CURRENT ELECTRICITY

It is a branch of physics, which deals with the flow of electrons in a conductor.

Electric Current:
It is defined as the time rate of flow of electrons (charges).
If Q is the quantum of charges passing through a conductor, then $\boxed{Q = ne}$, where 'n' is the number of electrons and 'e' is the charge on each electron and e =- 1.6 x 10^{-19}C
The strength of electric current is denoted by 'I'.

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

The S1 unit of electric current is ampere (A)

"One ampere is the current flowing through a conductor if 1c charge (electrons) passes through it in 1 second".

Potential at a point :
It is the amount of work done in bringing a unit positive charge from infinity to that point.
Potential difference: (PD)
Potential difference between two points or terminals is the amount of work done in bringing a unit positive charge from one terminal to another.
The PD between 2 points is denoted by 'V'.
The S1 unit of potential difference is volt (V).
"If 1 joule of work is done in bringing 1 coulomb positive charge from one terminal to the other, then the potential difference between the 2 terminals is one volt."

If W is the work done in bringing a quantum of charges q_o from one terminal to another, then the potential difference is $\boxed{V = \frac{W}{q_o}}$

NOTE : The positively charged body or positive terminal is at a higher potential compared to the negative terminal or the negatively charged body. We know that anything that flows would flow from higher concentration to lower concentration. The negative terminal has more number of electrons compared to the positive terminal. So the electrons flow from the negative terminal to the positive terminal when conducted by a conductor. But the convention is that any energy that flows would flow from higher potential to lower potential. Therefore, to keep with the convention, electric current flows from the positive terminal to the negative terminal as against the flow of electrons.

In the figure, current flows from A to B (A → B) as against the flow of electrons.

RESISTANCE:

"The obstruction offered to the flow of current [electrons] by the conductor or wire is called its resistance."

A metallic conductors has free electrons and an equal number of positive ions. The positive ions do not move while the electrons move almost freely inside the metal and are called the free electrons and in the process collide among themselves and with the positive ions. A conductor offers resistance to the flow of electrons but the potential difference applied across the ends of the conductor would make the electrons pass through the conductor. This is because, when the positive terminal is at a higher potential, it pulls more number of electrons towards it at a faster rate. Therefore the electrons do not move in bulk with a continuously increasing speed, but there is a drift of electrons towards the positive terminal. Hence the rate of flow of electrons, i.e current increases with increase in potential difference and decreases with decreases in potential difference. In other words, current passing through the conductor is directly proportional to the potential difference. This is Ohm's law…

OHM's LAW

It states that: 'The Current flowing through a cross section of the conductor is directly proportional to the Potential difference between its ends at a constant temperature.'

$$\boxed{V \alpha I}$$

$$\boxed{V = IR}$$

where

R = constant of proportionality and is the resistance offered by the conductor.

V = Potential difference.

I = electric current

The S1 unit of electrical resistance is ohm.

"One ohm is the resistance offered by a conductor when 1 ampere current passes through it when the conductor is connected across 1 volt potential difference."

Ohm is denoted by the symbol – Ω(omega)

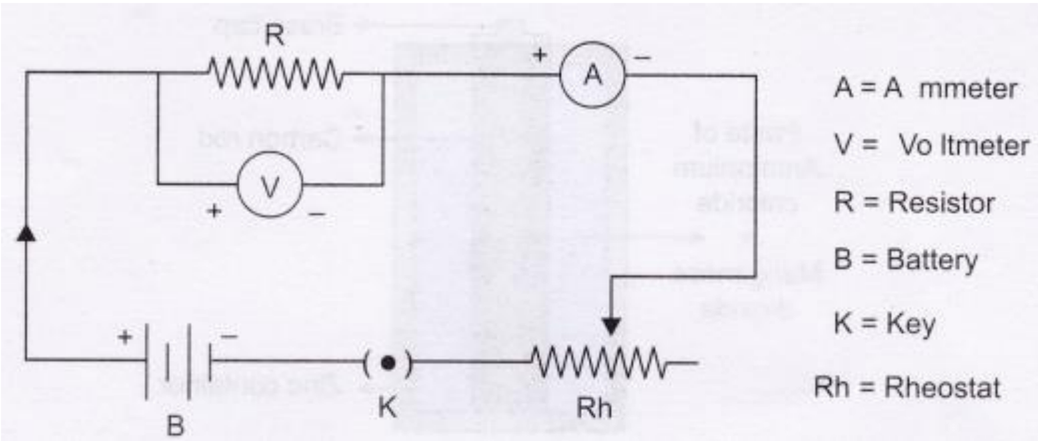
CIRCUIT

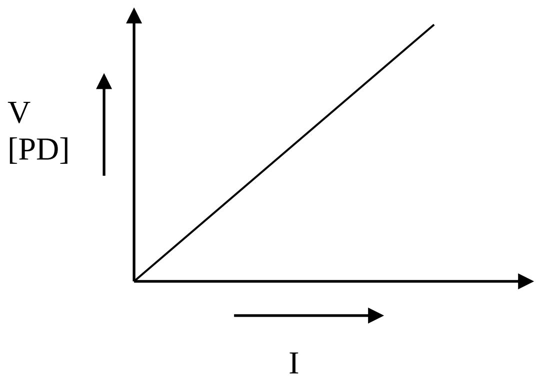
Circuit is the path along which the current flows in a conductor and all other gadgets connected.

OPEN AND CLOSED CIRCUITS

* When the current is passing through the circuit, it is said to be in closed circuit. i.e., there is a continuous conducting path between the two terminals of a battery.

* If there is a break in the circuit, i.e when one of the conductors or connections is cut off, due to overheating or any other reason or even when the switch connecting the different gadgets from the source is off, then no current passes through the circuit, then such a circuit is called as an Open circuit. There is no continuous connection between the two terminals.





Ohmic conductors:

Electrical conductors which obey Ohm's law are called as Ohmic conductors.

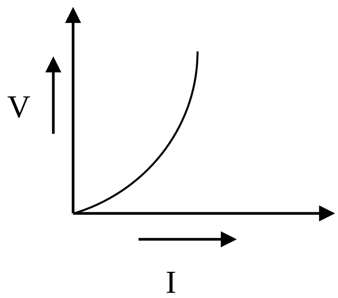
For Ohmic conductors, the V-I graph is a straight line inclined to X-axis. The slope of the graph gives the resistance offered by the conductors.

Ex. Metals – Fe, Cu, nichrome, Silver, Copper sulphate solution with copper electrodes, dil. H_2SO_4, etc., at a constant temperature.

*** Non Ohmic conductors :**

Conductors which do not obey Ohm's Law are called non ohmic conductors. The V-I graph for such conductors will not be a straight line, but a curve instead.

Ex. Diode valve, triode valve, thermistors, transistor, filament of a bulb, etc.,



FACTORS AFFECTING RESISTANCE OF A CONDUCTING WIRE :

a). **Length of the conductor**

Resistance is directly proportional to the length of the conducting wire. R α l

b). **Area of cross section or thickness**

Resistance is inversely proportional to the area of cross section or thickness. R α $\frac{l}{A}$

c). Resistance offered by a conductor also depends upon the **material of the conductor**. All metals are good conductors of electricity. The conductivity depends upon the material of the conductor.

Ex. Metals are good conductors of electricity. Silver [Ag] is a very good Conductor of electricity. For house hold circuits, generally Copper is used.

d).**Temperature:**

Resistance offered by a conductor is directly proportional to the temperature. Hence, the resistance of a conductor increases with an increase in its temperature.

CONDUCTANCE:

Conductance is the reciprocal of resistance. Its S1 unit is per ohm i.e ohm^{-1}[. Ω^{-1}] or Siemen. Conductivity is that property or the characteristic of the conductor which tells us about whether the given conductor is a good one or not i.e it gives the knowledge about the resistance offered by the conductor.

RESISTIVITY / SPECIFIC RESISTANCE OF A CONDUCTOR

Experimentally, it has been observed that the resistance of a conductor is directly proportional to the length of the conductor and inversely proportional to the area of cross section.

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

$$R = \rho \frac{l}{A} \qquad (\rho - \text{rho})$$

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

Where ρ is called as the resistivity as specific resistance of the given conductor.

If A = 1 and l = 1,

$$\rho = \frac{R \times \mathbf{1}}{\mathbf{1}}$$

then $\rho = R$

"Thus, specific resistance or resistivity is defined as the resistance offered by a conductor of unit length and unit area of cross section."

The unit of resistivity is ohm metre (Ωm)

CONDUCTIVITY / SPECIFIC CONDUCTANCE

It is the reciprocal of the specific resistance or resistivity.

It is denoted by σ (sigma).

$$\sigma = \frac{1}{\rho}$$

Its S1 unit is per ohm per metre (siemen/m)

FACTORS AFFECTING RESISTIVITY

* Resistivity depends upon the material of the conductor i.e it is less for a good conductor and more for a insulator.
* Resistivity depends upon temperature.
  Resistivity of a metal increases with increase in temperature and decreases with decrease in temperature. On the other hand, for a semi conductor, resistivity increases with decrease in temperature.

SUPER CONDUCTORS:

The conductors which offer zero resistance are called super conductors.

The conductivity with zero resistance is called super conductivity.

NOTE: Super conductivity is not possible at room Temperature. However, if this could be achieved at room temperature, then the size of computers would be reduced to pocket size and also the power transmission wires from one from far off places would become very thin.

Change in resistance when the length and area of cross section [thickness] of a conducting wire are changed simultaneously:

* If the length of a wire is doubled by stretching, the area of cross section would be reduced to half the original value.
  We know that $R \, \alpha \, \frac{l}{A}$
  Hence the new resistance would become 4 times the original resistance.

* If the length of a wire is tripled by stretching, the area of cross section would be reduced to $1/3^{rd}$ the original value.
  Hence the new resistance would become 9 times the initial resistance.

* If a wire is doubled on itself by folding, the area of cross section is doubled while the length is reduced to half.
  Hence the new resistance would be reduced to $¼^{th}$ the initial value.

* If a wire is tripled on itself by folding, the length of the wire would be reduced to $1/3^{rd}$ of its original length and the area of cross section would become 3 times the original thickness.
  Hence the new resistance would be reduced to $1/9^{th}$ the original value.

EMF (Electromotive Force) and Terminal Voltage (TV)

EMF is the potential difference across the ends of a battery or a cell or a source when it is connected in open circuit.

Terminal voltage is the potential difference measured between the terminals of a cell or a battery or a source when it is connected in closed circuit.

EMF > TV or EMF = TV

- The terminal voltage is always less than the EMF. This is because of the internal resistance; offered by the electrolyte in the cell or battery. Some energy is lost in overcoming the internal resistance offered by the electrolyte of the cell or battery because the electrolyte opposes or offers some resistance to the flow of electrons. Hence there is a drop in the expected potential difference and this drop in voltage is called as the voltage drop, denoted by ‘v_0’.

$$\boxed{\varepsilon = V + v_0}$$

Where ε is the EMF, V= terminal voltage and $v_0 =$ Voltage drop.

> “Voltage drop is defined as the amount of work done in moving a unit positive charge between the electrodes of a cell or a battery against the internal resistance offered by the electrolyte……..”

- If EMF= TV, then the internal resistance of the cell or the battery is negligible i.e. almost 0…………

INTERNAL RESISTANCE:

Internal resistance is the opposition to the flow of charges by the electrolyte of the cell or the battery. It is denoted by ‘r’

According to ohm’s Law, $\boxed{v_0 = Ir}$ is the voltage drop when a current of ‘I’ units is passing through the circuit and if ‘r’ is the internal resistance.

If ‘R’ is the resistance offered by a resistor connected in the circuit drawing a current of ‘I’ units, then the terminal voltage is $\boxed{V = IR}$

We know that EMF, $\boxed{\varepsilon = V + v_0}$

$$\boxed{\varepsilon = IR + Ir}$$

$$\boxed{\varepsilon = I(R + r)}$$

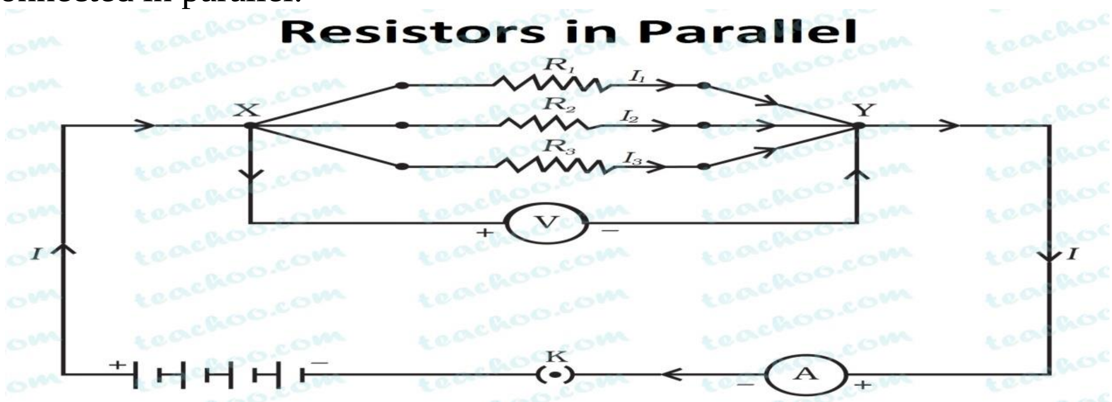
$$\boxed{I = \frac{\varepsilon}{R + r}}$$

Emf	Terminal Potential difference [Terminal voltage]
Emf will be equal to the potential difference across the terminals of the cell when the circuit is open.	To get potential difference across any two points in a conductor, current must pass through it. i.e, the circuit should be a closed circuit
Emf refers to the source of current or electrical generator	Potential difference refers to a part of the circuit
Emf is the cause	Potential difference is the effect
Emf is independent of external resistance in the circuit, internal resistance of the cell and current in the circuit	Potential difference depends upon external resistance in the circuit, internal resistance of the cell and current in the circuit

RESISTANCE IN SERIES AND PARALLEL

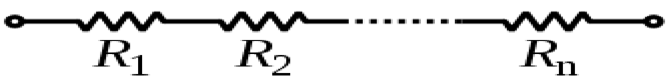
* If 2 or more resistors are connected end to end such that the second end of the first resistor is connected to the first, end of the second resistor, the second end of the second resistor to the first end of the third and so on, then the circuit is said to be in series. In this case, the first end of the first resistor and the second end of the last resistor are connected to the source of electric current.

* If the first ends of all the resistors are connected to 1 terminal, say ‘X’ and the second ends connected to another terminal, say ‘Y’ and if the ‘X’ and ‘Y’ terminals are connected to a source of current, then the resistors are said to be connected in parallel.



***To find the effective resistance when 2 or more resistors are connected in series;**

Consider resisters R_1, R_2 and R_3 in series to the terminals A and B which are in turn connected to a battery of emf ‘V’ and negligible internal resistance. We know that when the resistors are connected in series, same current flows and the potential difference across each resistor varies. Let ‘I’ be the current flowing across each resistor and V_1, V_2 and V_3 be the potential difference across the resistors R_1, R_2 and R_3 respectively.



The total potential difference = V = $V_1 + V_2 + V_3 + \ldots\ldots\ldots\ldots$
(no loss of energy)

$$I R_s = IR_1 + IR_2 + I R_3 + \ldots\ldots\ldots$$
$$R_s = I (R_1 + R_2 + R_3 + \ldots\ldots\ldots)$$

$$\rightarrow \quad \boxed{R_s = R_1 + R_2 + R_3 + \ldots\ldots\ldots\ldots}$$

If $R_1 + R_2 + R_3$ … are 'n' number of resistors connected in series, then equivalent or effective resistance $R_s = R_1 + R_2 + R_3 \ldots\ldots R_n$

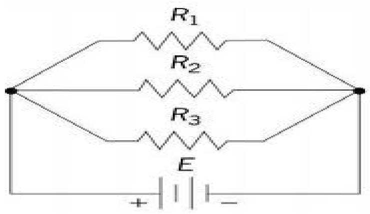
***To find the effective resistance when 2 or more resistors are connected in parallel:**

Consider resistors R_1, R_2 and R_3 connected in parallel to each other to 2 terminals A and B which are in turn connected to a battery of e.m.f.
and negligible internal resistance.

We know that when resistors are connected in parallel, potential difference would remain the same and the current passing across each resistor would differ.

Hence the total current in the circuit is split into I_1, I_2 and I_3

$$I = I_1, + I_2 + I_3$$



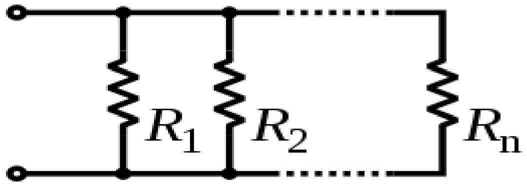
$$\frac{V}{Rp} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} + \ldots\ldots\ldots\ldots\ldots$$

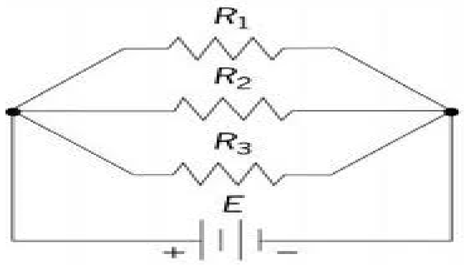
$$\frac{1}{Rp} = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots\ldots\ldots\ldots\right].$$

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

Reciprocal of effective resistance R_p is the sum of the reciprocals of the individual resistances.

RESISTORS IN SERIES AND PARALLEL:





*When 2 or more resistors are connected in series, the effective resistance is given by:

$$R_s = R_1 + R_2 + R_3 \ldots\ldots\ldots + R_n$$

If 'n' number of resistors having equal resistance of 'R' ohms, are connected in series, then $R_s = nR$

The current flowing through the circuit:

We know that, $I = \frac{V}{R}$

$$\boxed{I = \frac{\in}{R_s + r}}$$

Where 'ε' is the EMF of the cell or battery, R_s is the effective resistance and 'r' is the internal resistance of the cell or battery.
When 'n' number of equal resistors each of resistance value 'R' are connected in series, we know that : $R_s = n\,R$.

$$\boxed{I = \frac{\varepsilon}{nR + r}}$$

The resistance value increases, hence a very less current flows through the circuit.

* When 2 or more resistors are connected in parallel the effective resistance is denoted by R_p. The reciprocal of the effective resistance = the sum of the reciprocals of the individual resistances

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

If 2 resistors R_1 and R_2 are connected in parallel

$$\frac{I}{R_p} = \frac{I}{R_1} + \frac{I}{R_2}$$

$$\frac{1}{R_p} = \frac{R_2 + R_1}{R_1 R_2}$$

$$\boxed{R_p = \frac{R_1 R_2}{R_1 + R_2}}$$

$$\boxed{I = \frac{\varepsilon}{R_p + r}}$$

If 'n' number of equal resistors are connected in parallel, then:

$$\boxed{\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \ldots\ldots\ldots\ldots\ldots}$$

$$\frac{1}{R_P} = \frac{n}{R}$$

$$nR_p = R$$

$$\boxed{R_P = \frac{R}{n}}$$

Where n = number of resistors.

This means that, more the number of resistors connected in parallel, less would be the effective resistance. Hence the current flowing would increase as $I \alpha \frac{1}{R}$

Hence it is advantageous to connect more resistors in parallel than in series.

Resistance offered by the electrolyte of the cell is called internal resistance of the cell.

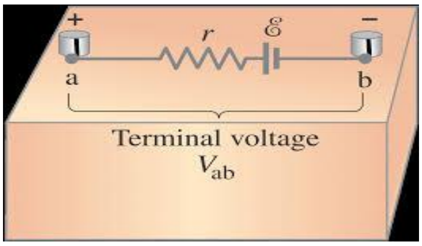
<u>FACTORS AFFECTING THE INTERNAL RESISTANCE OF A CELL:</u>

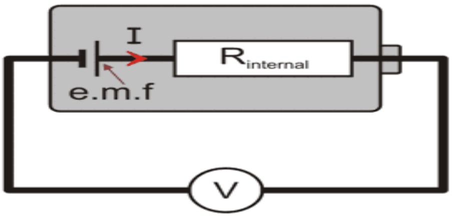
a). The nature and concentration of the electrolyte. More is the concentration of electrolyte, higher is the internal resistance of the cell.

b). The distance between the electrodes. More is the distance between the electrodes, higher is the internal resistance of the cell.

c). The area of electrode plates submerged in electrolyte. More the surface area of

the plate submerged in electrolyte, less is the internal resistance of the cell.
d). The temperature of the electrolyte. More is the temperature of electrolyte, less is the internal resistance of the cell. [inversely proportional]





<u>FACTORS AFFECTING THE EMF OF A CELL:</u>

The emf of a cell depends on :

1. The material of the electrodes
2. The electrolyte used in the cell.

<u>FACTORS NOT AFFECTING THE EMF OF A CEL:</u>

<u>The emf of a cell is independent of:</u>

1. The shape of the electrodes
2. The distance between the electrodes and
3. The amount of electrolyte.

<u>Choice of the material of a wire:</u>

1. Wires used for electrical connections and power transmissions are made up of copper or aluminium as they have very low resistivity. Silver cannot be used because of its high cost.
2. The resistance wires [or standard] resistors are made up of alloys such as manganin, constantan, etc. for which the resistivity is quite low and the effect of change in temperature on their resistance is negligible.
3. A fuse wire is made up of an alloy of lead and tin because its melting point is low and its resistivity is more.
4. The filament of electric bulb is made of tungsten because it has a very high melting point and high resistivity.
5. Heating elements in appliances such as heater, toaster, oven, etc. are made up of nichrome because the resistivity of nichrome is high and the increase in its value with increase in temperature is high.

<u>ELECTRICAL ENERGY, ELECTRIC POWER AND HOUSEHOLD CIRCUITS</u>

<u>ELECTRICAL ENERGY</u>:
Work is a form of energy. Electrical energy supplied can be defined in terms of electrical work.

Electrical energy is the electric work done when a potential difference is applied between the terminals of a circuit. Electrical energy is measured in terms of joule, watt-hour, kilowatt-hour.

When 1 joule of work is done causing 1 coulomb electric charges to flow from one terminal to the other terminal, then the potential difference is 1 volt.

If q is the quantum of charges that is passing through the cross section of a conductor when a potential difference V is applied, then the current W = q x v

$$W = V \times q$$

$$q = It \qquad \left[\because I = \frac{q}{t}\right]$$

$$W = It \times V$$

$$\boxed{W = VIt}$$

$$W = IR \times It \qquad \left(V = IR\right)$$

$$\boxed{W = I^2Rt}$$

$$W = VIt$$

$$W = V \times \frac{V}{R}\, t \qquad \left\{I = \frac{V}{R}\right\}$$

$$\boxed{W = \frac{V^2 t}{\mathbf{R}}}$$

* The S1 unit of energy is joule.

<u>Electrical Power:</u>

Electric power is the time rate of doing electrical work i.e. the amount of electrical energy supplied or given in unit time.

$$\boxed{Electrical\,Power = \frac{Work[Electrical\,energy]}{Time\ taken}}$$

If W is the electrical energy supplied in time t, then electrical power

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

'watt' is the unit of power denoted by 'W'

"1 watt is the electrical power consumed if the potential difference of 1 volt causes a current of 1 ampere to flow through the circuit."

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

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

$$\boxed{P = vI}$$

$$P = IR.\ I \qquad [\because V = IR]$$

$$\boxed{P = I^2R}$$

But we know that, $P = VI$

$$P = V \times \frac{V}{R} \quad \left[\because I = \frac{V}{R}\right]$$

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

OTHER UNITS OF ELECTRICAL ENERGY:

* The S1 unit of energy is joule.
  The commercial units of electrical energy are:
* Kilo Watt hour
* Watt hour

"1 watt hour is the electrical energy consumed by an electrical appliance of power 1 watt when it is used for 1 hour."

1 Watt hour = 1 watt x 1 hour
= 1 watt x 60 x 60s
= 3600 Ws (1J x 1W x 1s)

$\therefore$ $\boxed{\text{1 Watt hour = 3600 J}}$

"1 Kilo watt hour is the electrical energy consumed by on electrical appliance of Power 1 kilo watt when it is used for 1 hours."

1 kilo watt hour = 1000 Wh
= 1000 x 3600 J
= 3.6 x 10^6 J

$\boxed{1 \text{ kilo watt hour} = 3.6 \times 10^6 \text{ J}}$

NOTE: In electric bills, 1 unit electrical energy means 1 kilo watt hours.

HEATING EFFECT OF ELECTRIC CURRENT:

When current is passed through a conducting wire, heat is produced i.e electric energy is converted to heat energy. The amount of heat energy produced in the wire depends upon 3 factors :

1. Current passing through the wire :
   The heat energy is directly proportional to the square of the current passing through the wire
   i.e. $H \alpha I^2$

2. Resistance offered by the wire:
   The heat energy is directly proportional to the resistance.
   i.e. $H \alpha R$

3. Time for which the current is passed :
   The heat energy is directly proportional to the time.
   i.e. $H \alpha t$

Combining the results, we get :

$H \alpha I^2 Rt$

OR $H = I^2 Rt$

This is known as Joule's Law of Heating.

POWER RATING OF AN ELECTRICAL APPLIANCE:

On an electrical appliance, the power rating would be mentioned in terms of electrical power and potential difference by the manufacturer. This power rating would tell the consumer the potential difference across which the electrical appliance has to be connected in order to get the desired output.

Ex.1 An electric bulb is rated 100 W – 250 V
This means that the bulb is lighted on a 250 volt supply and consumes 100W electric power.

Ex.2 An electric mixer rated as 750W – 220v means – the mixer would consume 750 watts of power when connected across 220 volt supply.

From the Power rating of an appliance, we can calculate the following two quantities:

1. The resistance of the element when the appliance is in use

$$\boxed{R = \frac{(Voltage.rating.of.the.appliance)^2}{Power.rating.on.the.appliance}}$$

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

2. The safe limit of current which can flow through the appliance when it is in use.

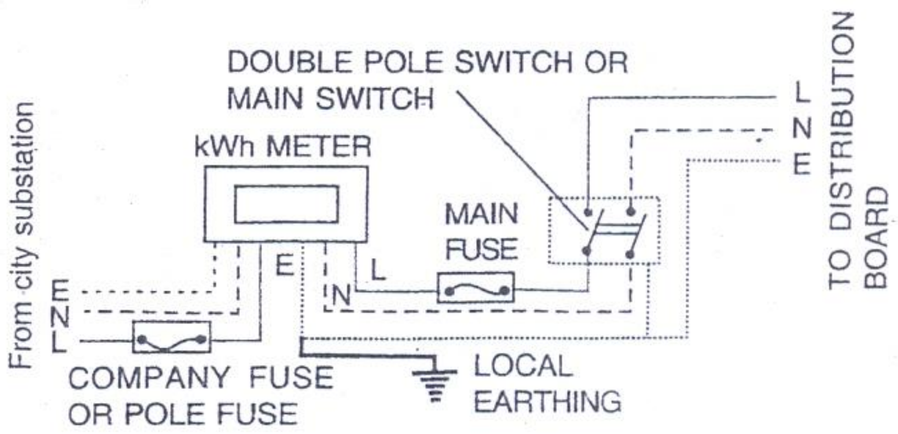
$$\boxed{Safe.Current, I = \frac{Power.rating.on.the.applianc}{Volage.rating.on.the.appliance} = \frac{P}{V}}$$

Household Circuits

Electric energy from the grid station is transmitted to the consuming station at a very high potential. At the consuming station, it is stepped down to 230 V in 3 stages and supplied to different households.
The company supplies electric power through overhead or underground cables to the meter box from the pole.
The neutral and earth wires are at the same potential as that of the earth i.e., they are at zero potential. The live or the phase wire is then at a potential of 220V with respect to either the neutral or the earth wire.
A company fuse is provided at the pole which is generally of 60A rating.

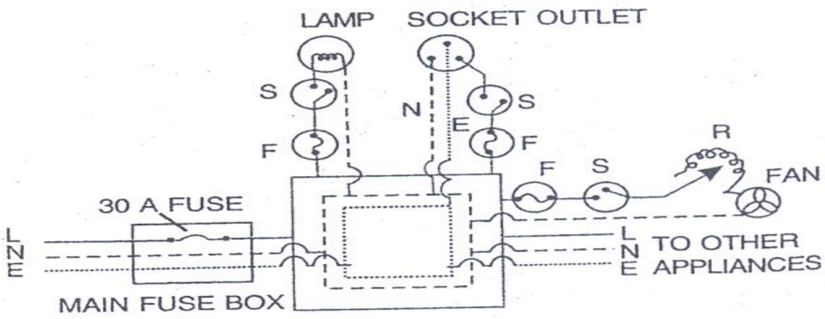
Electric meter [Kwh meter]:

As the supply line enters the house it is first connected to the input terminals of an electrical meter which reads the energy consumed in kilowatt hour.



Main switch [Double Pole switch]:

A double pole switch is used when it is desirable to cut off both the live and neutral lines of the electric supply at the same time. This ensures absolute safety, especially when one cannot distinguish between live and the neutral wire. Live wire is at a potential of 230V while neutral wire is at ground potential. In 'off' position, both the wires are disconnected while in 'on' position, there is a continuity in both the wires.
A local main fuse of 30A rating is inserted in the live wire as a safety precaution after the main switch.
The metal box of the main switch is connected to the earth. As a safety precaution, earthing is done at the electric meter.



Some essential components of household wiring:

1. Switches: A switch is a device for making or breaking of an electrical circuit. Switches are of various types:

The Single pole switch:

It has two terminals and a metal piece with a spring and an insulated handle attached to it to make or break the circuit. The switches which make or break one line only are called single pole switches. A switch is always connected to the live wire.

The double pole switch:

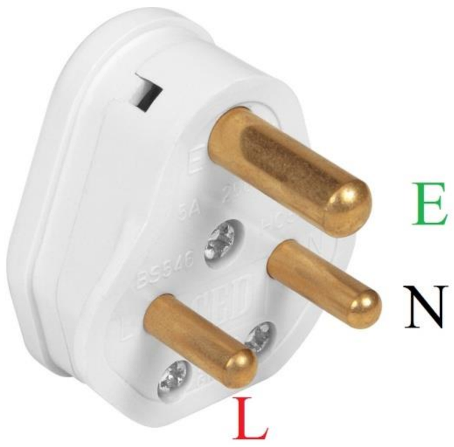
A double pole switch is used when it is desirable to cut off both the live and neutral lines of the electric supply simultaneously. This ensures absolute safety, especially when one cannot distinguish between the live and the neutral wires. This switch is usually used as a main switch.

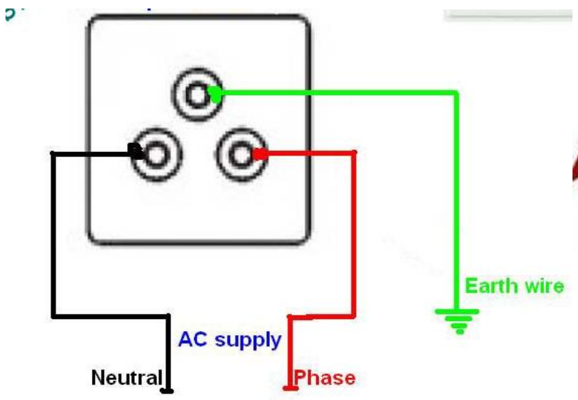
2. Plug:

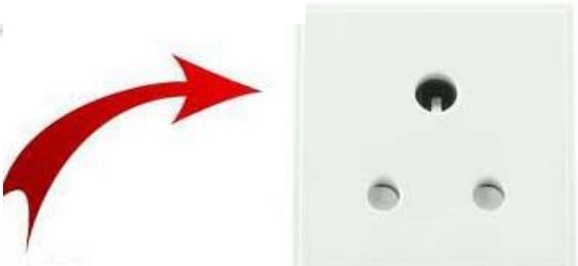
It is a device used to connect an electric appliance to the main supply through the socket. The plug has two or three metallic brass pins. **In a three pin plug, The pin at the top is thick and longer than the other two pins. This pin is the earth pin. It connects the appliance to the earth. It is made longer so that its connection is made first to ensure that the body of the appliance being used has a very good contact with the earth. It is made thicker so as to help us to identify the pin and avoid the chance of confusing it with the other two pins.**

The other two pins have equal thickness and length. Usually the pin to the right is for live and the other is for neutral wire.

On the other hand, a two pin plug has only two brass pins one for live and other for neutral.







3. Socket:

A socket is a device fixture in an electrical circuit which is used to connect the circuit to any appliance by inserting the plug connected to the appliance into it.
A three pin socket has three holes in the form of copper tubes. The plug is inserted into these holes. The top hole of the socket is bigger in size than the other two holes. This is used to accommodate the earth pin of a plug. Of the other two at the bottom, one on the right is for live connection and the other is for neutral connection.

4. MCB:

Stands for 'miniature circuit breaker'. This is a device that automatically 'switches off' the main supply if the current drawn exceeds the prescribed upper safe limit. It can be 'reset' with the help of a flip-over switch. It protects the circuit and appliances against short circuiting. Nowadays, MCB replaces the main fuse as it is more reliable, easy to operate and also more versatile than the main fuse.

Note:

An **Earth Leakage Circuit Breaker** (**ELCB**) is a safety device used in electrical installations with high earth impedance to prevent shock. It detects small stray voltages on the metal enclosures of electrical equipment, and interrupts the circuit if a dangerous voltage is detected. Once widely used, more recent installations instead use residual current circuit breakers which instead detect leakage current directly.

Earthing an appliance and purpose of earthing.:

The metallic bodies of all electrical appliances used commonly are connected to a metal plate buried deep in the moist earth. This process is called earthing.
It is very important to earth or ground the body of all domestic appliances to save the user from a dangerous/fatal shock. When an appliance is properly is earthed, any accidental contact of the live wire with its metallic part of the body will result in a heavy current flowing straight to the earth. This, in general, will blow out the fuse and stops the flow of electricity into the appliance. This it protects the user from any dangerous/fatal electric shock. Paint or varnish of a very small piece of the metallic part of the appliance is scraped and earthing wire is connected to this part.

Earthing at kWh meter:

Near the kWh meter, the earth wire is connected to a large metal place buried under the earth. The plate is surrounded by a mixture of charcoal and common salt to ensure good contact with the wet soil and the ground. The earthing wire is usually bare and thick. It provides a safe and easy path for the electric charge to flow down to the earth which acts as a very large sink.

FUSE:

An electric fuse is a device used to limit the flow of current.

An electric fuse is a safety device that is used to protect electric circuits and electrical appliances against high current caused by accidental short-circuiting or random voltage fluctuations or overloading.

The fuse wire is connected in series with the electrical circuit or wiring to be protected. If, by any accidental short circuiting or voltage fluctuations a high current more than the safety limit of the of the circuit or wiring tends to flow, the fuse wire because of the low melting point melts down and breaks the circuit. i.e., makes the circuit open. This prevents the high currents from flowing and thus protects the circuit or wiring.
Fuse wires are generally made from an alloy of tin [30%] and lead [37%]. Sometimes tinned copper is also used.

The two types of fuses used quiet often are the kit-kat fuse and the cartridge fuse. The older type is made of two metal clamps fixed on a porcelain base with a groove in between the fuse wire is connected in between the metal clamps which are inserted in the appropriate section of the circuit.

These days costly appliances are fitted with a cartridge type fuse. It consists of a length of fuse wire connected to metal caps at the end of a short glass tube.

Nowadays, MCB’s [Miniature circuit breakers] are the safety devices used instead of the fuse.

Characteristics of a fuse wire:

1. Fuse wires have low melting point relatively lower than the metallic wire [usually copper] used for making the 'connecting wires' in the household circuits.
2. The material should be a good conductor of electricity with high resistance.

The fuse rating is the maximum safe current permitted to flow in a fuse before it breaks.
A fuse is always connected to live wire before it enters the appliance because electric current passes into the appliance through live wire.

High tension wires:
The wires that carry heavy currents from an electric power generating station to the sub-station are called high tension wires. Current carrying wires of considerable thickness are twisted together to increase the area of cross section. They are quiet thick and have a relatively larger diameter with high melting point.

Colour coding of wires:
All electrical appliances are provided with a three core flexible cable. The wires used for electrical connection are made of copper since copper is a good conductor of electricity. Rubber insulations are provided to these connecting wires. To distinguish between the live, neutral and the earth wire these rubber insulations are of different colours. An internationally accepted colour code is used to identify the wire.

Wire	Old convention	New convention
Live	Red	Brown
Neutral	Black	Light blue
Earth	Green	Green and yellow stripes

Note:
1. A switch is not connected to the neutral wire of an electric appliance. This is because, if the switch is connected in the neutral wire, an electric appliance will remain connected to the live wire even when the switch is off and so if anyone happens to touch the appliance, he or she will get a shock which is sometimes fatal.
2. Domestic electrical connections are made in parallel. This is because:
   i). in parallel, potential across all appliances remains the same. Hence, efficiency of any particular appliance does not change with the switching on or off of the other appliances.,
   ii). in parallel, other appliances keep working even if one particular appliance is switched off while in series, the circuit will break and other appliances also stop working.

3. **The earth pin of the plug is always made longer and thcker than the other two for the following reasons:**
   i). The earth pin is longer so that the earth connection is made first when the plug is inserted. This protects the user from getting an electric shock.
   ii). The earth pin is made thicker so that it can never be plugged into the live or neutral hole of the socket even by accident.

4. For making electric heating element, nichrome wire is used. This is because, nichrome wire has a high melting point, has a higher resistivity than copper and does not get oxidized easily when in use.
5. Electricity is supplied to housed in our country at a voltage between 220V-240V.
6. If the plastic insulation of the wires get torn or if the naked parts of live and neutral wires come in contact with each other, the circuit gets shortened instead completing the entire path. This is called **short circuit**. If this happens, the appliance may draw a large current and also this results in electrical and fire accidents which may be fatal.
7. When too many appliances are connected simultaneously in a circuit, the total current drawn would be higher than the current that could be handled by the wires and the appliance. This is called **overloading.**

Precautions to be observed in using electrical gadgets:

1. Wires of high quality, proper amperage and good insulating material should be used.
2. All naked wires and joints must be covered with insulating tape.
3. All connections of plugs, switches and sockets must be tight.
4. Never touch any part of the circuits without wearing rubber shoes and rubber gloves.

   Do not touch the switches or gadgets with wet hand as water layer becomes a connecting layer between the body and the switch incase