proportionality constant called resistivity. It depends on the material.

7. What is resistivity (specific resistance)? How does it differ from resistance?

Resistivity is an intrinsic property of a material that measures how strongly it opposes current flow.

$$\rho = \frac{RA}{L}$$

The SI unit of resistivity is Ohm meter (Ω·m)

Unlike resistance, resistivity doesn't depend on the size and shape of the material.

For good conductors like copper and silver, resistivity is very low (~10^{-8} Ω·m).

For insulators like rubber and glass, resistivity is very high(~10^{12} Ω·m).

8. What happens to the total resistance when resistors are connected in series?

When resistors are connected in series, same current flows through all resistors, and voltage is divided among resistors.

Total resistance $R = R_1 + R_2 + R_3$

9. What happens to the total resistance when resistors are connected in parallel?

When resistors are connected in parallel, the voltage is the same across all resistors, and current is divided among resistors.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

10. What is electric power?

Electric power is the rate at which electrical energy is consumed by a device.

$$P = VI = I^2R = \frac{V^2}{R}$$

SI of electric power is Watt (W). 1 W = 1 J/s

Kilowatt (kW) is used for larger appliances. (1kW = 1000 W)

11. How is the commercial electricity usage measured?

The kilowatt-hour is the commercial unit of electrical energy — the energy consumed when a device of 1 kW power runs for 1 hour.

$1\ kWh = 1000 \times 3600 = 3.6 \times 10^6\ J$

Joule is too small for practical electricity billing.

1 kWh is the energy used by a 1000 W device (e.g., electric iron) for 1 hour.

In electricity bill: 1 unit = 1kWh

12. State Joule's law of heating.

When electric current flows through a resistor, electrical energy is converted to heat energy.

The heat produced in a conductor is directly proportional to the

square of current ($H \propto I^2$)

resistance ($H \propto R$)

time for which the current flows ($H \propto t$)

$H = I^2RT$

Electric heater, electric iron, filament bulb and fuse are some of the applications of the heating effect of electricity.

13. Write a note on 3 different applications of heating effect of electric current.

Electric heater/iron/toaster are made of high resistance elements like nichrome which heats up rapidly. Nichrome has a high melting point, and doesn't oxidise easily.

Incandescent light bulb - It has a tungsten filament which heats up to 2500°C and glows white.

Electric fuse - A fuse is a safety device in an electric circuit. It is a short piece of wire with a low melting point and high resistivity (made of tin/lead). When excess current (due to overloading or short circuit) flows, the fuse wire heats up rapidly and melts and breaks the circuit, stopping the current flow. Each fuse has a rating (e.g., 5A, 15A) — it melts if current exceeds this value.

14. What is a circuit diagram?

A circuit diagram is the schematic diagram of an electric circuit, in which every component is shown by its own standard symbol (cell, battery, switch, resistor, bulb, ammeter, voltmeter). We use symbols because drawing real components is difficult.

It shows how the components are connected with one another. Anyone can read the diagram and replicate it.

15. How is electric current measured in a circuit?

Electric current is measured by an ammeter.

The ammeter is connected in series with the component, so that the whole current to be measured passes through it. An ammeter has very low resistance, so it does not change the current in the circuit. Its SI unit is ampere (A).

16. How is potential difference (voltage) measured in a circuit?

Potential difference is measured by a voltmeter.

The voltmeter is connected in parallel across the two points (or across the component) whose potential difference is to be measured. A voltmeter has very high resistance, so it draws almost no current. Its SI unit is volt (V).

17. Will current flow more easily through a thick wire or a thin wire of the same material, when connected to the same source? Why?

Current flows more easily through the thick wire.

For wires of the same material and same length, resistance is inversely proportional to the area of cross section.

$$R \propto \frac{1}{A}$$

A thick wire has a larger area of cross section, so its resistance is lower. The source gives the same potential difference, so by I = V/R the smaller resistance allows a larger current to flow.