T1

Chapter: 3

Electricity

Electricity (Introduction and Discovery) Electricity is one of the oldest phenomenona discovered. It was around 600B.C. When, Thales of Milletus, a Greek philosopher observed that when amber (a resinous material) was rubbed with wool, it attracted bits of straw, dust particles, etc: towards itself. He called it "Electron". Later on in 1600 A.D William Gilberts also observed that many particles show the same property of attraction when rubbed with suitable materials. He called them "electrica" which is the origin of electricity. Then Du-Fay found that there are two types of charges and Benjamin Franklin gave the signs (+ve and –ve) to two types of charges.

Electric charge: Electric charge is a fundamental property of matter with which electrical and other related effect are experienced. It may be also defined as the property by virtue of which a substance attracts small other substances towards it. From the structure of atom it has revealed that a body gets +vely charged if it looses electrons and –vely charged if it gains electrons. The S.I unit of charge is Coulomb denoted by "C".

Properties of electric charge

1. Unlike (or opposite) charges attract each other and like (or similar) charges repel each other.
2. Electric charge is conserved (it can neither be created nor destroyed).
3. Electric charge is additive (total charge is the algebraic sum of the individual charges).
4. Electric charge is quantized and the quantum of charge (i.e. the minimum charge which is capable of free existence) is equal to the charge on an electron which is the fundamental charge of matter. Any other charged body will have a charge, Q where

   $$Q = ne$$

   Where n = ±1, ±2,……….,e = charge on an electron = 1.6×10^{-19} coulomb.
5. The force (F) between two charges varies directly as the product of two charges (q_1, and q_2) and inversely as the square of the distance (r) between them, (Columb's law)

   i.e. $F = \frac{q_1q_2}{r_2}$ or $F = K\,\frac{q_1q_2}{r_2}$

   Where K is a constant of proportionality.

Unit charge: A charge is said to be one coulomb if it exerts a force of 9×10^9 N on an equal charge placed at a distance of 1m from it in air. An electron is –vely charged particle of 1.609×10^{-19}C of charge.

Conductors and insulators: Those substances through which electricity can flow are called conductors e.g. silver, aluminium, copper etc. All metals, aqueous solutions of salts and ionized gases are conductors. The conductors contain free electrons in abundance which account for their ability to conduct electricity through them.

Those substances through which electricity can not flow are called as insulators, e.g. glass, ebonite, wood etc. In them there are a few electrons or free electrons are totally absent in them. However they can be charged easily by friction.

Electric potential: It is defined as the amount of work done in moving a unit +ve charge from infinity to present location. It is denoted by 'V' and is measured in volts. Potential at a point is said to be one volt if one joule of work is done in moving a unit +ve charge from infinity to that point.

Potential difference: The potential difference between two points in an electric circuit is defined as the amount of work done in moving a unit +ve charge from one point to the other point.

Mathematically; $\text{Potential difference} = \frac{\text{workdone}}{\text{Quantity of charge moved}}$

If W is the amount of work done in moving a charge of Q coulombs from one point to another, then potential difference V between two points is given by $V = \frac{W}{Q}$

Unit of electric potential difference: The S.I unit of potential difference is volt,

$$\text{if } w = 1J,\ Q = 1C$$

$$\therefore V = \frac{1J}{1C} = 1JC^{-1} = 1V$$

i.e. potential difference between two points is said to be one volt if one joule of work is done in moving a charge of 1C from one point to the another. The potential difference is measured by a device called the voltmeter. It is always connected in parallels to a conductor.

Electric current: Rate of flow of electric charge is called electric current. When two charged bodies at two different potentials are connected by a metal wire, the electric charge will flow from the body at higher potential to the body at low potential till both acquire the same potential. This flow of charges in the metal wire constitutes electric current. Thus electric current is defined as the rate of flow of electric charges i.e. the electric charges flowing per unit time is called electric current. If 'Q' be the amount of charges flowing through a conductor in a time 't', the electric current 'I' is defined as $I = {}^{Q}/_{t}$

The S.I unit of electric current is Ampere (A). If Q = 1C, t = 1S then $I = {}^{1C}/_{1S} = 1A$.

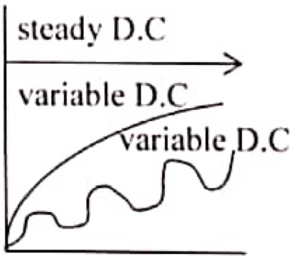
Thus electric current is said to be one ampere if a charge of 1C flows through a wire in one second. However, smaller units of current are also used which are milli ampere and micro ampere where $1mA = 10^{-3}A$ and $1\mu A = 10^{-6}A$.

The conventional direction of electric current is considered to be the direction of flow of +ve charges. So it is also called as conventional current. However, in a metallic conductor, the current is carried by the free electrons which is opposite to the conventional current and is called as electronic current. Electric current is a scalar quantity though it possesses direction. This is because it does not obey vector laws. Electric current is measured by a device called as ammeter. It is always connected in series to a conductor. An ideal ammeter has zero resistance.

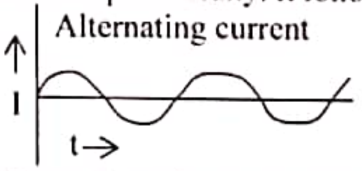
Types of electric current

(1) Direct current (D.C): An electric current is said to be direct current if its magnitude and direction do not change with time (steady D.C) (OR)

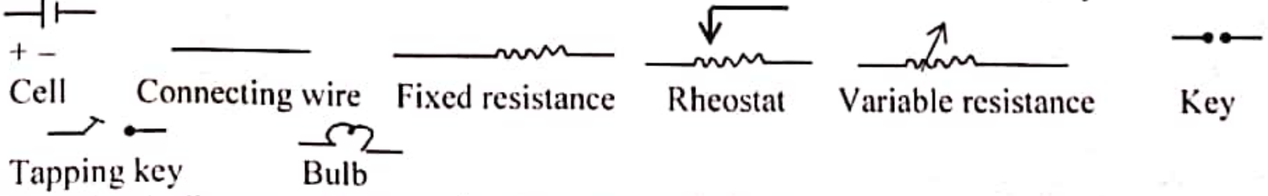
An electric current is said to be direct current if its magnitude changes with time and polarity remains same (variable D.C)



(2) Alternating current (A.C): An electric current is said to be alternating current if its magnitude changes with time and direction reverses periodically. It follows wave and alters with time.



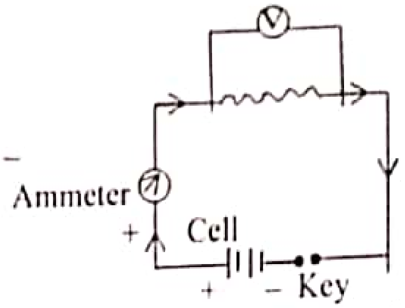
Electric circuit and its components: A continuous conducting path consisting of wires and other resistances (electric bulb, fan, press etc) and a switch, between the two terminals of a cell or a battery along which electric current flows is called as an electric circuit. A drawing showing the way the electric devices are connected in a circuit is a called a circuit diagram or schematic diagram. In these diagrams certain symbols are used to represent different devices as shown in figure.



The circuit diagram of an electric circuit comprising of a cell, a resistance, a key, an ammeter and a voltmeter is shown in following figure.

+ –

R



Ohm's Law: George Siemen Ohm derived a relationship between the potential difference applied across a conductor and the current flowing through it and this relationship is simply called Ohm's law which states that the current flowing through a conductor is directly proportional to the potential difference applied across its ends provided the physical conditions (like temperature, pressure, mechanical strain) are kept unchanged. Mathematically, if I is an electric current flowing through a conductor and V be the potential difference applied across its ends then according to Ohm's law;

$V \propto I$ (at T = constant)

$\Rightarrow V = IR$

Where 'R' is the constant of proportionality called as the resistance of the conductor whose value depends upon length, cross sectional area and the nature of the material of the conductor. The above equation can also be written as $^{V}/_{I} = R$

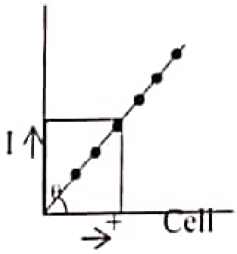
Thus, Ohm's law can also be stated as, "The ratio of the potential difference applied across the ends of a conductor to the current flowing through it is constant provided the physical conditions of the conductor do not change.

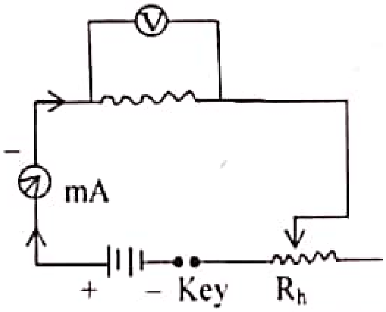
Experimental verification of Ohm's law: Ohm's law can be experimentally verified easily. Connect a conducting wire of resistance 'R' to a battery through a milli ammeter, a key and a rheostat. A voltmeter is also connected in parallels to the wire as shown in figure when the key is inserted, a current flows through the circuit. Adjust the rheostat and take a set of readings of V and I. Now plot a graph between V and I on a graph paper. It will be observed that the graph is a straight line passing through origin as shows in figure. This verifies Ohm's law because the linear graph indicates that V and I are proportional to each other.The slope (tanθ) of graph OL gives the resistance.

L

AP_A R B

O_VB





Resistance: Resistance means the obstruction or opposition offered by a conductor to the flow of electric current. It is symbolically denoted as 

Mathematically, the resistance is defined as $R = {}^{V}/_{I}$ when V is in volts and I in ampere.

Unit of resistance: The S.I unit of resistance is Ohm which is denoted by the symbol "Ω".

If V = 1V, I = 1A then $R = {}^{1V}/_{1A} = 1\Omega$

Hence, resistance of a conductor is said to be one ohm when a current of 1A flows through it against a potential difference of 1V. the resistance of a conductor depends upon (i) length (ii) area of cross section (iii) nature of material and temperature of the conductor. It has been found experimentally that the resistance is directly proportional to the length of the conductor and inversely proportional to the cross sectional area or thickness of the conductor, i.e.

$R \propto {}^{l}/_{A} \Rightarrow R = \rho {}^{l}/_{A}$ where ρ is called **resistivity** or specific resistance of the conductor which depends upon the nature of the material of the conductor.

Resistivity: From above equation, we get $\rho = {}^{RA}/_{l}$. If l = 1m and A = 1m² => ρ = R. Thus resistivity of a material is numerically equal to the resistance of material of unit length and unit area of cross section. It is also defined as the resistance offered by a cube of the material of side 1m when current flows perpendicular to the opposite faces of the cube. S.I unit of resistivity is Ohm meter (Ω m). Its value depends upon the nature of the material and the temperature and is independent of length and thickness of the substance.

Classification of material on the basis of resistivity: On the basis of their resistivity, the materials are divided into four categories.

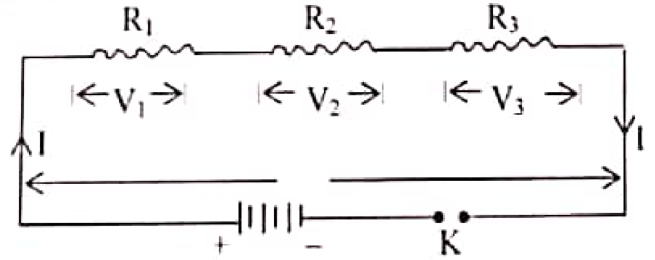
1. *Conductors (metals and alloys):* Metals have a large number of free electrons and as such their resistivity is small (in the range of (10^{-8} to 10^{-6}Ωm), which increases with temperature. In case of alloys like Manganin, Constantan, nichrome etc, resistivity is more than that of metals but it increases slowly with temperature.
2. *Semiconductors:* These possess a few free electrons and as such possess large resistivity (of the order of 3×10^{3}Ωm) as compared to conductors. But their resistivity decreases with the increase of temperature. Ge and Si are common examples of semiconductors.
3. *Insulators:* They do not posses free electrons and as such have a very high resistivity (of the order of 10^{12} to 10^{17}Ωm) which decreases with the increase in temperature, e.g. mica, glass, rubber, wood etc.
4. *Superconductors:* These are the materials which have zero resistance below a certain temperature called as critical temperature, e.g. Hg behaves as a super conductor at 4.2K and Pb at 9.2K. The property of super conductivity was discovered by Kamesling ones in 1911.

Combination of resistances: Resistances are used in almost all electrical circuits for practical purposes. we know that the resistances are available in a wide range, i.e. (10^{-8}Ω to 10^{17}Ω). Resistances are combined to give a required value which is used in a proper place either to increase the current or to decrease it. For this purpose resistances are combined in two ways. (i) Series (ii) Parallel

(i) Resistances in series: Resistances are said to be connected in series if they are connected end to end and same current flows through all of them when a potential difference is applied across the combination. Let R_1, R_2 and R_3 are three resistances connected in series to a source which gives a potential difference V and let I be the current flowing through the combination. Let V_1 and V_2 and V_3 be the potential differences across R_1, R_2 and R_3 respectively as shown in figure so that total potential difference across three resistances is equal to the applied potential difference by the battery, i.e.

$$V = V_1 + V_2 + V_3 \quad \underline{\hspace{3cm}} \quad \text{(i)}$$

V



Applying Ohm's law to each resistance separately we have,

$V_1 = IR_1$, $V_2 = IR_2$ and $V_3 = IR_3$

Putting these values of V_1, V_2 and V_3 in (i) we have,

$V = IR_1 + IR_2 + IR_3$

$$\Rightarrow V = I\,(R_1 + R_2 + R_3) \text{ ——— (ii)}$$

Let R_S be the equivalent or combined resistance of the combination such that current "I" flows through it when potential difference "V" is applied across it, then

$$V = IR_S \text{ \_\_\_\_\_\_\_\_\_\_ (iii)}$$

Comparing (ii) and (iii) we have,

$$IR_S = I\,(R_1 + R_2 + R_3)$$

$$\Rightarrow R_S = R_1 + R_2 + R_3 \text{ ——— (iv)}$$

Thus in series combination the equivalent resistance is sum of the individual resistances and becomes greater than the greatest. For n resistances in series, the equivalent resistance is given by;

$$R_S = R_1 + R_2 + R_3 + \text{———} + R_n$$

Thus for a series combination of resistances,

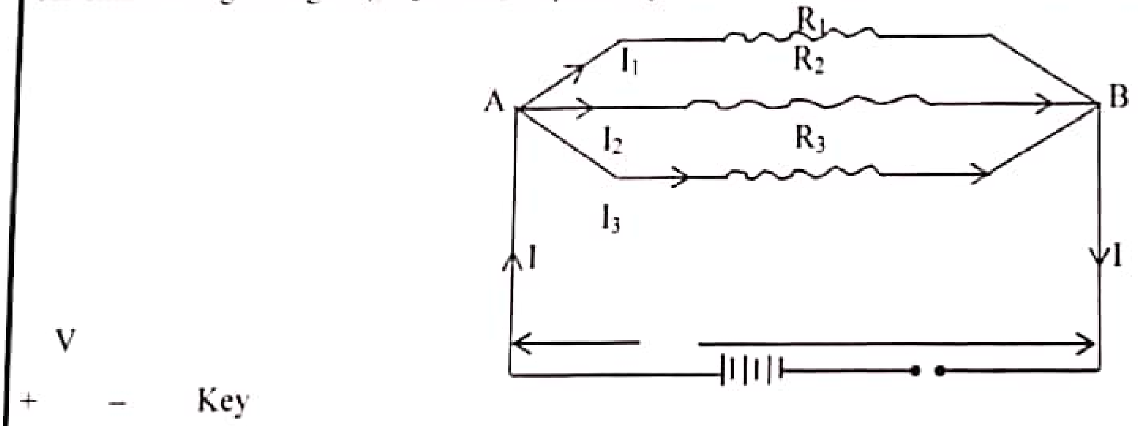
(i) Same current flows through all the resistances.

(ii) The potential difference across any one resistance is directly proportional to its resistance and

(iii) The equivalent resistance is the sum of the individual resistances forming the combination and becomes greater than the greatest.

(ii) Parallel combination or Resistances in parallel: *When two or more resistances are connected between two common points so that the same potential difference is applied across each other of them, they are said to be connected in parallels.*

Consider three resistances R_1, R_2 and R_3 connected in parallels between two points A and B and let V be the applied potential difference across A and B which remains same across each resistance. However, the current I on reaching point A gets branched up, and let I_1, I_2 and I_3 be the currents flowing through R_1, R_2 and R_3 respectively as shown in figure. Thus it is clear that;



$$I = I_1 + I_2 + I_3 \text{ \_\_\_\_\_\_\_\_\_\_\_\_\_\_ (i)}$$

Applying Ohm's law to each resistance respectively, we have;

$$\left.\begin{aligned} V = I_1R_1 &\;\Rightarrow I_1 = \frac{V}{R_1} \\ V = I_2R_2 &\;\Rightarrow I_2 = \frac{V}{R_2} \\ V = I_3R_3 &\;\Rightarrow I_3 = \frac{V}{R_3} \end{aligned}\right\} \text{ \_\_\_\_\_\_\_\_\_\_ (ii)}$$

Substituting (ii) and in (i) we have,

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \quad \Rightarrow I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) \text{ \_\_\_\_\_ (iii)}$$

Let R_P be the equivalent resistance so that current I flows through it against a potential difference of V. Then according to Ohm's law

$V = IR_P \Rightarrow I = \frac{V}{R_P}$ __________ (iv)

Comparing (iii) and (iv) we have,

$$\frac{V}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\Rightarrow \frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \quad \text{\_\_\_\_\_\_\_\_ (v)}$$

Thus the reciprocal of equivalent resistance is equal to the sum of reciprocal of individual resistances and the equivalent resistance becomes less than the least. In general if n resistances $R_1, R_2, \ldots\ldots\ldots R_n$ are connected in parallels then the equivalent resistance can be expressed as,

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots\ldots\ldots + \frac{1}{R_n}$$

Thus, for resistances connected in parallels

(i) The potential difference across each resistance is same and equal to the applied potential difference.

(ii) The current flowing through any resistance is inversely proportional to the resistance and

(iii) The reciprocal of the equilent resistance is the sum of reciprocals of individual resistances and becomes less than the least

Electric power: The rate at which work is done by an electric current is called electric power. It is also defined as the rate at which electric energy is consumed or dissipated. The electric power is mathematically expressed as;

$$\text{Power} = \frac{\text{workdone}}{\text{Time}} \text{ or } P = \frac{W}{t}$$

We know electric work is done when charge q is moved against a potential difference,

i.e. $W = qv$ but $q = It$

$\therefore W = VIt$ thus $P = \frac{VIt}{t} = VI$ $[\because V = {}^{W}/_{q}$ & $I = q/t]$

Thus electric power is numerically equal to the product of voltage and the current.

From Ohm's law; $V = IR$ =>Thus , $P = IR \times I$ => $P = I^2R$

Also $I = V/R$ => $P = \frac{V^2}{R}$

Units:-The S-I unit of electric power is JS^{-1}called as watt (W). Power of an electric device is said to be I watt if a current of 1A flows through it when a potential difference of 1V is applied. Watt is a small unit of power so we use bigger units of power as K W and M W where $1KW = 10^3w$ and $1MW = 10^6w$.

The commercial or trade unit of electric power is horse power (H.P) where 1H.P. = 746w.

Power rating:-Every electrical appliance has a label plate on it. Which tells about the maximum voltage up to which the device can be operated and the power consumption e.g. an electric bulb rated 100W, 220V means that it will give a power of 100w when operated at 220V.

Prob:- An electric bulb is rated 100w, 220v. Calculate the power consumed by it when operated on 110v.

Sol.: when P = 100W, V = 220V, Thus $R = \frac{V^2}{P}$ $[\because P = \frac{V^2}{R}]$

or $R \frac{(220)^2}{100} = 484\ \Omega$

Now when V = 110V, P = ?

As $P = \frac{V^2}{R}$ => $P = \frac{(110)^2}{484} = 25$ W

Electric energy:- The total work done by a current in an electric circuit is called electric energy. From the definition of power,

$$\text{Power} = \frac{\text{workdone}}{\text{Time}} \Rightarrow \text{workdone} = \text{power} \times \text{time}$$

i.e. $W = Pt$ but $P = VI$

$\Rightarrow W = VIt$

According to Ohm's Law; $V = IR \Rightarrow W = I^2Rt$

Also $I = V/R$

$$\Rightarrow W = \frac{V^2}{R}.t$$

Thus; $W = VIt = I^2Rt = \frac{V^2}{R}.t$

When V is measured in volt, I in ampere, t in second then w is in joule. This work done by the current measures the electric energy which is supplied by a source. From above equation it is clear that electric energy depends on I, R and t.

The S-I unit of electric energy is also called as watt-hour. One watt-hour is amount of electric energy consumed when an electric appliance of power 1 watt is used for 1 hour.

The watt-hour (wh) is small unit of energy. So the practical unit of electric energy is taken as killo watt-hour (Kwh). It is also the trade or commercial unit of electric energy. Where 1KWh = 10^3 W x 60 x 60s = 3.6×10^6J

One killo watt hour is the amount of electric energy when an electric appliance of power 1kw is used for 1 hour.

1kwh is also called as board of trade unit (BOTU) or simply one unit of electricity.

Heating effect of current: Whenever current flows through a conductor, it becomes hot after some time. This means that electric energy is converted into heat energy. The heat produced due to the flow of electric current is called as heating effect of current. It was first observed by Thomas joule so it is also called joule's heating effect. Electric bulb, electric iron, heater, gyser etc are the appliances based on this effect.

Practical applications of Heating effect of current:- The heating effect of current has many useful practical applications such as:

(i) An electric iron, electric geyser, electric toaster, electric oven, electric kettle etc. are some of the familiar devices based on joule heating or heating effect of current.

(ii) An electric bulb is used to provide light by heating its filament.

(iii) An electric fuse used as a safety device in electric circuits is another important application of joule heating (heating effect of current)

Cause of heating:- When a potential difference is applied across a conductor, the free electrons begin to drift from lower potential to higher potential (–Ve terminal to +Ve terminal). During their motion they experience a resistance on account of their collisions with other electrons as well as with kernels. As a result of this, some work is done to overcome this resistance. This work done is converted into heat.

Consider a conductor AB of resistance R, let V be the potential difference applied across its ends such that a current I flows through it for a time t. .: Total charge flowing from A to B in time t is $q = It$ ________ (1)

By definition of potential difference workdone is carrying unit +ve charge from A to B = V, therefore total workdone in carrying charge q from A to B = qv

$\therefore W = qv$ ____________(2)

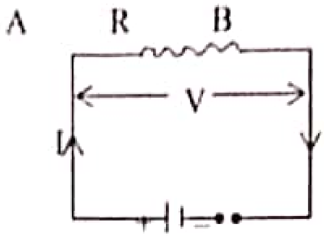
Substituting (1) in (2) we have,

$W = VIt = I^2Rt$

This workdone is called electric workdone. If this appears as heat, then amount of heat produced (H) is given by

$H = W = I^2RtJ = I^2Rt$ cal __________(3) [□1 cal = 4.18J]

$\overline{4.18}$



This equation (3) is a statement of Joule's law of heating. It states the amount of heat produced in a conductor when a current flows through it is directly proportional to (i) the square of the current flowing through the conductor (ii) Resistance of the conductor and (iii) time for which the current is passed through the conductor.

Prob:- Calculate the heat produced when 96500 C of charge is transferred in 1 hour through a potential difference of 50V.

Sol. We know $I = \frac{q}{t} \Rightarrow I = \frac{96500}{60 \times 60} = 26.67A$

Using Ohm's law $\frac{V}{I} = R = \frac{50V}{26.67A} = 1.87\Omega$

$\therefore$ Heat produced, $H = I^2Rt \Rightarrow H = (26.67)^2 \times 1.87 \times 60 \times 60 = 4788400J = 4788.4KJ$

[t = 1hr]

[$\therefore$ 1hr = 60x60 seconds

Prob:- Two resistance wires of the same material of equal lengths and equal diameters are first connected in series and then in parallels in a circuit. What is the ratio of heat produced in series and parallel combination.

Sol. Let the resistance of each wire = 'x'Ω.

(i) When they are connected in series total resistance = x + x = 2x

$\therefore$ Heat produced in series combination

$H_1 = I^2 \times 2x \times t = 2I^2xt$ ________ (1)

(ii) When they are connected in parallels

$\frac{1}{R_P} = \frac{1}{x} + \frac{1}{x} = \frac{2}{x} \quad \therefore R_P = \frac{x}{2}$

$\therefore$ Heat produced in parallel combination

$H_2 = I^2 \times (x/2) \times t = \frac{I^2xt}{2}$ ____________ (2)

From (1) and (ii) we have,

$\frac{H_1}{H_2} = \frac{2I^2xt}{I^2xt/2} = \frac{4}{1} \Rightarrow H_1 : H_2 = 4:1$

Q) How many electrons form one coulomb of charge?

Ans) We know $q = ne$; $e = 1.6 \times 10^{-19}C$ $q = 1C$

$\therefore n = \frac{q}{e} = \frac{1}{1.6 \times 10^{-19}} = 6.25 \times 10^{18}$

Q) Why are coils of electric toasters and electric irons made of an alloy than a pure metal?

Ans) Coils of electric toasters and irons are made of an alloy called Nichrome because;

(i) The resistivity of Nichrome is higher than the metals.

(ii) It has a high melting point and

(iii) It does not oxidize when it is red hot at (800°C).

Q) What are the advantages of connecting electrical devices in parallel with the battery instead of connecting them in series?

Ans) Because each device gets same potential difference as provided by the battery and it keeps on working even if other devices fail when connected in parallels.

Q) A copper wire has a diameter of 0.5mm and resistivity $1.6 \times 10^{-6}\Omega$ (i) How much of this wire would be required to make a 10Ω coil. (ii) How much the resistance changes if the diameter is doubled?

Ans) (i) Diameter, $D = 0.5mm = 0.5 \times 10^{-3}m$

Resistivity $\rho = 1.6 \times 10^{-6}\Omega m$

Required resistance $R = 10\Omega$

We know $R = \frac{\rho l}{\rho}$ => $l = \frac{RA}{\rho} = \frac{R(\pi D^2/_4)}{}$ ($\therefore A = \pi r^2 = \pi D^2/_4$)

A

(ii) When D is doubled original $R_1 = \frac{\rho l}{a} = \frac{\rho l}{\pi D^2/_4}$

Taking D = 2D, $R_2 = \frac{\rho l}{\pi D^2/_4} = \frac{\rho l}{\pi D^2/_4}$ $\therefore \frac{R_2}{R_1} = \frac{^{\rho l}/_{\pi D^2}}{^{\rho l}/_{\pi D^2/_4 \pi D^2}} = \frac{\cancel{\rho l}}{4\rho l} \times \frac{\cancel{\pi D^2}}{4} = \frac{1}{}$

=> $\frac{R_2}{R_1} = \frac{1}{4}$ Thus when diameter is doubled, resistance becomes ¼ times.

Q) Why is tungsten used almost exclusively for filament of incandescent lamps?

Ans) Tungsten has high melting point (3380^0C) and emits light i.e. becomes incandescent at a high temperature i.e. 2400K.

Q) Several electric bulbs are rated 100W, 220V. How many of them be connected in parallel with each other across two wires of 220V line if maximum allowable current is 5A?

Ans) Resistance of each bulb, $R = \frac{V^2}{P} = \frac{220 \times 220}{10} = 4840\Omega$

Total resistance in the circuit $R = \frac{220V}{5A} = 44\Omega$ $[\therefore R = \frac{V}{I}]$

let n bulbs be connected in parallels to obtain a resistance R

$\therefore \frac{1}{R} = \frac{1}{r} + \frac{1}{r} + \text{--------}\frac{1}{r} = \frac{n}{r}$ => $n = \frac{r}{R} = \frac{484}{44} = 110$

∴ 110 bulbs can be connected

Textual Questions

Q.1 What does an electric circuit mean?

Ans. A closed and continuous path through which an electric current flows is called an electric circuit.

Q.2 Name a device that helps to maintain potential difference across conductor.

Ans. A battery consisting of one or more electric cells.

Q.3 How much energy is given to each coulomb of charge passing through a 6 V battery?

Ans. We know w = qv => w = 1c x 6 v = 6 J.

Q.4 On what factors resistance of a conductor depends?

Ans. Resistance of a conductor depends upon i) Length, ii) Cross sectional area and iii, nature of material called resistively.

Q.5. Will current flow more easily through a thick wire or a thin wire of the same material connected to the same source. Why?

Ans. The current will flow more easily through a thick wire than through a thin wire. It is because that the resistance of thick wire is small as its cross sectional area is less than that of thin wire.

Q.6 **Let the resistance of an electrical component remain constant while potential difference across its ends decreases to half of its former value. What change will occur in the current through it?**

Ans. When potential difference becomes half of its former value, the current will become also half as resistance remains constant. This is because of obeying ohms law (V=IR).

Q.7 **Which among iron and mercury is a better conductor and which material is the best conductor.**

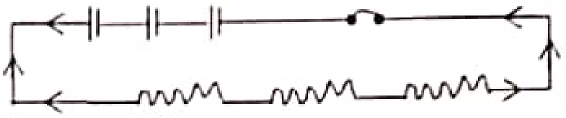
Ans. Iron is a better conductor than mercury because resistively of iron (10.0×10^{8} Ω m) is less than that of mercury (94×10^{-8} Ω). Silver is the best conductor as its resistivity (1.6×10^{-8} Ω m) is least.

Q.8 **Draw a circuit diagram of a circuit containing a battery of three cells of 2V each, a 5Ω resister, an 8Ω resistor and a 12Ω resister and a plug key, all connected in resies.**

K

Ans. Circuit diagram is shown in fig.

2v 2v 2v



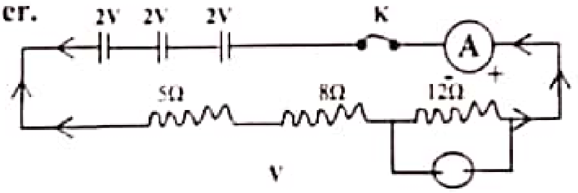
5 Ω8 Ω12 Ω

Q.9 **Re-Draw the circuit of above question putting in an ammeter to measure current and a voltmeter to measure voltage across 12Ω resistance what would be the readings in the ammeter and voltmeter.**

Ans. Circuit diagram is shown as below

Since all resistances are in series

∴ Total resistance of the circuit,



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R= 5+8+12=15Ω

∴ Current in the circuit, $I = \frac{\text{Pot diff applied}}{\text{Total Resistance}} = \frac{6V}{25\Omega} = 0.24A$

Potential difference across 12Ω resister

V = resistance x current = 12 x 0.24 = 2.8 8V.

Q.10 **Judge the equilent resistance when the following are connected in parallels**
(a) 1Ω and 10^6Ω b) 1Ω, 10^6Ω and 10^8Ω.

Ans. For both (a) and (b) approximately 1Ω (but less than 1Ω) because in parallels the resistance becomes less than the least.

Q.11 **An electric lamp of resistance 100Ω, a toaster of 50 Ω resistance and a water filter of resistance 500Ω are connected in parallel to 220V source, what is the resistance of an electric iron connected to the same source that takes as much current as all the three appliances and what is the current through it?**

Ans. Resistance of lamp r_1 = 100 Ω, resistance of toaster r_2 = 50Ω. Resistance of water filter r_3= 500Ω. Since r_1, r_2 and r_3 are connected in parallel.

∴ Their equilent resistance R_p is given by

$$\frac{1}{R_p} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} = \frac{1}{100} + \frac{1}{50} + \frac{1}{500} = \frac{5+10+1}{500} \quad \frac{16}{500}$$

$$R_p = \frac{500}{16} = 31.25\Omega$$

Current through the three appliances i.e. $I = \frac{V}{R} = \frac{220}{31.25} = 7.04A$

Since electric iron is connected to the same source, takes as much current as all the three.

∴ Resistance of electric iron is equal to R_p = 31.25Ω. and current through it = 7.04A

Q.12 How can three resistances 2Ω, 3Ω be connected to give a total resistance of (a) 4Ω and (b) 1Ω.

Ans. To get a resistance of 4Ω from 2 Ω, 3 Ω and 6 Ω, the resistances 3 Ω and 6Ωshould be connected in parallel then connected in series with 2 Ω i.e R_P of 3 Ω and

6 Ω = 3x6 = 18 = 2 Ω
3x6 9

So that Rs of 2 Ω and 2 Ω is 2 + 2 = 4 Ω.

In order to get 1 Ω from 2,3 and 6 Ω connect then in parallels.

$\therefore {}^{1}/_{RP} = {}^{1}/_{2} + {}^{1}/_{3} + {}^{1}/_{6} = \underline{3+2+1} = {}^{6}/_{6} = 1 \quad \therefore R_P = 1\Omega$
6

Q.13. What is the (a) highest and the (b) lowest total resistance that can be secured by combinations of four coils of resistance 4Ω, 8Ω, 12Ω and 24Ω

Ans. The highest resistance is secured when all for coils are connected in series

$\therefore Rs = 4 + 8 + 12 + 24 = 48\ \Omega$

The lowest resistance can be recurred when for coils are connected in parallel

${}^{1}/_{RP} = {}^{1}/_{4} + {}^{1}/_{8} + {}^{1}/_{12} + {}^{1}/_{24} = \underline{6+3+2+1} = {}^{12}/_{24}$
24

$=> R_P = 2\ \Omega.$

Q.14. Why does the cord of an electric heater not glow while the heating element does?

Ans. Since the cord of an electric heater is made of thick copper wire and has much lower resistance than its element. For the same current I flowing through cord and the element heat produced ($I^2 R^*$) in the element is much more than that produced in the cord. Consequently, the element becomes very hot and glows whereas the cord does not become hot and as such does not glow.

Q.15. Compute the heat generated while transferring 96000C of charge in one hour through a potential difference of 50V.

Ans. Here q = 96000 C, t = 1h = 60 x 60 = 3600S, V= 50 V.

$\therefore$ Heat produced W = QV = 96000 x 50 = 48×10^5 J.

Q.16. An electric iron of resistance 20 Ω takes a current of 5A. Calculate heat developed in 30S.

Ans. Here R = 20 Ω, I = 5A, t = 30S. $\therefore$ Heat developed = $I^2 Rt = 5^2 \times 20 \times 30 = 15000$J.

Q.17 What determines the rate at which energy is delivered by a current.

Ans. Electric power.

Q.18. An electric motor takes 5A from 220V line. Determine the power and energy consumed in 2h.

Ans. Here I = 5A, V = 220V, t = 2h = 2 x 60 x 60 = 7200S.

$\therefore$ P = V I = 220 x 5 = 1100W.

Q.19. How is voltmeter connected to measure potential difference.

Ans. Voltmeter is always connected is parallel across the pts between which the potential difference is to be determined.

Q.20. A battery of av is connected in series with resistors of 0.2 Ω, 0. 3Ω, 0.4Ω, 8.5Ω and 12Ω. How much current will flow through 12Ω.

Ans. Since all the resistors are connected in series $\therefore$ equilent resistance.

Rs = 0.2 + 0.3 + 0.4 + 0.5 + 12 = 13.4 Ω

$\therefore$ Current through the circuit = ${}^{V}/_{Rs} = {}^{9}/_{13.4} = 0.67$A.

In series, same current flows through all the resistors. Hence through 12 Ω resistor the current will be same i.e. 0.67A.

Q.21. Which uses more energy a 250W T.V. set in 1h or a 1200W toaster in 10 minutes?

Ans. Energy used by TV. In 1h = 250 W x 1h = 250 Wh.

Energy used by toaster in 10 min. $= {}^{20}1200\ \text{w} \times {}^{10}/_{60} = 200$ Wh.
Hence a TV of 250 W in 1h consumes more energy than 1200 w toaster for 10 m

Q.22. An electric heater of resistance 8 Ω draws 15 A from a service line for 2hrs. calculate the rate at which heat is developed.

Ans. Here I = 15 A, R = 8 Ω **t = 2h.**

∴ Rate at which heat is developed = electric power = I^2R

∴ $P = (15)^2 \times 8 = 1800\text{W} = 1800\ {}^{J}/_{s}$.