ELECTRICITY & IT'S HEATING & CHEMICAL EFFECTS

Electricity: The study of flow of charge is called electricity. Electricity classified into two parts:

(1) Static Electricity (2) Current Electricity

1. **Static Electricity:** The physical phenomena occur due to charge is called Static Electricity. For example: The attraction or repulsion between two isolated charged body.
2. **Current Electricity:** The physical phenomena occur due to motion of charge is called current electricity. The working of all electrical appliances are the examples of current electricity.

Electric Charge: The SI unit of electric charge is coulomb (C) one coulomb charge is that quantity of charge which is present on 6.25×10^{18} electrons. A body said to be positively charge, if it has deficiency of electrons, conversely, a body is said to be negatively charge, it has excess of electrons. There are two type of charges: (i) positive charge (ii) negative charge

One Coulomb positive charge: A body is said to have one coulomb positive charge if it has 6×10^{8} electrons less than as compared to the normal electrons on the body.

One Coulomb negative charge: A body is said to have one coulomb negative charge if it has 6×10^{18} electrons more than as compared to the normal electrons on the body.

Charge on one Electron: We know that 6.25×10^{18} electrons have a charge = 1 C

Therefore 1 electron has a charge= $\frac{1}{6.25 \times 10^{18}}$ C

$= 1.6 \times 10^{-19}$ C.

Properties of Electric Charge:

1. Unlike charges attract each other and like charge repel each other.
2. The force between the two charges directly proportional to the product of charges and inversely proportional to the square of distance between them:

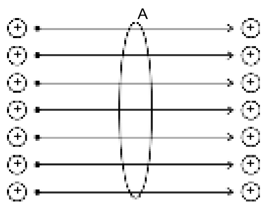
$$F \alpha \frac{q_1 \times q_2}{r_2} \Rightarrow F = k \frac{q_1 \times q_2}{r^2}$$

above equation is the mathematical statement of coulomb's law.
3. Electric charge is conserved, i.e., it can neither be created nor destroyed.
4. Electric charge is additive,i.e., total charge is the algebraic sum of the individual charges.

Topic: Electric Current

Definition: The rate of flow of charge is called Electric current. Suppose **Q** units of charge flows through a conductor in time **'t' second,** then electric current (I) passes through the conductor in time 't' is given by

$$\text{Electric Current} = \frac{\text{Charge}}{\text{time}} \Rightarrow I = \frac{Q}{t}$$



Note: The S.I unit of electric current is **ampere** and it is denoted by letter **A**. Electric current is a **scalar** quantity.

One Ampere: When one coloumb chose flows through a conductor in one second, then current flowing through the conductor is said to be one ampere. We know,

$$\text{Electric current } (I) = \frac{Q}{t}$$

$$\Rightarrow \text{Ampere} = \frac{1\,\text{Coloumb}}{1\,\text{Second}}$$

The Smaller and Bigger Units of Electric Current are given below:

1 mili Ampere (mA) = 10^{-3}A
1 micro Ampere (μA) = 10^{-6}A
1kilo Ampere (kA) = 10^{3}A
1mega Ampere (mA) = 10^{6}A
1giga Ampere (GA) = 10^{12}A

Electric Current in terms of number of electrons: According the Definition of current. We know that:

$$\text{Current, } I = \frac{Q}{t} \quad \text{(i)}$$

Suppose **'n'** electons passes through a conductor in time 't' second then total amount of charge passes through the conductor in time 't' is given amount of

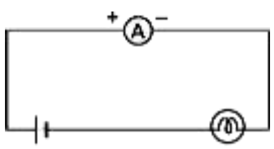
by: $Q = n \times e^-$

put $Q = n \times e^-$ in (1), we get

$$\mathbf{I = \frac{n \times e^-}{t} = \frac{n \times 1.6 \times 10^{-19}}{t}}$$

Direction of Electric Current: Conventionally, the direction of electric current in a conductor or a wire is just opposite to the direction of flow of electrons in the conductor or the wire

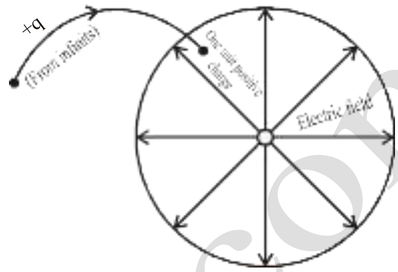
Note: Electric current measured by in instrument called ammeter. It is always connected in series in electric circuit. The resistance of ammeter is negligible.



Ammeter in a circuit

Topic: Electric Potential

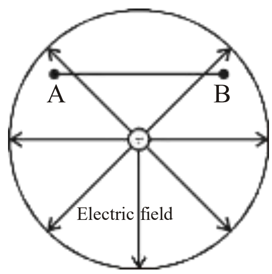
Definition: The electric potential at a point in an electric Field is the amount of work done in bringing a unit positive charge from infinity to that point. Electric potential is a **scalar** quantity the SI unit of electric potential is volt and it is denoted by letter **V**.



Potential Difference: The amount of work done to transfer one coulomb change from one point to another point in the electric field is called potential difference. If **'Q'** units of charge are moved from one point to another point in the electric field, such that **'W'** is the amount of work done then potental difference between two points in the electric field is given by

$$\text{Potential Difference} = \frac{\text{Work done by Charge}}{\text{Quantity of Charged transfer}}$$

$$\text{Potential Difference}(V) = \frac{W}{Q}$$



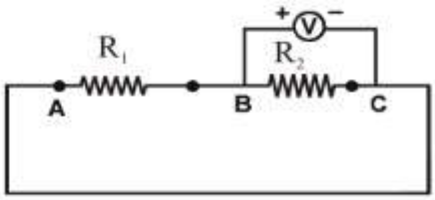
Definition of one volt: If one Joule of work is done in moving one coulomb of charge from one point to another point in the Electric Field, then Potential difference between the two point is said to be 1 volt. According the definition of potential difference:

$$V = \frac{W}{Q} \Rightarrow \mathbf{1\,Volt = \frac{1\,Joule}{1\,Coulomb}}$$

The Smaller & Bigger Units of Electric Potential are given below:

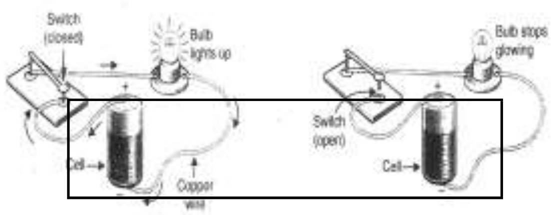
1 mili Volt (mV) = 10^{-3}V
1 micro Volt (μV) = 10^{-6}V
1kilo Volt (kV) = 10^{3}V
1mega Volt (MV) = 10^{6}V
1giga Volt (GV) = 10^{12}V

Note: Potential difference is a **scalar** Quantity it is measured by an Instrument called voltmeter. It is always connected in the parallel of Electric circuit, the resistance of voltmeter is approx. infinite.

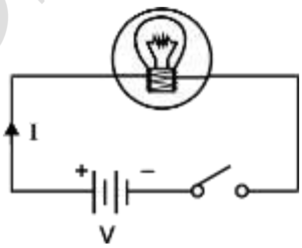


Voltmeter in a circuit

Electrical Circuit: A continuous path consisting of conducting wires and other resistances and a switch between the two Terminals of battery, along which an electric current flows, is called a Electrical Circuit.

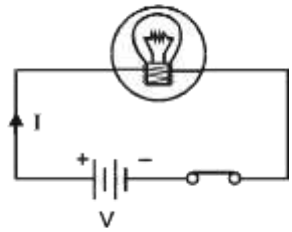


Open Electric Circuit: An electric circuit through which no electric current flow is known as open electric circuit.



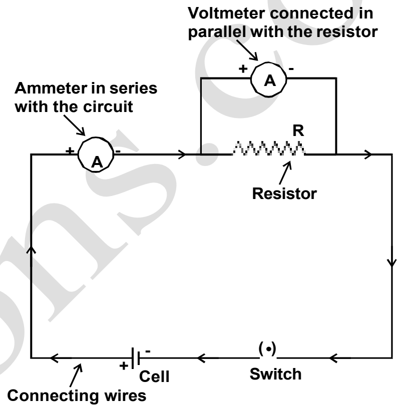
Open circuit

Closed Electric Circuit: An electric circuit through which electric current can flow continuously is known as closed circuit.



Close circuit

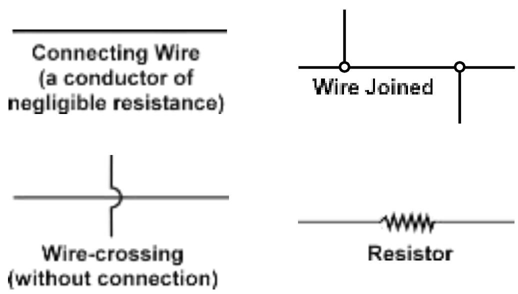
Circuit Diagram: A diagram which indicates how different components in a electric circuit are connected by using their symbols is called a circuit diagram.

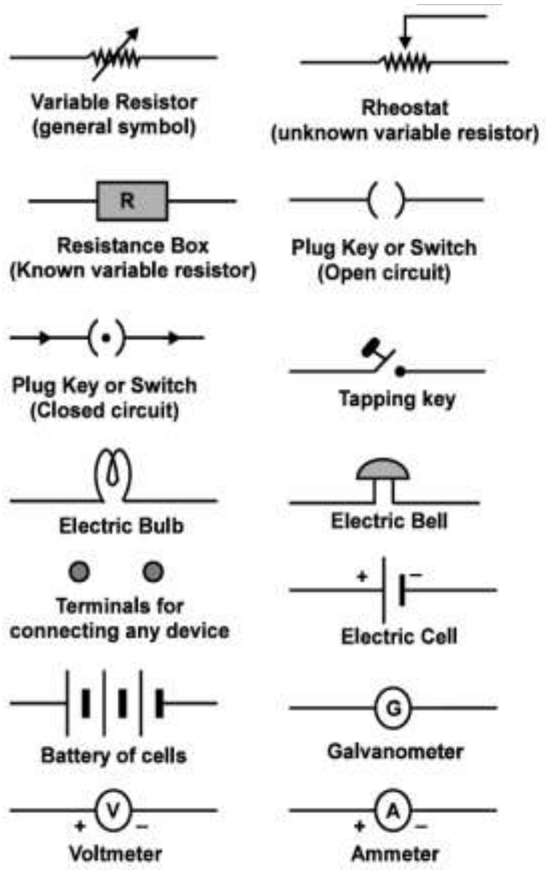


Difference between closed circuit and open circuit:

Closed circuit	Open circuit
(i) In closed circuit plug key is called	(i) Open circuit plug key is open
(ii) In closed circuit current flows continuously.	(ii) In open circuit current do not flows.

Topic: Electrical Symbols





Conductors: Those substances through which electricity can flow are called conductors. All metals are conductors, all alloys (like nicrome, constant, manganin etc.) are the examples of conductor.

Insulators: Those substances through which electricity can not flow are called insulators glass, ebonite, rubber, plastic, drywood, cotton, mica, bakelite, porclien and air are the examples of insulators.

Ex 1: Charge of 400 C flows through a conductor for 13 min and 20 sec. find the magnitude of the current flowing through the conductor.

Sol.: Q = 400 C, t = 13×60 + 20 = 800s.

We know that,

$$I = \frac{Q}{t} \Rightarrow I = \frac{400}{800} = \frac{1}{2} = 0.5A$$

Ans: Current flowing = 0.5

Ex 2: A dry cell can supply a charge of 300 C. If the current is drawn from the cell is 60mA, find the time in which the cell completely discharges.

Sol.: Q = 300 C, t =?

$$I = 60mA = \frac{60}{1000} A$$

We know current

$$I = \frac{Q}{t} \Rightarrow \frac{60}{1000} = \frac{300}{t}$$

$$\therefore \quad t = \frac{300 \times 1000}{60} = 5000 \text{ s}$$

Ans: Require Time = 5000 s

Ex 3: A charge of 25 mA flows for 2 hours through a conductor. Calculate the number of electrons which drift in the conductor.

Sol.: $Q = n \times 1.6 \times 10^{-19}$ C, t = 7200 s,

$$I = 25mA = \frac{25}{1000} A$$

We know

$$I = \frac{Q}{t} \Rightarrow \frac{25}{1000} = \frac{n \times 1.6 \times 10^{-19}}{7200}$$

$$\therefore \quad n = \frac{25 \times 7200}{1000 \times 1.6 \times 10^{-19}} = \frac{25 \times 72}{10 \times 1.6} \times 10^{19}$$

$= 112.5 \times 10^{19} = 1.125 \times 10^{21}$ electrons

Ans: No. of electrons = 1.125×10^{21}

Ex 4: 50 colombs of charge is brought from infinity to a given point in an electric field when 62.5 J of work is done. What is the potential at that point.

Sol.: Q = 50 C, W = 62.5 J

$$\therefore \quad (V) = \frac{W}{Q} = \frac{62.5}{50} = 1.25 \text{ Volts.}$$

Ans: 1.25 Volts

Topic: Ohm's Law

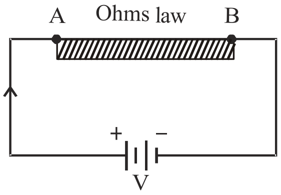
At constant temperature, the amount of current through the conductor is directly proportional to the potential difference across the ends conductor.

If **I** is the current flowing through a conductor and **V** is the potential difference across the ends of conductor then according ohm's law.

$I \propto V$

or $V \propto I$

$\Rightarrow$ $\mathbf{V = RI}$



Where 'R' is a constant called 'Resistance' of the conductor.

ACTIVITY 12.1

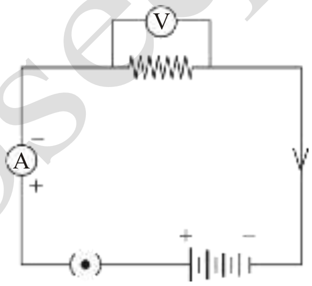
AIM: Describe an experiment to find the relation between potential difference (V) across a conductor and current (I) through it. (Verify Ohm's Law)

MATERIAL REQUIRED: Nicrome wire of 0.5 m length, an ammeter, a voltmeter and four cells each of 1.5 volt.

Note: Nichrome is an alloy of nickle, chromium, manganese and iron metal (Ni + Cr + Mn + Fe).

PROCEDURE:

Step 1: Complete the circuit diagram by connecting one cell and Plug the key.



Step 2: Note the reading in the ammeter for the electric current I and in the voltmeter for the potential difference (V) across the nichrome wire.

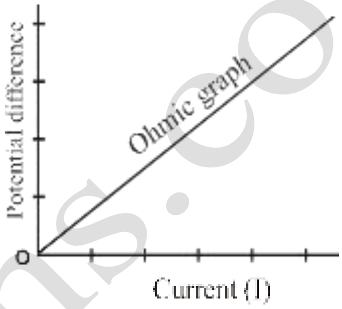
Step 3: Repeat the above steps using two cells, three cells and four cells and every time note the reading of Ammeter and voltmeter.

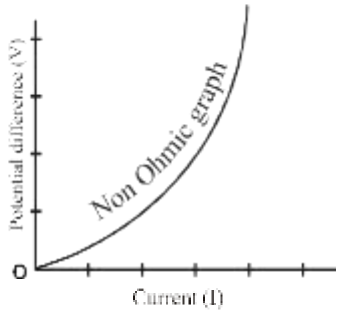
Step 4: Find the ratio of V and I for each observation.

Step 5: Plot a graph between V (on the y-axis) and I (on the x-axis)

OBSERVATION:

1. Reading Voltmeter and reading increases as the number of cells increase in series.
2. The value of $\frac{V}{I}$ is same in each case.
3. V - I graph is a straight line passing through the origin.





CONCLUSION:

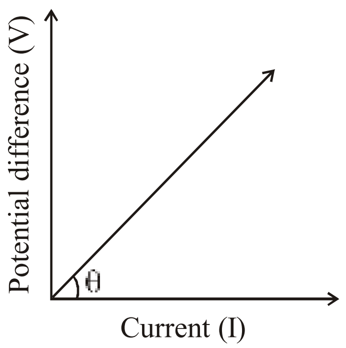
1. V/I is a constant ratio and equal to the resistance of the nichrome wire i.e., $\frac{V}{I} = R$.
2. Straight line directly graph shows that the current is directly proportional to the potential difference i.e. $I \propto V$.
3. The slope of V - I graph gives the value of resistance of the nichrome wire.

Note: The slop of graph between potential difference and current gives the resistance of conductor.

(i) If we take the potential difference (V) on the y-axis and current (I) on the x-axis the resistance is directly proportional to the slope of graph line.

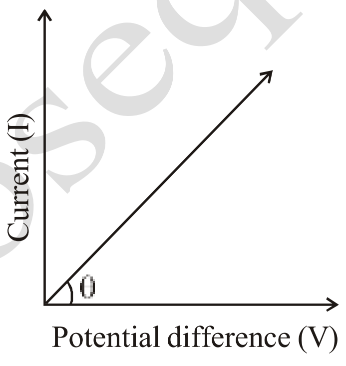
Observations in tabular form

S.No.	Number of cells used in the circuit	Potential difference across the nichrome wire, V (volt)	Current through the nicrome wire(in ampere)	Ratio of V and V / I(volt / ampere)
1	1	1.2	1A	$\frac{1.2}{1} = 1.2$
2	2	2.4	2A	$\frac{2.4}{2} = 1.2$
3	3	3.6	3A	$\frac{3.6}{3} = 1.2$
4	4	4.8	4A	$\frac{4.8}{4} = 1.2$



Resistance & slope of the graph line

(ii) If we take the potential difference (V) on the x-axis and current on the y-axis. The resistance is inversely proportional to the slope of graph line.



Resistance & slope of the graph line

Topic: Resistance of a Conductor

The property of a conductor due to which it opposes the flow of charge through it is called resistance of the conductor.

We know that $V = RI$

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

From the above expression it is clear

The numerically the resistance of conductor is the ratio of potential difference across the ends of conductor and the current flowing through the conductor.

Note: The S.I unit of resistance is **ohm**, which is denoted by symbol omega **(Ω)**. Resistance is a **scalar** quantity. The Bigger Units of Resistance are Kilo Ohm, Mega Ohm and Giga Ohm.

$$1\text{kilo Ohm } (k\Omega) = 10^3\Omega$$

$$1\text{mega Ohm } (M\Omega) = 10^6\Omega$$

$$1\text{giga Ohm } (G\Omega) = 10^{12}\Omega$$

Important Information: The resistance of a conductor does not depend upon the potential difference across the ends of the conductor and current of passing through the conductor.

Definition of one ohm: If one ampere current flows through a conductor at a potential difference of one volt, then the resistance of the conductor is said to be one ohm. We know $R = \frac{V}{I}$

$$\Rightarrow \textbf{1ohm} = \frac{\textbf{1volt}}{\textbf{1ampere}}$$

Variation of electric current: According to Ohm's law $V = I \times R$

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

From the above expression it is clear

(i) The current flowing through a conductor is inversely proportional to the resistance of the conductor i.e. $I \propto \frac{I.}{R}$

(ii) The current flowing through a conductor is directly proportionalto the potentialdifference across the end of conduction ie. $I \propto V$.

ACTIVITY 12.2

AIM: To show that the current flowing through a conductor is inversely proportional to the resistance of the conductor.

MATERIAL REQUIRED:

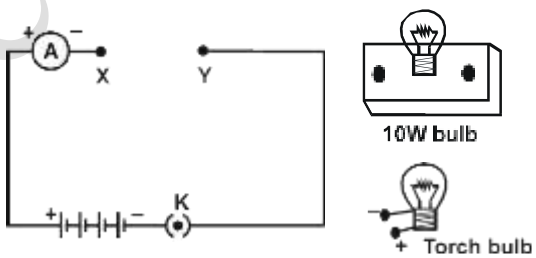
Two bulbs of 50W and 100W and an ammeter (0 – 5A range) a plug key and some connecting wires.

PROCEDURE:

Step 1: Set up the electric circuit by connecting four dry cells of 1.5V each in series with ammeter leaving a gap XY in the circuit as shown in figure.

Step 2: Complete the circuit by connecting the 50W bulb in the gap XY. Plug the key. Note down the ammeter reading. Take out the key from the plug.

Step 3: Replace the 50W bulb by 100W bulb in the circuit and find the current through it by measuring the reading of the ammeter.



OBSERVATION: We observe that ammeter gives different reading with different bulb.

CONCLUSION:

The reading of ammemeter minimum with 50W bulb and maximum with 100W bulb it is clear the current flowing through a resistor is inversely proportional to the resistance of the conductor.

Dependence of resistance of a conductor: The resistance of a conductor depends upon the following factors.

1. **Length of conductor:** The resistance of a conductor is directly proportional to its length i.e., **R × ℓ**.

   From the above expression, it is clear along wire has more resistance and a short wire of same material and same area of cross section.

2. **Area of cross section of conductor:** The resistance of a conductor is inversely proportional to its area of cross-section i.e., $R \propto \frac{1}{A}$

   From the above expression it is clear, a thick wire has less resistance then a thin wire of same material and same length.

   We know that $R \propto \ell$ and $R \propto \frac{1}{A}$

3. **Diameter of conductor:** The resistance of a conductor is also inversely proportional to the square of the diameter of the conductor i.e.,

   $$R \propto \frac{1}{d^2}$$

   A thick wire having short length has low resistence and vise versa.

4. **Nature of material:** The resistance of a conductor depends upon the nature of the material of the conductor. **For example:** a Nicrome wire has 60 times more resistance then a pure copper metal of similar length and similar area of cross section manganin (Cu + Mn + Ni) has 25 times more resistance then pure copper metal and constant an (Cu + Ni) has 30 times more resistance then pure copper metal.

5. **Temperature of conductor:** The resistance of the conductor depends upon the temperature of conductor as following manner.
For example:
(i) The resistance of pure metal always increases with rise in temp and vice - versa if means resistance of a pure metal is directly proportional to the change in temperature.
(ii) The resistance of alloys like, german silver, manganin, constantan and nicrome slightly increase or decrease to the change in temperature or remains unaffected.
(iii) The resistance of semi conductors like silicon, germanium, etc. are decreases on increase increasing the temperature i.e. resistance of semi-conductor is inversily proportional to the change in temperature.

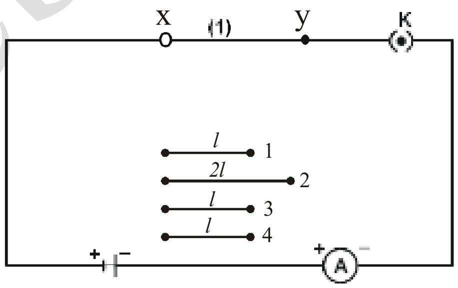
ACTIVITY 12.3

AIM: To show that the resistace of a conductor depends on the length of the conductor and area of cross section of the conductor and nature of the material.

MATERIAL REQUIARED:
A cell,an ammeter,nichrome wires of different length but same area of cross - section (thickness), nichrome wires of same length but different thickness,copper and iron wire of the same length and same thickness as that of any nichrome wire.

PROCEDURE:

Step 1: Connect the cell,an ammeter and plug key in series with nichrome wire of length 'l' (marked 1) in the gap XY as shown.



Step 2: Close the key and note the reading of ammeter. Let it is I_1 'I' wire (marked 'I').

Step 3: Replace the marked 1 wire with another nichrome wire having same area of cross - section but of double length '2l' (marked 2)

Step 4: Close the key and note the reading of ammeter. Let it is I_2.

Step 5: Again replace the marked 2 wire with marked 3 wire which has the same length but is thicker than marked 1 and 2 nichrome wires.

Step 6: Close the key and note the reading of ammeter. Let it is I_3.

Step 7: Remove marked 3 nichrome wire. Connect the copper wire marked 4 having same length and same area of cross-section as that of nichrome wire maked 1.

Step 8: Plug the key again and note that ammeter reading.

Step 9: Repeat the experiment with iron wire and measure the current (I_5).

OBSERVATION:

1. Current 'I_2' is half of I_1 i.e., $I_2 = \frac{1}{2} I_1$
2. Current I_3 increases when thicker wire of same length and same material i.e., nichrome is used.
3. Current I_4 and I_5 is different for copper and iron wire.

CONCLUSION:

1. Different wires drew different amount of current from the same cell.
2. First observation indicates that the resistance of the conductor increases with increase in length. So, resistance is directly proportional to length.
3. Second observation shows that thicker wires have lesser resistance. So, resistance is inversely proportional to area of cross section of the wire.
4. Third observation shows that resistance of the conductor depends on the nature of its metarial.

Topic: Resistivity (or Specific Resistance)

We know that the resistance of a conductor is directly proportional to its length i.e.,

$$R \propto \ell \qquad \text{(i)}$$

and The resistance of a conductor is inversely proportional to its area of cross section i.e.,

$$R \propto \frac{1}{A} \qquad \text{(ii)}$$

combing equation (i) and (ii), We get

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

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

where **ρ** (rho) is a constant, known as resistivity of the material resistivity is a scalar quantity, we know that:

$$R = \rho \times \frac{\ell}{A}$$

or $$\rho = \frac{R \times A}{\ell}$$

If $A = 1m^2; l = 1m$ then $\boldsymbol{\rho = R}$

Definition: The resistivity of a substance is numerically equal to the resistance of a conductor when its length is 1 m and area of cross section is $1m^2$. The resistivity of copper is 1.69×10^{-8} ohm metre, it means if we take a rod of copper metal 1 meter long and 1 square meter in area of cross section, then its resistance will be 1.69×10^{-8} ohm.

Note: A good conductor of electricity should have a low resistivity and poor conductor of electricity will have a high resistivity.

Dependence of resistivity of a conductor:

Resistivity of a conductor depends upon the following factors: (i) Natural of material (ii) Temperature

(i) **Natural of Material:** Resistivity of a conductor depends upon the nature of material, for **example** the resistivity of nicrome wire is 60 times more than more than the pure copper metal.

(ii) **Temperature:** Resistivity of a conductor depends on the temperature as following:

(a) The resistivity of pure metal is directly proportional to the change in temperature.

(b) The resistivity of alloys (like constantant, manganin and nicrome) is slightly directly proportional to the change in temperature or remains uneffected.

(c) The resistivity of semiconductor (like silicon, germanium etc is inversely proportional to the change in temperature.

Units of Resistivity:

We know that: $R = \rho \times \frac{\ell}{A}$

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

The unit of resistance is Ohm(Ω), the unit of area is m^2 and SI unit of length is metre, therefore the unit of resistivity is given by

$$\rho = \text{ohm} \times \frac{m^2}{m}$$

$$\rho = \text{ohm. m}$$

Note: The resistivity of a conductor does not depends upon the length and area of cross section of the material.

Alloy: An alloy metal is a homogenous mixture of two or more metal or a metal and non metal in a fixed proportion.

Properties of an alloy:

(i) Resistivity of an alloy is generally higher than that of its constituents. So it has a high resistance.

(ii) Alloys do not oxidise readily even at high temperature.

(iii) Resistivity of an alloy generally does not affected due to change in temperature.

Uses of Alloy:

(i) Due to high resistivity and does not oxidise readily, alloys are used in electrical devices such as room heater, water heater, electric iron, toaster and cooking utensils etc.

(ii) Due to negligible effect of temperature, alloys are used to make wire of standard resistance, resistance box, rheostat etc.

Resistivity of Some Material:

Type of substance	Name of Substances	Resistivity (ohm m)
Metals	Aluminium	2.63×10^{-8}
	Copper	1.62×10^{-8}
	Tungsten	5.2×10^{-8}
	Mercury	94×10^{-8}
	Silver	1.6×10^{-8}
Alloys	Constantant	49×10^{-6}
	Manganin	44×10^{-6}
	Nichrome	100×10^{-6}
Insulators	Diamond	10^{12} - 10^{13}
	Ebonite	10^{15} - 10^{17}
	Glass	10^{14}
	Paper (dry)	10^{12}

From the above table it is clear that resistivity of metals < resistivity of alloys < resistivity of insulators.

1. **Why connecting wires in an electric circuit are made of copper and aluminium metal**
   Ans: The connecting wires are metal of copper and aluminium metal. This is because they have very low resistivity so, electric current flows easily through them. Silver is the best conductor of electricity. But it is not used as connecting wire this is because it is costly as compared to other metals.
2. **Why Filament of an electric bulb is made of tungsten metal.**
   Ans. Filament of an electric bulb is made of tungsten metal due to following reason.
   (i) It has high melting point (3380^0C).
   (ii) If does not oxidised easily.
   (iii) It has high resistivity.
3. **Heating elements of electric appliances like electric iron, electric heater, electric toaster, room heater, immersion rod are made of nichrome wires.**
   Ans. Heating elements of electric appliances are made of nicrome wires due to following reasons:
   (i) It has high resistivity.
   (ii) It does not oxiding easy.
   (ii) It has high melting point.

Conductors, Resistors and Insulators

Conductors: Those substances which have very low electrical resistance are called Conductors. All the metals are conductor but Silver metal is the best conductor of electricity copper, and Aluminium metals also good conductor of electricity.

Resistors: Those substances which have comparatively electrical resistance are called resistors. The alloys like, nichrome, manganin and constantan (euraka) are examples of resistors.

Insulators: Those substance which have infinitely high electrical resistance are called Insulators. Ex. Dry wood, Rubber, Plastic, mica, glass, air are examples of Insulators. Vacuum is the best Insulators.

Super Conductor (H. Kammerling): The phenomenon of loss of electrical resistance by a substance on cooling to an extremely low temp. is known as super conductivity and the substance under these condition are called Super Conductor and such Temp. is called Critical temp. For example, as the temperature of mercury metal was lowered, its resistance is decreased gradually and at a very low temperature of 4.12 K (-269ºC), the electrical resistance of mercury metal disappeared completely.

Critical Temperature: The temperature at which a substance loses its total electrical resistance is called critical temperature. For example : the mercury metal loses its total electrical resistance at a temperature of 4.12 Kelvin (–269^O C).

Note: Since a superconductor does not offer any resistance, current passes through it without any loss of energy. Thus, no electrical energy is wasted as heat when current flows through a superconductor.

SOLVED NUMERICAL PROBLEMS

Ex 1: A simple electric circuit has a 24V battery and a resistor of 60 ohm. What will be the current in the circuit.

Sol.: V = 24 v, R = 60 ohm I =?

Now, V = R I

24 = 60 I ; I = 0.4 amperes.

Ans: = 0.4 amperes

Ex 2: A copper wire of length 2 m and area of cross section $1.7 \times 10^{-6} m^2$ has a resistance of 2×10^{-2} ohms. Calculate the resistivity of copper.

Sol.: $R = 2 \times 10^{-2}\Omega$, $A = 1.7 \times 10^{-6}$ m^2,

l = 2m, ρ =?

$$\rho = \frac{R \times A}{l} = \frac{2 \times 10^{-2} \times 1.7 \times 10^{-6}}{2}$$

$\rho = 1.7 \times 10^{-8}$ ohm m.

Ans: 1.7×10^{-8} ohm m

Ex 3: Potential difference between two points of a wire carrying 2 ampere current is 0.1 v. Calculate the resistance between these points.

Sol.: I = 2A, V = 0.1 V, R =?

Now, V = R I ; 0.1 = R × 2

R = 0.05 ohms.

Ans: 0.05 ohm

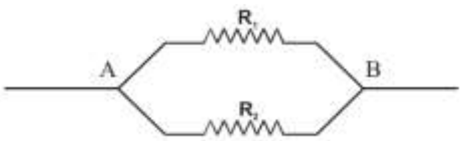
TOPIC: COMBINATION OF RESISTANCES (OR RESISTORS)

Apart from potential difference, current in a circuit depends on resistance of the circuit. So in the electrical circuit it is necessary to combine two or more resistance to get the required current. Resistance can
be combined in two ways.

(1) In Series (2) In parallel.

(i) **Series Combination:** When two or more resistance are connected end to end consecutively. They are said to connected in series. In the given fig. resistance R_1 and R_2 are connected in series.

(i) **Parallel Combination:** When two or more than two resistance are connected between the same two points they are said to be connected in parallel. In the given fig. two resistance R_1 and R_2 are connected in parallel.



(ii) **Law of combination of Resistance in series:** The combined Resistance of any number of resistances connected in series is equal to the sum of individual resistances, suppose resistances $R_1, R_2, R_3 \ldots\ldots R_n$. at are connected in series, then their resultant resistance. 'R' is given by the formula

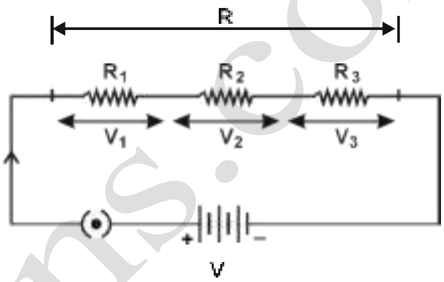
$$\mathbf{R = R_1 + R_2 + R_3 \ldots\ldots R_n}$$

Law of combination of resistance in parallel: The reciprocal of the combined resistances of a number of resistances connected in parallel is equal to the sum of the reciprocals of all the individual resistances. Let resistances R_1, R_2 $R_3 \ldots\ldots R_n$ are connected in parallel, then their resultant resistance 'R' is given by the formulae

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

Derivation for resistance in series: Let three resistances R_1, R_2 and R_3 are connected in series through supply voltage V. Let supply current be I. Suppose P.D. across aero according P.D. across resistance R_1 P.P. across resistance R_2 P.D. across resistance R_3 is given.

$$V_1 = I \times R_1 \Rightarrow V_1 = IR_1$$
$$V_2 = I \times R_2 \Rightarrow V_2 = IR_2$$
$$V_3 = I \times R_3 \Rightarrow V_3 = IR_3$$



Let combined resistance of the electrical circuit be 'R' then the supply potential (V) according ohms is given by

$$V = I \times R \Rightarrow V = IR$$

Since resistance are connected in series. Therefore supply potential (V) will be equal to the sum of potential differences across each resistance.

$$V = V_1 + V_2 + V_3$$
$$IR = I \times R_1 + I \times R_2 + I \times R_3$$
$$IR = I(R_1 + R_2 + R_3)$$

$$\boxed{\mathbf{R = R_1 + R_2 + R_3}}$$

Characteristics of Series Combination:

(i) The resultant resistance of the circuit is equal to the sum of the each individual resistance. i.e., $R = R_1 + R_2 + R_3 \ldots\ldots$

(ii) In series combination current passes through each resistor is same.

(iii) In series combination the potential different across each resistor is directly proportional to value of the resistance i.e., $V \propto R$.

(iv) In series combination supply potential is equal to the potential differences across the each resistor i.e., $V = V_1 + V_2 + V_3$

(iv) In series combination resultant resistance always greater than each resistance. The equivalent resistance of series combination is greater than any individual resistance.

Disadvantages of series combination:

(i) In series combination, if one electrical appliance stops working due to some defect, then other appliances also stop working.

(ii) In series combination, all the electrical appliances have only one switch due to which they cannot be turned on or off separately.

(iii) In series combination, all electrical the appliances do not get same potential (220V) as that of the supply potential line so all appliances do not work properly.

(iv) In series combination, of the overall resistance of the circuit increases too much due to which the supply current reduces.

Practical applications of series combination:

(i) In decorative light string (on festival).

(ii) Thermostate in heating device electric bulb connecting in series to control the temperature are connected in series.

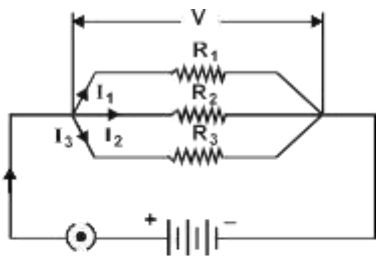
(iii) Light switches and wires are connected in series with line wire.

(iv) Batteries are connected in series to get higher voltage.

(v) Ammeter connected in series to measure the current.

(vi) Light emitting diodes (LED) are usually connected in series in the electronic devices.

Derivation for Resistance in Parallel: Let three resistances R_1,R_2 and R_3 are connected in parallel across supply potential 'V'. Let I_1,I_2 and I_3 current passes through resistances R_1,R_2 and R_3 then



According Ohm's law current passing through resistant R_1 is given by:

$$I_1 = \frac{V}{R_1}; \quad I_2 = \frac{V}{R_2}; \quad I_3 = \frac{V}{R_3}$$

If 'R' is the combined resistance of the electric circuit then supply current I given by

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

Since the resistances are connected in parallel. Therefore supply current will be equal to the sum of current passing through each resistance.

$$\therefore \quad I = I_1 + I_2 + I_3$$

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

$$\frac{V}{R} = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

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

Characteristics of Parallel Combination

1. In parallel combination potential difference across each resistance is same and is equal to supply potential.

2. In parallel combination current passing through each resistance is inversely proportional to the resistance i.e., $I \alpha \frac{1}{R}$

3. In parallel combination supply current is equal to the sum of the current passing through the individual resistance i.e., $I = I_1 + I_2 + I_3$.

4. In parallel combination of the reciprocal of the combined resistance is equal to the sum of reciprocals of each resistance i.e., $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

5. In parallel combination is Equivalent resistance is always less than the least resistance.

Advantages of parallel combination:

(i) In parallel combination, if one electrical appliance stops working due to some defect, then all other appliances keep working normally.

(ii) In parallel combination, each electrical appliance has its own switch due to which it can turned on or turned off independently, without affecting other electrical appliances.

(iii) In parallel combination, each electrical appliance gets the same voltage (220V) as that of the power supply line due to this each resistance work properly.

(iv) In the parallel combination appliances, the overall resistance of the electric circuit is reduced due to which battery supply more current.

Disadvantages of parallel circuit:

1. There could be risk of fire in some cases. If multiple power sources are connected in parallel to the same single power source.

Practical applications uses of parallel combination:

1. Parallel combination are used for independ operations of all the electrical devices in office, homes, factory, industries.
2. Volt meter connected in parallel to measure potential difference.
3. In parallel combination batteries gives more current.

- **Important Information:**
  (i) To decrease the total resistance in a circuit resistors are connected in parallel.
  (ii) To increase the total resistance in a circuit resistor are connected in series

— *Notes* —

SOLVED NUMERICAL PROBLEMS

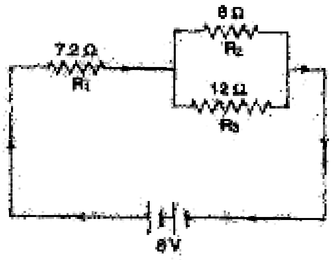
Ex 1: In the given circuit diagram, find:

a. Total resistance of the circuit.

b. Supply current of the circuit.

c. The p. d. across R_1

d. Current flowing through 8 ohm.



Sol.:

a. 8 ohms and 12 ohms resistance are in parallel. Let there combine resistance

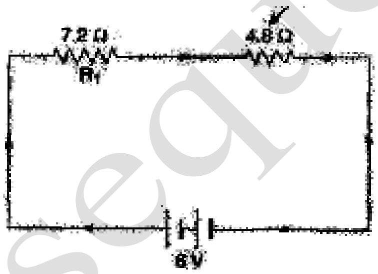
c. be x. Then their combined resistance x given by:

$$\frac{1}{x} = \frac{1}{R_2} + \frac{1}{R_3} \Rightarrow \frac{1}{x} = \frac{1}{8} + \frac{1}{10}$$

$$\Rightarrow \frac{1}{x} = \frac{3+2}{24} \Rightarrow \frac{1}{x} = \frac{5}{24}$$

$$\Rightarrow x = 4.8 \text{ ohms}$$

Above circuit can be reduced as



Now, 7.2 ohm and 4.8 ohm resistances are in series. Therefore the total resistance of the circuit given by

$$R = R_1 + x \Rightarrow R = 7.2 + 4.8 \Rightarrow R = 12 \text{ohms}$$

Ans: Total resistance of the circuit = 12 ohm

b. v = 6 V, R = 12 ohm, I =?

We know,

$$V = R\,I \Rightarrow 6 = 12 \times I \Rightarrow I = 0.5 \text{ A}$$

Ans: Supply current in the circuit = 0.5 A

The potential difference across resistance R_1 given by

$$V = I \times R_1 \Rightarrow V = 2 \times 7.2 \Rightarrow V = 3.60 \text{ V}$$

Ans: PD across resistance R_1 = 3.60 V

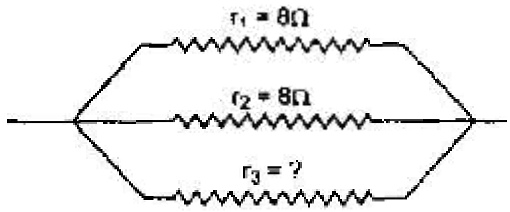
PD across resistance 8 ohm and 12 ohm will be same because they are in parallel and there PD given by: V = 6-3.6 ⇒ V = 2.4V

d. Current flowing through 8 ohm resistance given by

$$I_1 = \frac{V}{R_2} = \frac{2.4}{8} = 0.3\text{A}$$

Ans: Current flowing resistance 8 ohm=0.3 A

Ex 2: The combined resistance of the given diagram is 2Ω. Calculate the magnitude of resistance.



Sol.: Let combined resistance of the given circuit be r.

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}$$

$$\frac{1}{2} = \frac{1}{8} + \frac{1}{8} + \frac{1}{r_3}$$

$$\frac{1}{2} = \frac{2}{8} + \frac{1}{r_3}$$

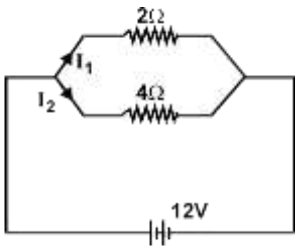
$$\frac{1}{2} - \frac{2}{8} = \frac{1}{r_3}$$

$$\frac{4-2}{8} = \frac{1}{r_3}$$

Ans : $r_3 = 4\Omega$

Ex 3: Two resistor of resistance 2 ohm and 4 ohm respectively are connected in parallel across the P.D of 12V find total resistance of the circuit

Sol.



$R_1 = 2\Omega,\ R_2 = 4\Omega$

Since resistances R_1 and R_2 connected in parallel. Therefore their combined resistance R is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow \frac{1}{R} = \frac{1}{2} + \frac{1}{4}$$

$$\frac{1}{R} = \frac{2+1}{4} = \frac{3}{4} \Rightarrow R = \frac{4}{3}\Omega$$

Ans: R = 4/3 Ω

Ex 4: A copper wire having resistance R is cut into four equal parts. (i) Find the resistance of each part in terms of original resistance of the wire v and (ii) Find the resistance of the combination if these four parts are connected in parallel.

Sol.: Original resistance = R

(i) Since R = length (l)

So the resistance of each part R/4

(ii) When four wires each of resistance R/4 are connected in parallel, then the resistance of the combination (R') is given by

$$\frac{1}{R'} = \frac{1}{\frac{R}{4}} + \frac{1}{\frac{R}{4}} + \frac{1}{\frac{R}{4}} + \frac{1}{\frac{R}{4}}$$

$$= \frac{4}{R} + \frac{4}{R} + \frac{4}{R} + \frac{4}{R} = \frac{16}{R} \Rightarrow R' = \frac{R}{16}$$

Ex 5: A wire of resistance 20 ohm is bent in the form of a closed circle. What is the effective resistance between two points at the ends of any diameter of the circle?

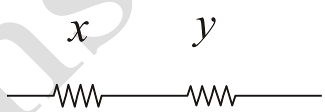
Sol.: The effective resistance between two points at the ends of the diameter (AB) of the circle is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{10} + \frac{1}{10} = \frac{2}{10} = \frac{1}{5}$$

R = 5 ohm **Ans: R = 5Ω**

Ex 5: Give the law of combination of resistances in series.

Sol.: Let two resistances be x and y.



Case (i) When resistance x and y are connected in series, the

$$R = x + y$$

$$9 = x + y \qquad \text{(i)}$$

Case (ii) When resistance x and y are connected in parallel them

$$\frac{1}{R} = \frac{1}{x} + \frac{1}{y}$$

$$\frac{1}{2} = \frac{1}{x} + \frac{1}{y}$$

$$\frac{1}{2} = \frac{y+x}{xy}$$

$$\frac{1}{2} = \frac{9}{x+y} \qquad \text{from (i)}$$

$$xy = 18$$

$$x - y = 3 \qquad \text{(ii)}$$

Now $(x-y)^2 = (x+y)^2 - 4xy$

$$(x-y)^2 = (9)^2 - 4 \times 18$$

$$= 81 - 72 = 9$$

So (i) and (ii), we get $x = y$

and $y = 3$

TOPIC: ELECTRIC POWER & ELECTRIC ENERGY

Electric Power: When electric current flows through a conductor electrical energy is used up and we say that the current is doing work. The rate of doing of electric work is called the electric power. OR electric power is the rate at which electrical energy consumed.

If **'w'** is the amount of electric work done in time **t** second**.** Then electric power is given by:

$$\text{Electric Power} = \frac{\text{Work Done}}{\text{Time Taken}} \Rightarrow \mathbf{P = \frac{W}{T}}$$

or

$$\text{Electric Power} = \frac{\text{Electric energy consumed}}{\text{time taken}} \Rightarrow P = \frac{E}{t}$$

Note: The S.I unit of electric power is **watt**. which is denoted by the letter **'w'**. Electric Power is a scalar quantity. Bigger unit of power is kilowatt, Megawatt and Gigawatt and Horse Power is a scaler quantity.

One Kilowatt (1 Kw) = 10^3 W
One Megawatt (1 Mw) = 10^6 W
One Gigawatt (1 Gw) = 10^{12} W
One Horse Power (1HP) = 746 W

1 Watt: The power of one watt is defined when electric current works 1J of work in one second.

$$P = \frac{W}{t} \Rightarrow \mathbf{1 Watt = \frac{1 Joule}{1 Second}}$$

Formulae For electric power:

(i) **Power in terms of voltage & current:** If **'w'** is the amount of electric work done by electric current in time 't' seconds, then electric power is given by

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

The work done by electric current against potential difference 'V' is given by:

$$W = V \times Q$$

Putting $W = V \times Q$ in above expression, we get,

$$\Rightarrow \quad P = \frac{V \times Q}{t}$$

$$\Rightarrow \quad P = V\,I \qquad \left(\because I = \frac{Q}{t}\right)$$

From the above expression it is clear

(i) Power is directly proportional to the potential difference i.e, $P \propto V$

(ii) Power is directly proportional to the current passing through the conductor

2. Power in terms of I and R:

We know, that $P = V\,I$

According Ohm's Law

$$V = IR$$

Putting the value of V in above equation

$$P = I \times R \times I \qquad (\because V = I\,R)$$

$$\mathbf{P = I^2 \times R}$$

From the above expression it is clear

(i) Power is directly proportional to the square of the current i.e, $P \propto I^2$

(ii) Power is directly proportional to the resistance of the conductor i.e. $P \propto R$

3. Power in terms of V and R:

We know, that $P = V\,I$

According to Ohm's Law

$$\left(I = \frac{V}{R}\right)$$

Putting value of 'I' in the above expression

$$P = V \times \frac{V}{R} \qquad \left(I = \frac{V}{R}\right)$$

$$\mathbf{P = \frac{V^2}{R}}$$

- **Hot Information:**

(i) Formula $P = VI$, applying when either V or I or both V and I are varying.

(ii) Formula $P = I^2R$ is applied when current I is constant in the electric circuit.

(iii) Formula $P = \frac{V^2}{R}$ is applied when potential difference is constant in the electric circuit.

Topic: Electrical Energy

Electric energy is the total amount of work done by electric current in a given time or electrical energy is the total amount of energy consumed in an electric circuit in the given time.

We know, that

$$\text{Electric Power} = \frac{\text{Work done by electric current}}{\text{time taken}}$$

Now, work done by electric current = Electric energy consumed

$$\text{Electric Power} = \frac{\text{Electric energy consumed}}{\text{time taken}}$$

$$P = \frac{E}{t} \quad \Rightarrow \quad \mathbf{E = Pt}$$

It is clear from above expression electric energy consumed by an electrical appliance is directly proportional to the power of electrical appliance i.e. $E \propto t$.

Electric energy consumed by an electrical appliance is directly proportional to the time for which the appliance is used i.e. $E \propto t$.

Note: Commercial unit of Electrical energy is Kilowatt-hour (kWH).

1 kWH: is the amount of electrical energy consumed by an electric appliance of rating one kilowatt and used for one unit.

One unit = 1 kWH

1 kWh is also known as Board of Trade Unit.(BOT)

One watt hour: One watt hour is the amount of electrical energy consumed by an electrical appliance of rating 1watt and used for 1 hour.

1 Joule: 1 Joule is the amount of electrical energy consumed by an electrical appliance of rating 1watt, is used for one second.

Relationship between commercial unit (kWH) and S.I. unit (Joule) of energy

$$1\text{ kWH} = 1000\text{ w} \times 1\text{ hour}$$
$$= 1000 \times 1\text{ w} \times 1\text{ hour}$$
$$= 1000 \times \frac{1\text{J}}{1\text{s}} \times 60 \times 60\text{ s}$$
$$(\because 1\text{watt} = 1\text{J}/1\text{s})$$
$$= 3600000\text{ J} = 3.6 \times 10^6\text{ J}$$

$$\therefore 1\text{kWH} = 3.6 \times 10^6\text{ J}$$

Topic: Effect of electric current

There are three effects produced by electric current:

(i) Heating effect of electric current.

(ii) Chemical effect of electric current.

(iii) Magnetic effect of electric current.

(i) **Heating effect of electric current:** When an electric current is passed through a high resistance wire, (like nichrome wire), the resistance wire becomes very hot and produces heat. This is called the heating effect of electric current. For example: When electric current passing through a room heater, water heater etc. if becomes red hot and produces large amount of heat.

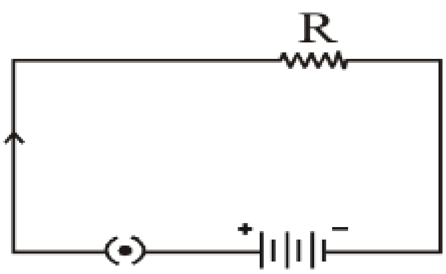
(ii) **Chemical effect of electric current:** When chemical change occur the presence of electric current is called chemical and heat of electric current. For example, when electric current passes through water (H2O), it decomposes to form hydrogen gas and oxygen gas.

$$H_2O \xrightarrow{\text{Electric Current}} H_2 + O_2$$

(iii) **Magnetic effect of electric current:** When an electric current flows through a wire, it produces a magnetic field around it. This effect of electric current is called magnetic effect of electric current. Electric motor, electric fan, electromagnets etc are examples of magnetic effect of electric current. For example: When electric current passing through a motor in electric meter it behaves like a magnet and starts rotating between a magnetic field.

Expression for heating effect of electric current (or Joules Law of Heating):

(i) **Heating effects in terms of I,R and T:** Consider a conductor AB of resistance **R** is connected across a supply potential 'V'. Let **I** be the current flowing through the conductor for time **t** then work done by current against P.D. is R given by:



$W = V \times Q \qquad (\because V = W/\theta)$

$W = V \times I \times t \qquad (\because Q = I \times t)$

$W = I \times R \times I \times t \qquad (\because V = IR)$

$W = I^2 \times R \times t$

Assuming that all the electrical work done by electric current is converted into heat energy, then above equation can be written as:

$$\boxed{H = I^2 \times R \times t} \qquad (i)$$

From the above expression it is clear

(i) Heat produced in a resistor is directly proportional to the square of current i.e, **$H \alpha I^2$**

(ii) Heat produced in a resistor is directly proportional to the resistance i.e, **H α R.**

(iii) Heat produced in a resistor is directly proportional to the time for which the current flows through the resistor i.e, **H α t.**

(ii) **Heating effects in terms of V, I and t:**

(i) According Ohms Law, we know, $V = RI$ Putting the value of $V = I \times R$ in Equation $H = I^2 \times R \times T$ we get

$H = I \times I \times R \times t$

$H = I \times V \times t$

$H = VIT$

From the above expression it is clear

(i) Heat produced in a resistor is directly proportional to the potential difference across the resistance i.e., **H αV.**

(ii) Heat produced in a resistor is directly proportional to the current passing through the resistance i.e., **H α I.**

(iii) Heat produced in a resistor is directly proportional to the time for which the current passing through the resistance i.e., **H α t.**

(iii) **Heat produced in terms of V, t and R:**

According Ohms law, $V = IR \Rightarrow I = V/R$,

Putting the value of $I = V/R$

Equation (i), we get

$H = I^2 \times R \times t$

$H = \left(\frac{V}{R}\right)^2 \times R \times T \qquad \because V = I \times R$

$H = \frac{V^2}{R^2} \times R \times T \qquad \therefore I = V/R$

$H = \frac{V^2 t}{R}$

From the above expression it is clear;

(i) Heat produced in a resistor is directly proportional to the square of potential difference i..e, H α V^2.

(ii) Heat produced in a resistor is directly proportional to the time for which the current is passing through the resistor i..e, H α t.

(iii) Heat produced in a resistor is inversely proportional to the resistance of the conductor i..e, H α 1/R.

Causes of Heating effect:

When energy source i.e., cell is connected across the ends of a conductor, a large number of free electrons gets accelerated towards the positive ends of the conductor, they suffer frequent collision with the ions or atoms and transfer their kinetic energy to them. Consequently the temperature of the conductor increases. Thus the chemical energy of the cell gets converted into heat energy in the resistive conductor.

Applications of Heating effect of electric current:

1. The heating effect of electric current is utilized in the electrical heating appliances such as electric iron, room heater, water heater, electric kettle, electric toaster, electric ovan etc. The heating elements of the electric appliance are made of nicrome alloy because of the following reasons.

(i) It has high (or resistivits)

(ii) It does not oxidise easily

(iii) it has high melting point.

Note: The temperature of the heating elements of an electrical heating device when it become red hot and glows is about 900° C.

2. The heating effect of electric current is utilized in electric bulb for producing light. When electric current passes through a very thin, high resistance tungstun filament of an electric bulb it becomes white hot and emits light.

Note: Tungstun metal is used for making the filaments of electric bulb because of the following reasons:

(i) It has very high melting point. (3380°C)

(ii) It has high resistance.

(iii) It does not oxidises easily.

Important Discussion: The electric bulb is filled with a chemically unreactive gas like argon and nitrogen instead of air because of hot tungstun filament would burn up quickly in the presence of air. Whenever inert gas does not react with hot filament.

3. The heating effect of electric current is utilised in electric fuse because of the following reasons:

(i) It has low melting point.

(ii) It has high resistance.

Note: A fuse is a safety device that does not allow high electric current to flow through an electric circuit. A fuse is a short length of thin tin-lead alloy or tin plated copper wire.

— *Notes* —

SOLVED NUMERICAL PROBLEMS

Ex 1: What will be current drawn by an electric bulb of 40W when it is connected to a source of 220 V.

Sol.: p = 40 w, v = 220 v,

Now, $P = VI \Rightarrow 40 = 220 \times I$

$I = 0.18$ A

Ans: Current drawn by bulb = 0.18 A

Ex 2: A radio set of 60 W runs for 50 hours. How much electric energy is consumed.

Sol.: p = 60 w = 0.06 K.W, t = 50 hours.

Now, $E = P \times t \Rightarrow E = 0.06 \times 50$

= 3 k.w.h.

Ans: Energy consumed by bulb = 3 kWh.

Ex 3: Two bulbs of 100 W each and two coolers of 250 W each, work on the average for six hours a day. If the energy costs Rs. 1.75 kWh, calculate the monthly bill.

Sol.: Power of 2 bulbs = $2 \times 100 = 200$ W

=.2 kw

En. consumed by two 100 W bulbs in a day

$E = .2 \times 6 =$ **1.2 kwh**

Power of 2 coolers = $2 \times 250 = 500$ W

=.5kWH

En. cons. by two 250W coolers in a day

$E = .5 \times 6 =$ **3 kWh**

Total Energy consumed by coolers and bulbs in one day = 1.2 + 3 = **4.2 kWh**

Total energy consumed by coolers and bulbs in a month = $30 \times 4.2 =$ **126 kWh.**

Monthly bill = $126 \times 1.75 =$ **220.50**

Ans: Monthly Bill = Rs. 220.50

Ex 4: Calculate the monthly bill for a heater of resistance 40 ohm which is used on 220 V mains, such that its daily use is for 5 hours. The cost of electric energy is Rs. 1.80 per kWh.

Sol.: V = 220 V R = 20Ω

Power consumed by heater (P) = $\frac{V^2}{R}$

$= \frac{220 \times 220}{40} = 1210W = 1.210kW$

Energy consumed by heater in a day

$= 1.210 \times 5 = 6.050$ kWh.

Energy consumed by heater in 30 days

$= 30 \times 6.050 = 181.5$ kWh.

Ans: Monthly Bill = 181.5×30 = Rs. 326.70

Ex 5: Calculate the energy transferred by a 5A current flowing through a resistor of 2 ohms for 30 minutes.

Sol.: I = 5A, R = 2 ohms, t = 0.5 h

Now, $P = I^2 \times R$

$P = (5)^2 \times 2$

$= 25 \times 2$

= 50 Watt. = **0.05 kWh**

Now, $E = P \times t$

0.05×0.5

E = 0.025 kWh

Ans: Energy transvers = 0.025 kWh.

Ex 6: A bulb is rated at 200 V-100W. What is its resistance. Five such bulbs burn for 4 hr. What is the electrical energy consumed. Calculate the cost if the rate is 50 paise per unit.

Sol.: V = 200 V, P = 100 W =.1kW

t = 4 hr

Now, $P = \frac{V^2}{R} \Rightarrow 100 = \frac{200^2}{R}$

$100\,R = 40000 \Rightarrow R = 400\ \Omega$

Electrical energy consumed by 5 bulbs given by: $E = 5 \times P \times t = 5 \times .1 \times 4 = 2.0$ kWh.

Cost of Electricity = $\frac{2 \times 50}{100}$ = Rs.1

Ans: Cost of electricity = Rs. 1

Ex 7: For a heater rated 4kW and 220 V, calculate the current of the heater.

Sol.: P = 4kW = 4000 W, V = 220 V

Now, $P = VI$

$4000 = 220 \times I \Rightarrow I = 18.18$ A

Ans: current = 18.18 A

Ex 8: A potential difference of 220 V is applied across a resistance of 440 ohm in an electric iron. Calculate heat produced in 30 sec.

Sol.: V = 220 V, R = 440 ohm, t = 30 s

$$H = \frac{V^2}{R} \times t \Rightarrow \frac{(220)^2}{440} \times 30$$

= 3300 J

Ans: Heat produced = 3300 J

Ex 9: A resistance of 2Ω is connected to a 12 V battery. Calculate the heat energy in joules generated per minute.

Sol.: R = 12 Ω, V = 12 V,

$t = 1 \times 60 = 60$s ; H =?

Now, $V = R \times I$

$12 = 12 \times I$

$I = 1$ A

Now, $H = I^2 \times R \times T$

$= 1^2 \times 12 \times 60 = 720$ J

Ans: Heat produced = 720 J

Ex 10: An electric room heater has a resistance of 25 Ω and operates at 220 V for 12 minutes. Calculate the heat energy dissipated by the heater in kilojoules.

Sol.: R = 25 Ω, V = 220 V,

$t = 12 \times 60 = 720$ s H =?

$V = R \times I$

$\Rightarrow 220 = I \times 25$

$I = 8.8$ A

Now, $H = I^2 \times R \times T$

$= (8.8)^2 \times 25 \times 720$

= 1393920 J

= 1393.920 kj

Ans: Heat energy produce = 1393.920 kj

Ex 11: A torch bulb of 3V, draws a current of 0.4 A. If the bulb is switched on for 5 minutes, calculate the energy drawn by the bulb.

Sol.: V = 3V, I = 0.4 A

$t = 5 \times 60$ T = 300 s H =?

$H = V \times I \times t$

$H = 3 \times 0.4 \times 300 = 360$ J **Ans**

Ex12: Two resistance wires of the same material and of equal lengths and equal diameters are first connected in series and then in parallel in an electric circuit. The ratio of heat produced in series and parallel combination would be:

(a) 1: 2 **(b) 2: 1**

(c) 1: 4 **(d) 4: 1**

Sol. Since both wires have same length, same material, same diameters therefore they have same resistance i.e., be x..

Ex13: Calculate the amount of heat produced in an electric heater of resistance 1000 ohms if 6A current is passed through it for 10 minutes.

Sol. R = 1000 W I = 6A H =?

$t = 10$ min $= 10 \times 60 = 600$ s

Using $H = I^2 Rt$, we get

$H = (6)^2 \times 1000 \times 600$ J

$= 21600000$ J $= 2.16 \times 10^7$ J

Ans: $H = 2.16 \times 10^7$ J