SANJEEVANI PUBLIC SCHOOL, UTTAM NAGAR
CLASS- X (SCIENCE)
ELECTRICITY

(BY RUPESH GUPTA SIR)

Electricity is one of the forms of energy and it can be produced from other types of energy, such as the energy of a chemical reaction or of mechanical rotation of dynamo. It's a great advantages over all other types of energy are it's.

- Cleanness (absence of smoke or smell)
- Flexibility (regarding voltage)
- Efficiency and
- Easier transmission over long distances.

It is impossible to say as to when electricity was first discovered.

Thales of Miletus (one of the seven wise men of ancient Greece) is said to have observed the attraction of amber, when previously rubbed, for bits of straw. The word electricity has been derived from the Greek word elektron meaning amber.

Sir William Gilbert found that other substances besides amber could also be electrified e.g. glass rod when rubbed with silk. Gilbert classified these materials under two heads **Vitreous and Resinous**. They are named later as positive and negative.

Charles François du Fay of France found that there are two kinds of electricity.

Benjamin Franklin gave the name of positive and negative electricity (Charges).

Charge: - When two (or more) substance rubs together they produce a charge by transfer of electron. This kind of electric charging of an object was called charging by friction.

There are two kinds of charge positive charge and negative charge.

When a body is negatively charged it has excess electrons and if a body is positively charged it has less electrons

- A body can be charged by three ways
  By Friction By Induction By Conduction

PROPERTIES OF ELECTRIC CHARGES

1. Opposite charges (or unlike charges) attract each other and similar charges (or like charges) repel each other.
2. Electric charge is conserved (i.e. charge neither be created nor be destroyed)
3. Electric charge is additive (I.e. total charge is the algebraic sum of the individual charge)
4. Electric charge is quantized and the quantum of charge is equal to that of one electron.
   Q = ne where n = $\pm1, \pm2, \pm3, \pm4, \pm5, \pm6, \pm7$ etc.; e= charge on electron=$1.6X10^{-19}$ Coulomb

COULOMBS LAW: - The force between two electric charges at rest is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of distance between them.

$$F = K \frac{q1q1}{r2}$$

Where K= 9×10^{9} Nm^{2}/c^{2} is a constant of proportionality.

Principle of conservation of electric charge: - The total electric charge in an isolated system is covered. Electric charge can neither be created nor be destroyed.

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Conductors: - Substance through which charges can easily pass is known as conductors. Metals, aqueous solutions of salt and ionized gases are all conductors.

Insulators: - Substances through which charges cannot pass are called insulators. Glass, pure water and all gases are insulators. Insulator is called dielectrics.

Semi Conductors: - Such substances which have resistivity between conductors and insulators are known as semiconductors. They are used to make integrated Circuit (IC) and other elements of electronic circuits.

Electricity is broadly classified as:

1. Static electricity
2. Current electricity.

Electrostatics or static electricity: - This branch of electricity deals with the study of charge at rest

Current electricity: - This branch of electricity deals with the study of charge at motion.

Electric current: - An electric current is defined as the ordered motion of electric charges. OR
Electric current is defined as the rate of flow of electric charge through a particular area of cross-section. If a charge (Q) flows through a conductor in a time (t) then current (I) flowing through the conductor is given as

$I=\frac{Q}{T}$ i.e. (q=ne)

The SI unit of current is called an ampere (A) in hour of French scientist Andre Marie. (It is measured by ammeter). Ammeter is connected in series.

One ampere: - $1\text{ampere} = \frac{1\text{coulomb}}{1\text{ second}}$
Current flowing through a conductor is said to be one ampere if one coulomb of charge flows through it in one second.

One coulomb: - One coulomb of charge is that quantity of charge which flows through a circuit when one ampere of current flows through it in one second.

Prob: - 1 A conductor carries a current of 0.2 A find the amount of charge that will pass through the cross connection of the conductor in 30.s. How many electrons will flow in this time interval if the charge on one electron is 1.6×10^{-19}c

Prob: - 2 the filament of an electric lamp draws a current of a 0.4 A which lights for 3 hours. Calculate the amount of charge that flows through the circuit

Prob : - 3 An electric iron draws a current of a 0.5 A when a voltage is 200 V. Calculate the amount of charge flowing through it in one hour.

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<u>Electrostatic potential</u>: - The electrostatic potential at any point is defined as the work done in bringing a unit positive charge from infinity to that point.

<u>Potential difference:</u> - The potential difference between two points in an electric field is defined as the amount of work done in moving a unit positive charge from one point to another point.

$$\text{Potential difference} = \frac{work\ done}{quantity\ of\ charge\ transffered}$$

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

The S.I unit of potential difference is volt (V) named after Alessandro Voltra Italian Physicist.

<u>One volt:</u> - The potential difference b/w two points is said to be 1 volt if 1 joule of work is done in moving 1 coulomb of electric charge from one point to another.

$$1\text{volt} = \frac{1\,joule}{1\ coulomb}$$

Potential difference is a scalar quantity. It is measured by voltmeter. Voltmeter is connected in parallel.

<u>Ohm's law</u>: - George Simon Ohm was the first to make a quantitative study of this phenomenon and established that;

If physical condition like temperature etc. of a conductor is kept unchanged, the strength of current flowing through it is directly proportional to the potential difference across its ends.

$$I \propto V \qquad \text{or}$$

$$V \propto I$$

$$V = IR$$

Where R is constant of proportionality and known as electric Resistance or Resistance of the conductor.

<u>Resistance:</u> - The resistance of a conductor is the ratio of the potential difference across its ends to the strength of the current flowing through it.

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

The S.I unit is the practical unit of resistance and is called ohm. It is repressed by Ω

<u>One Ohm</u>: - The resistance of a conductor is said to be one ohm if a current of one ampere flows through it when a potential difference one volt is applied its ends.

$$1\ \Omega = \frac{1V}{1A}$$

<u>FACTOR AFFECTING THE RESISTANCE OF A CONDUCTOR</u>

1. Length of the conductor ($R \propto L$)
2. Area of cross - section of the conductor ($R \propto \frac{1}{n}$)
3. Nature of the material of the conductor
4. Temperature of the conductor

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Resistivity: - the resistance of a given conductor is directly proportional to its length

$R \propto L$ ------------------- (1)

The resistance of given conductor is inversely proportional to its area of cross – section

$R \propto \frac{1}{A}$ ---------------------- (2)

By combining (1) and (2)

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

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

Where ρ (rho) is a constant known as resistivity.

- $R = \rho$ if $l = 1m$ and $A = 1\ m^2$

The resistivity of a substance is numerically equal to the resistance of a rod of that substance which is 1 meter long and 1 square meter in cross – section.

Unit: - Ohm meter.

Super conductors: - Dutch Physicist H. Kammerling ones found that as the temperature of the metal conductor is lowered, and then it's electric resistance decreases, and at particular low temperature the resistance of metal conductor becomes negligible to zero. This phenomenon is known a super conductivity and the substance under these conditions are known as super conductor.

Some conducting materials for specific use: -

Tungsten: - It has high melting point (3300 K) and becomes incandescent at 2400 k. But its resistivity is low and as such a thin wire of tungsten which has high resistance is used as a filament of incandescent lamps. At high temperature, tungsten reacts with air forming oxide .It is due to this reason that an electric bulb is filled with an inert gas like nitrogen or neon.

Nichrome: - It is an alloy (Ni: 60%, Cr: 12%, Mn: 2%, Fe: 26%) which has high resistivity and high melting point. It does not react with air when it is red hot ($800\ ^0C$) as such it is used as an element in heating devices such as electric heater , electric iron , electric toaster and geyser.

Constantan and manganin: - Constantan (cu : 60%, Ni : 40%) manganin (Cu : 84%, Mn : 12%, Ni : 4%) and have moderate resistivity which is almost independent of temperature. As such these are used for making standard resistance, resistance boxes and rheostats etc.

Tin – Lead Alloy: - It has low resistivity and low melting point and it is used as a fuse wire in electric circuits.

Copper and Aluminium: - These metals posses' low resistivity and such are generally used in electric circuits and transmission lines.

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Combination of resistances (or Resistors): - The resistances can be combined in two ways:
(1) In series and (2) In Parallel

Resistors in series: - A number of resistors are said to be connected in series if these are joined end to end and the same (i.e. total) current flows through each one of them when a potential difference is applied across the combination.
Suppose three resistors R_1, R_2, R_3 are connected in series with v- volt battery. In series current remain same so the current passes through each resistor is I, and the potentials of resistors R_1, R_2, R_3 is V_1, V_2 and V_3.
By ohms law "V= IR"
Potential difference of each resistors is $V_1 = IR_1$
Potential difference of each resistors is $V_2 = IR_2$
Potential difference of each resistors is $V_3 = IR_3$
Total potential difference $V = V_1+V_2+V_3$
$IR = IR_1+IR_2+IR_3$
$IR = I(R_1+R_2+R_3)$
$R = R_1+R_2+R_3$

- If n resistance are connected in series $R_s = R_1 + R_2 +$ ---------- $+ R_n$
- If n identical resistance are connected in series $R_s = nR$

In series combination the equivalent resistance is greater than the greatest resistance in the combination

Resistors in parallel: - A number of resistors are said to be connected in parallel if one end of each resistors is connected to one point and the other end is connected to another point so that the potential difference across each resistor is the same and is equal to the applied potential difference between the two points.
Suppose three resistors R_1, R_2, R_3 are connected in parallel with V-volt battery. In parallel combination potential difference in each resistor remains same i.e. V and the current across R_1, R_2, and R_3 is I_1 , I_2 and I_3 respectively.
By ohm's law $V = IR \Rightarrow I = \frac{V}{R}$
Current across R_1, R_2, and R_3 is
$I_1 = \frac{V}{R1}$ $I_2 = \frac{V}{R2}$ and $I_3 = \frac{V}{R3}$
Total current in the circuit

$$I = I_1 + I_2 + I_3$$

$$\frac{V}{R} = \frac{V}{R1} + \frac{V}{R2} + \frac{V}{R3}$$

$$\frac{V}{R} = V\left(\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}\right)$$

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

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- If two resistance are connected in parallel $R_P = \frac{R1R2}{R1+R2}$
- If n resistance are connected in parallel

$$\frac{1}{RP} = \frac{1}{R1} + \frac{1}{R2} + \text{-----------------} + \frac{1}{Rn}$$

- If n identical resistance are connected in parallel $R_P = R/n$

In parallel combination the equivalent resistance is lesser than the least of all the resistances.

<u>Electric energy</u>: - The total work done by a current in an electric circuit is called electric energy.

$$E = W = VQ$$

The unit of electrical energy is Joule.

<u>Electric Power</u>: - The rate at which work is done by an electric circuit is called electric power.

$$P = W/T$$

OR $P = E/T$

OR $P = VI$

Unit of an electric energy is **Joule** and electric power is **Watt.**

<u>One watt:</u> - The power of an electric circuit is said to be one watt if one ampere of current flows in it against a potential difference of one volt.

<u>One Joule</u>: - work done is said to be one joule when a force of one Newton actually moves a body through a distance of one meter in the direction of applied force.

Or

Work done is said to be one joule when one coulomb charge is passed through a conductor of potential difference one volt.

<u>Heating Effect of Electric Current</u>

Whenever a current is passed through a conductor, it becomes hot after sometime. This means that electric energy is being converted into heat energy.

In a conductor, resistance opposes the flow of current so work is done. Now we will calculate the work done by a current I when it flows through a resistance R for time t. now, when an electric charge q moves against a potential difference V, the amount of work done is

$W = Vq$

$W = V \times It$ (As $q = It$)

By ohm's law $V = IR$

So $W = IR \times It$

$W = I^2Rt$

Work is in form of Heat

So $H = I^2Rt$

This is known as joule's law of heating

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Heat produced in a wire depend on

(1) Heat is directly produced proportional to the square of the current.
(2) Heat is directly produced proportional to the resistance of wire.
(3) Heat is directly produced proportional to the time for which current is passed.

- Commercial unit of electric energy is called Kilowatt hour or Board of Trade Unit (BOTU) or unit.
- 1 KWh = 3.6 X 10^6 Joule

FORMULAS	
I = q/t Q = ne I = ne/t V = w/q W = Vq V = IR (ohm's Law) F = K $\frac{q1q1}{r2}$ (Coulomb law) R = $\rho\frac{l}{A}$ here ρ (rho) is the resistivity P = VI E = Pt H = I^2Rt	If n resistance are connected in series $R_s = R_1 + R_2 +$ ---------- + R_n If n identical resistance are connected in series R_s = nR **In series combination the equivalent resistance is greater than the greatest resistance in the combination** If two resistance are connected in parallel $R_P = \frac{R1R2}{R1+R2}$ If n resistance are connected in parallel $\frac{1}{RP} = \frac{1}{R1} + \frac{1}{R2}$ +----------------- $+ \frac{1}{Rn}$ If n identical resistance are connected in parallel R_P = R/n **In parallel combination the equivalent resistance is lesser than the least of all the resistances.**