3

ELECTRICITY

INTRODUCTION

The electrical devices we encounter most often in modern life such as computers, lights and telephones involve moving charges which we call electric currents.

Electric currents are both important and common. Exampled ranges from the large currents constituting lightining strikes to the tiny nerve currents regulating our muscular activity to electric eel. The currents in household wiring, in light bulbs and electrical appliances are familiar to most of us.

Do you know Electric eels can generate an electrical charge of up to 600 volts in order to stun prey and keep predators at bay. Up to 6,000 electro-plates are arranged like a dry cell in the eel's body. Its internal organs are all in a small area behind the head, with 7/8 of the eel being tail. The electrical shocks come from muscles mainly in the tail portion of the electric eel's body.

Figure : Electric eel

The body of an electric eel is similar to a battery. The tail end of the eel has a positive charge and the head region is negatively charged. When the eel touches its tail and head to other animals it sends electric shocks through their bodies. When the eel is at rest, there is no generation of electrical impulses.

Although all living creatures generate bio-electricity all known creatures that produce electricity useful for navigation, communication and for attack/defence are water dwelling creatures.

Electricity is a practical means of transforming energy to the desired form in which it its need.

The incandescent lamp is a familiar application of the heating effect of an electric current to give light. When we switch on the electric bulb, our room gets lighted. As the electric current flows through the filament of the bulb, it becomes white hot and begins to glow, converting a small part of electric energy into light.

As liquid flows from higher gravitational level to lower gravitation level, heat flows from a body at higher temperature to a body at lower temperature, similarly flow of charge takes place from higher potential to lower potential. As rate of flow of liquid is called liquid current, rate of flow of heat is called heat current, similarly the rate of flow of flow of charge is called electric current. The direction of electric current is considered as the direction of force on positive charge or movement of electrons. As pressure difference is required to maintain the liquid current, in the same manner potential difference is required to maintain the electric current.

ELECTRIC CURRENT

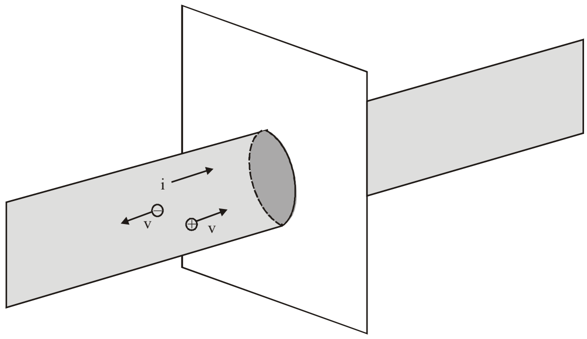
We define the electric current, or simply the current, to be the net mount of positive charge passing per unit time across any section through the conductor in the sense from the positive toward the negative terminal.

If ΔQ is the amount of charge that passes through this area in a time interval Δt, the average current, I_{av}, is equal to the ratio of the charge to the time interval. $I_{av} = \dfrac{\Delta Q}{\Delta t}$

The SI unit of current is the ampere (A), where 1A = 1 C/s

That is, 1A of current is equivalent to 1C of charge passing through the surface in 1s. In practice, smaller units of current are often used, such as the milliampere ($1mA = 10^{-3}$ A) and the microampere ($1\mu A = 10^{-6}$ A)

When charges flow through the surface in figure, they can be positive, negative or both. It is conventional to choose the direction of the current to be in the direction of flow of positive charge. In a conductor such as copper, the current is due to the motion of the negatively charged electrons.
Therefore, when we speak of current in an ordinary conductor, such as a copper wire, the direction of the current will be opposite the direction of flow of electrons.If the charge on an electron is e and n electrons pass through a point in time t then the total charge passing through that point will be Q = ne.

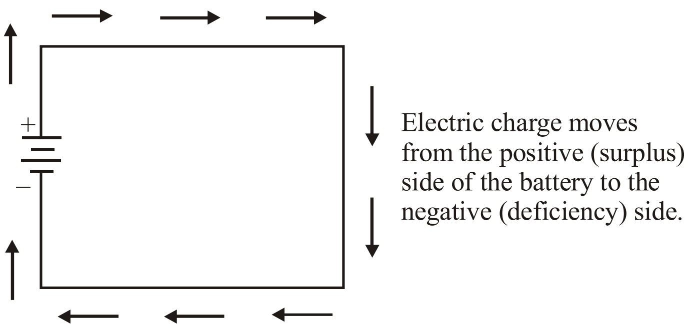


Therefore the current $I = \frac{ne}{t}$, where $e = 1.6 \times 10^{-19}$ coulomb.

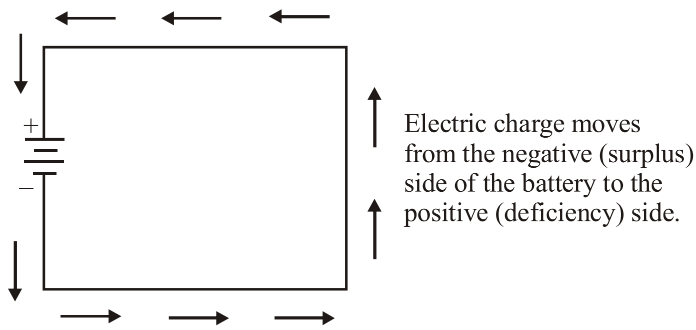
CONVENTIONAL FLOW NOTATION

When Benjamin Franklin made his conjecture regarding the direction of charge flow (from the smooth wax to the rough wool), he set a precedent for electrical notation that exists to this day, despite the fact that we know electrons are the constituent units of charge, and that they are displaced from the wool to the wax -- not from the wax to the wool -- when those two substances are rubbed together. This is why electrons are said to have a negative charge: because Franklin assumed electric charge moved in the opposite direction that it actually does, and so objects he called "negative" (representing a deficiency of charge) actually have a surplus of electrons.
By the time the true direction of electron flow was discovered, the nomenclature of "positive" and "negative" had already been so well established in the scientific community that no effort was made to change it, although calling electrons "positive" would make more sense in referring to "excess" charge. You see, the terms "positive" and "negative" are human inventions, and as such have no absolute meaning beyond our own conventions of language and scientific description. Franklin could have just as easily referred to a surplus of charge as "black" and a deficiency as "white," in which case scientists would speak of electrons having a "white" charge (assuming the same incorrect conjecture of charge position between wax and wool).
However, because we tend to associate the word "positive" with "surplus" and "negative" with "deficiency," the standard label for electron charge does seem backward. Because of this, many engineers decided to retain the old concept of electricity with "positive" referring to a surplus of charge, and label charge flow (current) accordingly. This became known as conventional flow notation (figure (a)):

Conventional flow notation



Electron flow notation

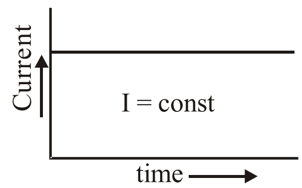


Others chose to designate charge flow according to the actual motion of electrons in a circuit. This form of symbology became known as electron flow notation (figure (b)):
In conventional flow notation, we show the motion of charge according to the (technically incorrect) labels of + and –. This way the labels make sense, but the direction of charge flow is incorrect. In electron flow notation, we

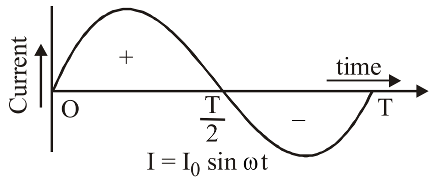
follow the actual motion of electrons in the circuit, but the + and - labels seem backward. Does it matter, really, how we designate charge flow in a circuit? Not really, so long as we're consistent in the use of our symbols. You may follow an imagined direction of current (conventional flow) or the actual (electron flow) with equal success insofar as circuit analysis is concerned.

Types of Current :

(a) Direct Current : The current whose magnitude and direction does not vary with time is called direct current (dc). The various sources are cells, battery, dc dynamo etc.



(b) Alternating Current : The current whose magnitude continuously changes with time and periodically changes its direction is called alternating current. It has constant amplitude and has alternate positive and negative halves. It is produced by ac dynamo.



Interesting (1) : When an electric light switch is closed the light comes on immediately. An electric signal in a conductor travels at a speed of about 3×10^8 m/s.

Interesting (2) : The current may be constituted by motion of different type of charge carries in different situations.

S.No.	Nature of material	Cause of current
1.	Conductors	Motion of electrons
2.	Vacuum tubes	Motion of electrons
3.	Semiconductors	Motion of holes and electrons
4.	Electrolytes	Motion of positive and negative ions
5.	Discharge tube	Motion of positive and negative ions

Example 1 :

If a current 3.2 ampere per second flows through a conducting wire, calculate the number of electrons passing through the wire.

Sol. Here, I = 3.2, t = 1 second, n = ?, c = 1.6×10^{-19} coulomb

$$I = \frac{ne}{t} \;;\; 3.2 = \frac{n \times 1.6 \times 10^{-19}}{1} \quad \text{or} \quad n \times 1.6 \times 10^{-19} = 3.2 \;\; \text{or} \;\; n = \frac{3.2}{1.6 \times 10^{-19}} \quad \therefore\; n = 2 \times 10^{19} \text{ electrons}$$

Example 2 :

If 25 coulomb charge flow in a conductor in 5 seconds then find out the value of electric current in it.

Sol. Electric current $(I) = \frac{Q}{t}$ [Q = 25 coulomb, t = 5 second, I = ?] ; $I = \frac{25}{5} = 5$ ampere

Example 3 :

If a light bulb uses 0.50 amperes of current, how much charge flows through it in 5 minutes ?

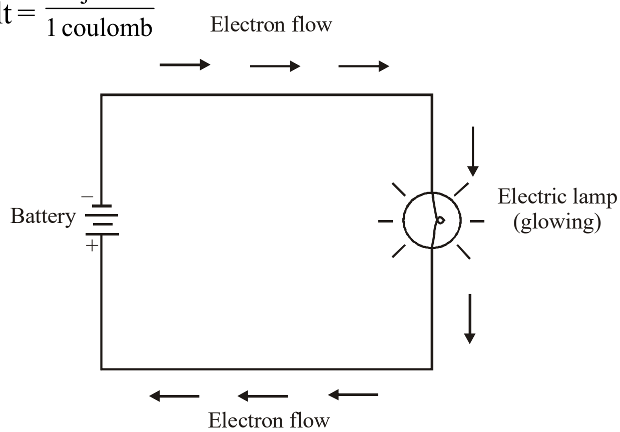
Sol. Five minute is 300 seconds, so from $\Delta q = I\Delta t = (0.50A)\,(300s) = 150$

ELECTRIC POTENTIAL

The electric potential of a charged body can be defined as its electrical condition, which determines the direction of flow of charge. When two charged bodies are placed in electrical contact with each other then positive charge always flow from the body at higher potential to the body at lower potential. If there is no potential difference between two charged bodies then no current or change will flow between them when they are in electrical contact. Therefore potential difference is the necessary condition for the flow of current.

The potential difference between two points on a circuit equals to the work done per unit by the charge in moving test charge from one point to the other.
The volt is the practical unit of potential difference. It is defined by reference to the joule, the practical unit of energy as follows.
1 Volt is the potential difference between two points, if 1 joule of energy is spent (1 joule of work is done) when on coulomb of charge moves from one point to another. $1 \text{ volt} = \frac{1 \text{ joule}}{1 \text{ coulomb}}$

RESISTANCE

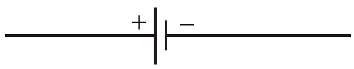


Directly connecting the poles of a voltage source together with a single piece of wire is dangerous because the magnitude of electric current may be very large in such a short circuit, and the release of energy very dramatic (usually in the form of heat),you may have heared about firing due to short circuit. Usually, electric circuits are constructed in such a way as to make practical use of that released energy, in as safe a manner as possible.
One practical and popular use of electric current is for the operation of electric lighting. The simplest form of electric lamp is a tiny metal "filament" inside of a clear glass bulb, which glows white-hot (incandesces) with heat energy when sufficient electric current passes through it. Like the battery, it has two conductive connection points, one for electrons to enter and the other for electrons to exit. Connected to a source of voltage, an electric lamp circuit looks something like this.
As the electrons work their way through the thin metal filament of the lamp, they encounter more opposition to motion than they typically would in a thick piece of wire. This opposition to electric current depends on the type of material, its cross-sectional area, and its temperature. It is technically known as resistance. (It can be said that conductors have low resistance and insulators have very high resistance.) This resistance serves to limit the amount of current through the circuit with a given amount of voltage supplied by the battery, as compared with the "short circuit" where we had nothing but a wire joining one end of the voltage source (battery) to the other.
When electrons move against the opposition of resistance, due to friction heat is generated. Just like mechanical friction, the friction produced by electrons flowing against a resistance manifests itself in the form of heat. The concentrated resistance of a lamp's filament results in a relatively large amount of heat energy dissipated at that filament. This heat energy is enough to cause the filament to glow white-hot, producing light, whereas the wires connecting the lamp to the battery (which have much lower resistance) hardly even get warm while conducting the same amount of current. How to deal with resistance mathematically? You will find the answer in ohm's law section.

ELECTRIC CIRCUIT

To learn more an electricity we need to draw electric circuits with elements like batteries (combination of cells), bulbs, wire, switches, ammeter, voltmeter, Rheostat etc.

1. **Cell :** Direct current source of electro motive force.



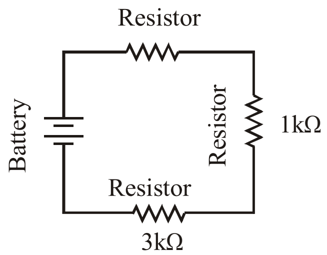
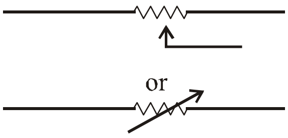
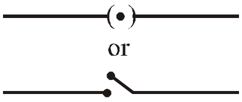


Figure : Simple circuit showing battery and resistor

2. **Rheostat (variable resistance) :** Wire of special type of alloy like constant on manganin, eureka, nichrome etc. is wound on a hollow cylinder of china clay. It controls the current in the electric circuit.

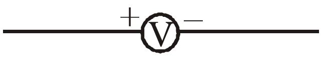


3. **Switch :** It is used to close or open the electric circuit, controls the movement of electrons in a circuit.



4. **Ammeter :** Determines the value of current flowing in the circuit.
The resistance of ammeter is small and it is used in series with the circuit.

5. **Voltmeter :** Determines the potential difference between two points in the circuit. Its resistance is high and it is used in parallel with the resistance wire.

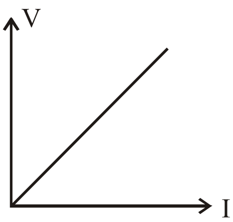


OHM'S LAW

According to Ohm's law "The current passing through a conductor is directly proportional to the potential difference its ends, provided the physical conditions of conductor remain unchanged."

$V \propto I$ or $V = RI$

where R is a constant which is called resistance.



Unit of resistance $R = \frac{V}{I} = \frac{\text{volt}}{\text{ampere}} = \text{ohm } (\Omega)$

If I = 1 ampere, V = 1 volt then R = 1Ω.

The resistance of a conductor is 1 ohm if a potential difference of 1 volt is produced across its ends when 1 ampere of the current flows through it.

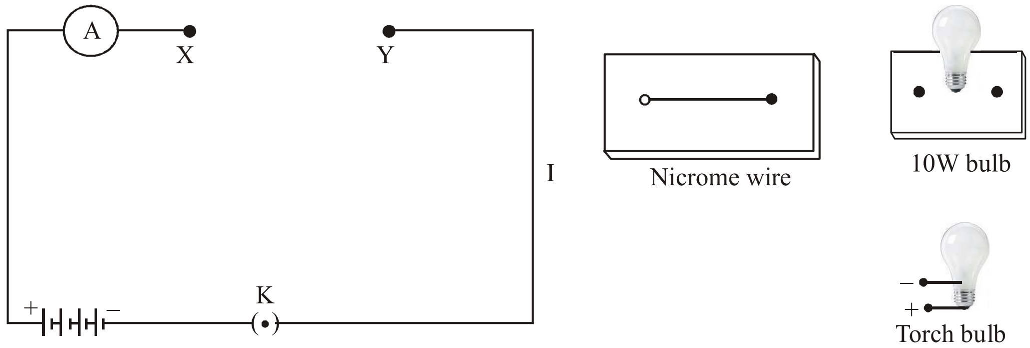
The conductors, which obey the Ohm's law are called the ohmic conductors or linear resistances. All metallic conductors (such as sliver, aluminium, copper, iron, etc.) are the ohmic conductors.

The conductors, which do not obey the Ohm's law are called the non-ohmic conductors or non-linear resistances. Examples are, diode valve, triode valve, transistors, electrolyte etc.

Interesting : It is sometimes contended that $R = \Delta V/i$ (or $\Delta V = iR$) is a statement of Ohm's law. That is not true! This equation is the defining equation for resistance, and it applies to all conducting devices, whether they obey Ohm's law or not. If we measure the potential difference ΔV across and the current i through and device, even a bulb or other non-ohmic device, we can find its resistance at that value of ΔV as $R \equiv \Delta V/i$. The essence of Ohm's law, however, is a plot of i versus ΔV that it is straight line, so that the value of R is independent of the value of ΔV.

Activity :

- Take a nichrome wire, a torch bulb, a 10 W bulb and an ammeter (0 – 5 A range), a plug key and some connecting wires.
- Set up the circuit by connecting four dry cells of 1.5 V each in series with the ammeter leaving a gap XY in the circuit, as shown in Figure



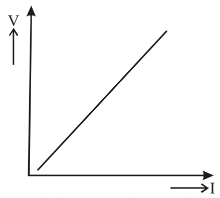
- Complete the circuit by connecting the nichrome wire in the gap XY. Plug the key. Note down the ammeter reading. Take out the key from the plug. Always take out the key from the plug after measuring the current through the circuit.
- Replace the nichrome wire with the torch bulb in the circuit and find the current through it by measuring the reading of the ammeter.
- Now repeat the above step with the 10 W bulb in the gap XY.
- Are the ammeter readings differ for different components connected in the gap XY? What do the above observations indicate?
- You may repeat this Activity by keeping any material component in the gap. Observe the ammeter readings in each case. Analyse the observations.

Verification of Ohm's law :

Set up a circuit as shown in figure with a battery switch (S), a rheostat (Rh), ammeter (A), a resistor (R) and a voltmeter (V). Close the circuit and adjust the rheostat such that the ammeter and the voltmeter show a measurable reading I and V respectively. Repeat the experiment for different values of I and V by adjusting the rheostat. Tabulate your results as shown below :

Trial No.	Potential difference V-volt	Current I -ampere	$\frac{V}{I}$ = r ohm
1. 2. 3.			

Plot a graph of V against I. If it is a straight line passing (fig.) through the origin we can conclude that P.D. 'V' is directly proportional to the current 'I' and Ohm's law is verified.



Limitation of Ohm's law :

1. Ohm's law does not apply to conductors such as diode radio valves, metal rectifiers, electricity through gases.
2. Ohm's law is applicable only when the physical conditions remain constant, for example the resistance of some conductors will vary if the wires are heated or placed under tension.
3. Ohm's law is applicable only when the temperature of the conductor is constant. Generally the resistance of pure metals increases with temperature but the resistance of certain other conducting materials like carbon decreases with temperature. There are certain metal alloys of magnesium and copper whose resistance changes with temperature.

Specific use of conducting materials :

(a) The heating element of devices like heater, geyser, press etc. are made of nichrome because it has high resistivity and high melting point. It does not react with air and acquires steady state when red hot at 800°C.

(b) Fuse wire is made of tin lead alloy because it has low melting point and low resistivity. The fuse is used in series, and melts to produce open circuit when current exceeds the safety limit.

(c) Resistances of resistance box are made of manganin or constantan because they have moderate resistivity and very small temperature coefficient of resistance. The resistivity is nearly independent of temperature.

(d) The filament of bulb is made up of tungsten because it has low resistivity, high melting point of 3300 K and gives light at 2400 K. The bulb is filled with inert gas because at high temperature it reacts with air forming oxide.

(e) The connection wires are made of copper because it has low resistance and resistivity.

THERMISTORS

A thermistor is a heat sensitive device made of semiconducting material where resistivity changes rapidly with change of temperature. It has a large temperature coefficient. The temperature coefficient may be positive or negative. These can be used over wide range of temperature.

Important Applications

(1) The thermistors are used to detect small temperature changes because they respond rapidly to temperature changes.

(2) The thermistors with a large negative temperature coefficient is used in resistance thermometer in very low temperature measurement.

(3) These are used in temperature control units of industry.

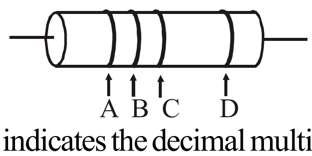
(4) Thermistors are used in protection of windings of generators, motors and transformers.

(5) They are used for voltage stabilisation, remote sensing and safe guarding filament of picture tube of T.V.

COLOUR CODE FOR CARBON RESISTORS

First Colour Code

Colour	Strip A	Strip B	Strip C	Strip D Tolerance
Black	0	0	10^0	
Brown	1	1	10^1	
Red	2	2	10^2	
Orange	3	3	10^3	
Yellow	4	4	10^4	
Green	5	5	10^5	
Blue	6	6	10^6	
Violet	7	7	10^7	
Grey	8	8	10^8	
White	9	9	10^9	
Gold	–	–	10^{-1}	±5%
Silver	–	–	10^{-2}	±10%
No Colour	–	–	–	±20%



Aid to memory BBROY Great Britain Very Good Wife.

The first two rings give first two significant figures of resistance. The third ring indicates the decimal multiplier i.e. the number of zeroes that will follow the two significant figures. The fourth ring shows tolerance or percentage accuracy.

Example 4 :

Calculate the potential difference required across a conductor of resistance 5Ω to flow a current of 1.5 A through it

Sol. Given R = 5Ω , I = 1.5 A, V = ?

From Ohm's law V = IR = 1.5 × 5 = 7.5 V

Example 5 :

How much electric current is produced on applying potential difference of 30 volts on a wire of resistance 20 ohm?

Sol. $I = \frac{V}{R} = \frac{30}{20} = 1.5$ ampere

Example 6 :

If ampere current flowing through a resistance wire develops a potential difference of 50 volts across its ends, find the resistance of the resistance wire.

Sol. $R = \frac{V}{I} = \frac{50}{5} = 10$ ohm

Example 7 :

The potential difference between the terminals of an electric heater is 60V when it draws a current of 4A from the source. What current will the heater draw if the potential difference is increased to 120 V ?

Sol. We are given, potential difference V = 60V, current I = 4A.

According to Ohm's law, $R = \frac{V}{I} = \frac{60V}{4A} = 15\,\Omega$

When the potential difference is increased to 120V the current is given by : Current $= \frac{V}{R} = \frac{120V}{15\Omega} = 8A$

The current through the heater becomes 8A.

Example 8 :

A relay with a resistance of 12 ohms is in an electric circuit with one side at a potential of 85 volts and the other at 71 volts. How much current is in the relay ?

Sol. The potential difference across the relay is 85V – 71V = 14V.

$$I = \frac{\Delta V}{R} = \frac{14V}{12\Omega} = 1.2\text{ A}$$

SELF CHECK

Q.1 A current of 0.5 A is drawn by a filament of an electric bulb for 10 minutes. Find the amount of electric charge that flows through the circuit.

Q.2 An Automobile battery can supply 50 amperes of current for 6 minutes before running down. How much charge does it separate?

Q.3 Write the value of the current flowing in a resistance wire of 100 ohms across which the potential difference is 200 volts.

Q.4 A current of 5 ampere flowing through a resistance wire develops a potential difference of 60 volts between its ends. Calculate the resistance of the wire.

Q.5 How much is the current in a light bulb whose resistance is 350 ohms when the bulb is connected to a 110 volt outlet?

Q.6 A current of 0.15 ampere flows through a 20 ohm resistor away from a point in a circuit where the potential is 45 volts. What is the potential at the other end of the resistor ?

Q.7 How much work is done in moving a charge of 2 C across two points having a potential difference 12 V?

ANSWERS

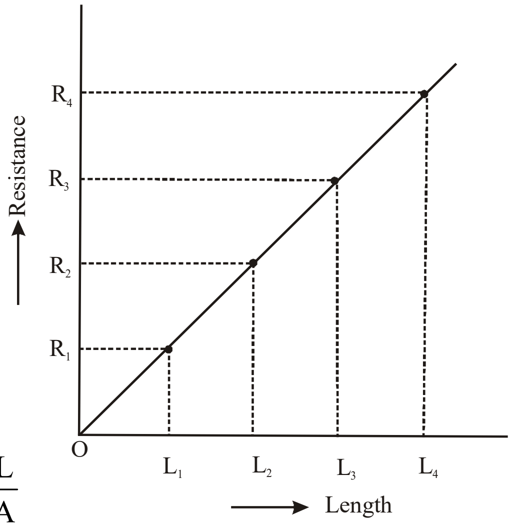
(1) 300 C (3) 2 ampere (4) 12 ohm (5) 0.31 A (7) 24 J

FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS

The resistance of ohmic circuit elements such as metal wires or carbon resistor depends on their geometries.

To find dependence, first we will keep the thickness of the object (like a copper wire) fixed and just increase or decrease the length of the wire. If we apply a potential difference across the ends of the wire and use current and potential difference measurements, we can determine its resistance as a function of length. We find that there is a proportionality between the length L of the wire and the resistance of the wire R.

Thus we can write $R = kL$



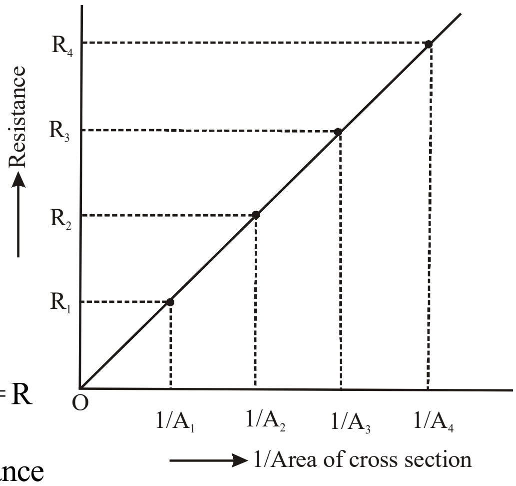
If instead we fix the length of the copper wire and vary the thickness or cross-sectional area A then we find the resistance of the copper decreases as the cross-sectional area A of the wire increases.

In fact we get an inverse relationship so that

$R = k'\frac{1}{A}$ Combining these two expressions gives us : $R = kk'\frac{L}{A}$

To simplify this expression, we can replace the product of the two constants with a single new constant and write $R = \rho\frac{L}{A}$

Where ρ is a constant, which is called the specific resistance or resistivity of the conducting material. It does not depend on the area of cross-section. Resistivity depends only on the nature of material and temperature.



$K = R\frac{L}{A}$ $\therefore$ unit of $K = \frac{\text{ohm} \times m^2}{m} = \text{ohm} \times \text{meter}$

Definition of resistivity : If L = 1 meter, A = 1 square meter then ρ = R (numerically) i.e. resistance of a wire of unit length and unit area of cross section is numerically equal to the resistivity or specific resistance of the material of wire. Remember resistance is a property of an object. Resistivity is a property of a material.

Resistance of some metallic conductors rises with increase in temperature, e.g. copper, silver etc. Resistance of some alloys such as manganin and constant on changes very slowly with increase in temperature. Contrary to this resistance of semiconductors such as germanium (Ge), silicon (Si) etc. decreases with increase in temperature. On decreasing temperature of some metals, the resistance becomes zero at a certain temperature. This phenomena is known as copper conductivity. For example : Resistance of mercury becomes zero at 4.2 K temperature.

Activity : Complete an electric circuit consisting of a cell, an ammeter, a nichrome wire of length l [say, marked (1)] and a plug key, as shown in Figure.

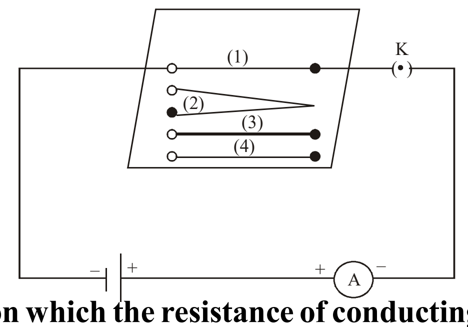


Figure : Electric circuit to study the factors on which the resistance of conducting wires depends

Now, plug the key. Note the current in the ammeter.

Replace the nichrome wire by another nichrome wire of same thickness but twice the length, that is 2l [marked (2) in the Fig]. Note the ammeter reading. Now replace the wire by a thicker nichrome wire, of the same length l [marked (3)]. A thicker wire has a larger cross-sectional area. Again note down the current through the circuit.

Instead of taking a nichrome wire, connect a copper wire [marked (4) in Fig.] in the circuit. Let the wire be of the same length and same area of cross-section as that of the first nichrome wire [marked (1)]. Note the value of the current.

Notice the difference in the current in all cases.

Does the current depend on the length of the conductor?

Does the current depend on the area of cross-section of the wire used?

NOTE : If wire is stretched such that length become n times resistance become n^2 times because due to stretching a cross-section area decreases to n times as volume (or mass) remain constant.

$$\text{Volume (V)} = A\ell\ ;\ A\ell = A'n\ell$$

New cross-sectional area $A' = \frac{A}{n}$. New resistance $R' = \frac{\rho n\ell}{A/n} = \frac{n^2\rho\ell}{A} = n^2R$

The fractional change in resistance without change in volume or mass are :

(a) When change in length is small (≤5%) fractional change in R is $\frac{\Delta R}{R} = \frac{2\Delta L}{L}$

(b) When change in radius is small (≤ 5%) fractional change in R is $\frac{\Delta R}{R} = \frac{-4\Delta r}{r}$

(c) When change in area is small (≤ 5%) fractional change in R is $\frac{\Delta R}{R} = \frac{-2\Delta A}{A}$

Example 9 :

The resistivity of copper at room temperature is 1.72×10^{-6} ohm-centimeter. What is the resistance of a copper wire 35 meters long and 0.025 centimeter in cross section.

Sol. $R = \frac{\rho\ell}{A} = \frac{(1.72\times10^{-6}\,\Omega.\text{cm})\ (3500\text{cm})}{0.025\ \text{cm}^2} = 0.24\ \Omega$

Example 10 :

The resistance of a wire of length 100 cm. and of uniform area of cross-section 0.020 cm^2, is found to be 2.0 ohm. Calculate sp. resistance of wire

Sol. ℓ=100 cm, $a = 0.020\ \text{cm}^2$, $R = 2.0\ \Omega$. Sp. resistance $\rho = \frac{Ra}{\ell} = \frac{2.0\times0.020}{100} = 0.0004\ \Omega-\text{cm}$

Example 11 :

What length of resistance wire of resistivity 100×10^{-8} Ωm, area of cross-section 2.5×10^{-7} m^2, would be needed to make a resistor of 57.6Ω.

Sol. R = 57.6Ω, $A = 2.5 \times 10^{-7}\ m^2$, I = ?

$\rho = 100\times10^{-8}\ \Omega\text{m}$, $R = \frac{\rho I}{A}$ so, $I = \frac{RA}{\rho} \Rightarrow I = \frac{57.6\times2.5\times10^{-7}}{100\times10^{-8}}\frac{\text{m}^2}{\text{m}} = 1.44\ \text{m}$

COMBINATION OF RESISTORS

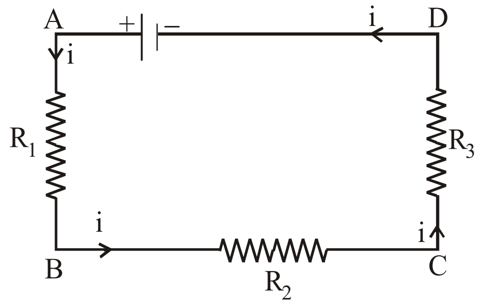
In many practical applications to have desired value of resistance two or more resistances are required to be combined. This can be done in two ways : (i) In series and (ii) In parallel. Sometimes resistances are to be combined in such a way that some resistances be in series and some in parallel. Such a combination is called mixed grouping.

If, in an electrical circuit, two or more resistances connected between two points are replaced by a single resistance such that there is no change in the current of the circuit and in the potential difference between those two points, then the single resistance is called the 'equivalent resistance'.

When the resistance of a circuit is to be increased, they are combined in series and when heavy current is to be passed, they are combined in parallel so as to decrease the total resistance.

Series combination : In this combination the resistances are joined end to end. Thus the second end of each resistance is joined to the first end of the next resistance, and so on. The first end of the first resistance and the second end of the last resistance are connected to the cell. In this combination, the same current flows in all the resistances but the potential differences between their ends are different according to their resistances.

In figure, three resistances AB, BC and CD are connected in series. Suppose their resistances are R_1, R_2 and R_3 respectively. Let the 'equivalent resistance' of these resistances be R.



Suppose a current is flowing in all the three resistances. Suppose the potential differences between the ends of the resistances R_1, R_2 and R_3 are V_1, V_2 and V_3 respectively. Then, according to Ohm's law we have

$V_1 = i\,R_1$, $V_2 = i\,R_2$ and $V_3 = i\,R_3$.

If the potential difference between points A and D be V, then

$$V = V_1 + V_2 + V_3 = iR_1 + iR_2 + iR_3 = i\,(R_1 + R_2 + R_3) \quad \text{.......... (1)}$$

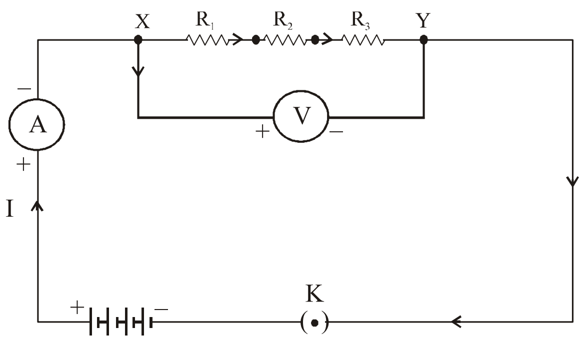
The equivalent resistance between points A and D is R. Therefore

$$V = i\,R \quad \text{.......... (2)}$$

Comparing eq. (1) and (2), we get $iR = i\,(R_1 + R_2 + R_3)$; $R = R_1 + R_2 + R_3$

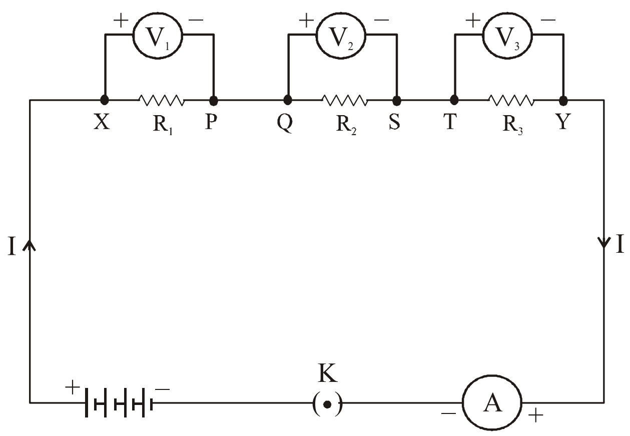
That is, the equivalent resistance of the resistances connected in series is equal to the sum of those resistances and is thus greater than any individual resistance.

ACTIVITY



- Join three resistors of different values in series. Connect them with a battery, an ammeter and a plug key, as shown in Fig. You may use the resistors of values like 1Ω, 2Ω, 3Ω etc., and a battery of 6V for performing this Activity.
- Plug the key. Note the ammeter reading.
- Change the position of ammeter to anywhere in between the resistors. Note the ammeter reading each time.
- Do you find any change in the value of current through the ammeter ?

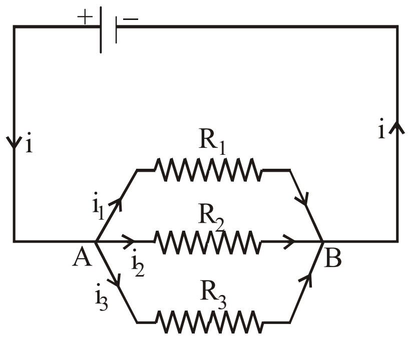
ACTIVITY



- In previous Activity, insert a voltmeter across the ends X and Y of the series combination of three resistors, as shown in Fig.
- Plug the key in the circuit and note the voltmeter reading. It gives the potential difference across the series combination of resistors. Let it be V. Now measure the potential difference across the two terminals of the battery. Compare the two values.
- Take out the plug key and disconnect the voltmeter. Now insert the voltmeter across the ends X and P of the first resistor, as shown in Figure.
- Plug the key and measure the potential difference across the first resistor. Let it be V_1.
- Similarly, measure the potential difference across the other two resistors, separately. Let these values be V_2 and V_3, respectively.
- Deduce a relationship between V, V_1, V_2 and V_3.

Parallel Combination : When two or more resistances are combined in such a way that their first ends are connected to one point and the second ends to another point then this combination is in parallel. In this combination, the potential difference between the ends of all the resistances is same but the current in difference resistances are different.

In figure, three resistances R_1, R_2 and R_3 are joined in parallel between the points A and B. Suppose the current flowing from the cell is i. At the point A, this current is divided into three parts. Suppose i_1, i_2 and i_3 are the currents in R_1, R_2 and R_3 respectively. At the point B, these three currents meet and form the main current i.



Thus, we have $i = i_1 + i_2 + i_3$ .... (1)

Let the potential difference between the points A and B be V.

Since each resistance is connected between A and B, the potential difference between the ends of each will be V. Therefore,

$$i_1 = \frac{V}{R_1}, \quad i_2 = \frac{V}{R_2} \text{ and } \quad i_3 = \frac{V}{R_3}$$

Substituting these values in eq. (1) we get, $i = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$ .... (2)

If the equivalent resistance between the points A and B be R, then $i = V/R$ .... (3)

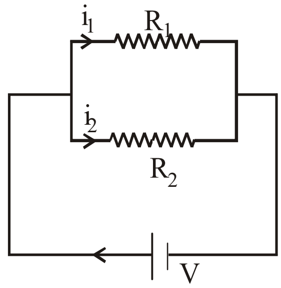
Comparing eq. (2) and (3), we get $\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$ or $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

That is, the reciprocal of the equivalent resistance of the resistances connected in parallel is equal to the sum of the reciprocals of those resistances.

In parallel combination, the equivalent resistance R is less than even the smallest resistance connected.

For example, if we connect two resistors of resistance 1Ω and 100 Ω in parallel, the equivalent resistance R will be less than 1Ω as shown :

$$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}=\frac{1}{2}+\frac{1}{100}=\frac{101}{100} \qquad \text{or} \qquad R=\frac{100}{101}=0.99\ \Omega$$



If resistance R_1 and R_2 are connected in parallel and i is the total current drawn from cell then

$$i = i_1 + i_2 \quad .... (1) \qquad V = i_1R_1 = i_2R_2 \quad .... (2)$$

Solving eq. (1) and (2), $i_2 = \frac{iR_1}{R_1+R_2}$ and $i_2 = \frac{iR_1}{R_1+R_2}$

ACTIVITY

Make a parallel combination, XY, of three resistors having resistances R_1, R_2, and R_3, respectively. Connect it with a battery, a plug key and an ammeter, as shown in Fig (a). Also connect a voltmeter in parallel with the combination of resistors.

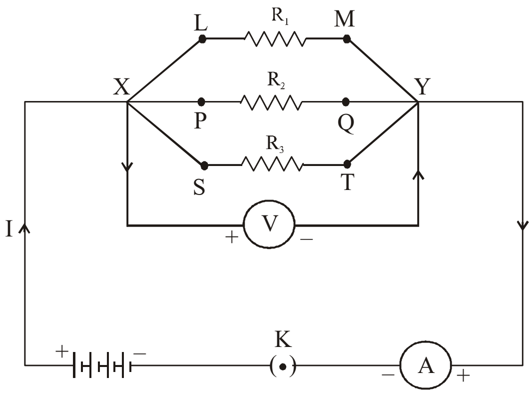


Figure : (a)

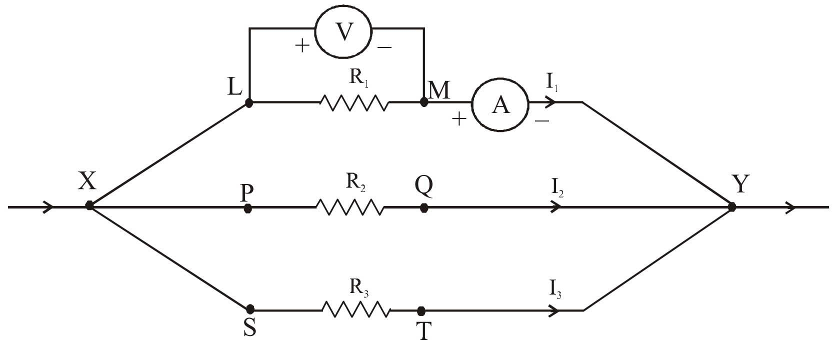


Figure : (b)

Plug the key and note the ammeter reading. Let the current be I. Also take the voltmeter reading. It gives the potential difference V, across the combination. The potential difference across each resistor is also V. This can be checked by connecting the voltmeter across each individual resistor (Fig. (b)).

Take out the plug from the key. Remove the ammeter and voltmeter from the circuit. Insert the ammeter in series with the resistor R_1, as shown in Fig. (b). Note the ammeter reading, I_1.

Similarly, measure the currents through R_2 and R_3. Let these be I_2 and I_3, respectively. What is the relationship between I, I_1, I_2 and I_3 ?

DIFFERENCE BETWEEN EMF AND POTENTIAL DIFFERENCE

EMF OF A CELL	POTENTIAL DIFFERENCE
1. The emf of a cell is the maximum potential difference between the two electrodes of a cell when the cell is in the open circuit.	The potential difference between the two points is the difference of potential between these two points in a closed circuit.
2. Emf is independent of resistance of circuit and depends upon the nature of electrodes and electrolyte.	This depends upon the resistance between two points of the circuit and current flowing through the circuit.
3. The term emf is used for source of current.	Potential difference can be measured between any two points of circuit.
4. This is a cause.	It is an effect.

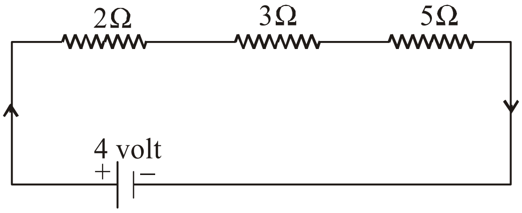
Example 12 :

Three resistance of 2, 3 and 5 ohms are connected in series. If the combination is connected to a battery of 4 volt then what will be (i) current in each resistance (ii) potential difference across each resistance ?

Sol. Total resistance in series

$R = R_1 + R_2 + R_3$

$R = 2 + 3 + 5 = 10\ \Omega.$



(i) Current flowing through each resistance will be same

$$I = \frac{V}{R} = \frac{4}{10} = 0.4 \text{ ampere}$$

(ii) Potential difference across each resistance will determined by formula V = IR.

Potential difference 2Ω resistance $V_1 = IR_1 = 0.4 \times 2 = 0.8$ Volt

Potential difference 3Ω resistance $V_2 = IR_2 = 0.4 \times 3 = 1.2$ Volt

Potential difference 5Ω resistance $V_3 = IR_3 = 0.4 \times 5 = 2.0$ Volt

Example 13 :

Three resistors of 2Ω, 3Ω and 4Ω are connected in (i) series, (ii) parallel. Find the equivalent resistance in each case.

Sol. Given $R_1 = 2\Omega$, $R_2 = 3\Omega$ and $R_3 = 4\Omega$

(i) In series, the equivalent resistance is $R = R_1 + R_2 + R_3 = 2 + 3 + 4 = 9\Omega$.

(ii) In parallel, the equivalent resistance is R, then

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \text{ or } \frac{1}{R} = \frac{1}{2} + \frac{1}{3} + \frac{1}{4} = \frac{13}{12} \text{ or } \frac{1}{R} = \frac{1}{2} + \frac{1}{3} + \frac{1}{4} = \frac{13}{12}$$

Example 14 :

6Ω and 3Ω resistors are connected in parallel and an 8Ω resistor is connected in series with them. A current of 2A passes through the 8Ω resistor. Find

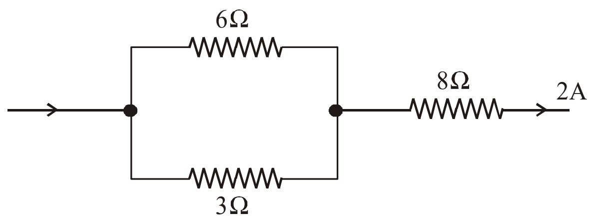
(a) the combined resistance (b) the potential difference across the combined resistor

(c) the current through the 3Ω resistor

Sol. Find the combined resistance R of the resistors in parallel.

$R = ?,\ R_1 = 6\Omega, R_2 = 3\Omega,$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{6} + \frac{1}{3} = \frac{3}{6} = \frac{1}{2}$$



$R = 2\Omega$

The equivalent circuit is shown in figure.

(a) Let the combined resistance of all three resistors be R

$R = ?,\ R_1 = 8\Omega, R_2 = 2\Omega\ ;\ R = R_1 + R_2 = 8\Omega + 8\Omega = 10\Omega$

(b) Let the potential difference across the combined resistors be V.

$V = ?\ ,\ I = 2A,\ R = 10\Omega\ ;\ V = I \times R = 2A \times 10\Omega = 20V$

(c) The combined resistance of the parallel network is 2Ω. Hence potential difference V across the parallel resistor is $V = I \times R = 2A \times 2\Omega = 40V$

For the 3Ω resistor $V = 4V,\ I = ?, R = 3\Omega,\quad I = \frac{V}{R} = \frac{4V}{3\Omega} = 1\frac{1}{3}A$

Example 15:

Three resistors are connected in series to 24 volt battery, and an ammeter in the circuit reads 0.50 amperes. The first resistor is rated at 22 ohms, and the second at 8 ohms. Find (a) the total resistance (b) the resistance of the third resistor, and (c) the potential difference across the third resistor.

Sol. (a) The total resistance of the circuit is

$$R = \frac{\Delta V}{I} = \frac{24V}{0.50\ A} = 48\ \Omega$$

(b) In a series circuit, resistance add, so $22\ \Omega + 8\Omega + R_3 = 48\Omega$ and $R_3 = 18\Omega$.

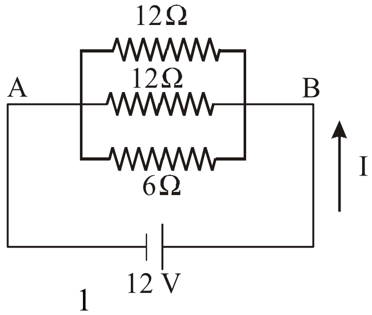
(c) For any circuit element, $\Delta V = IR$ so $V_3 = (0.50\ A)\ (18\ \Omega) = 9V$

Example 16 :

In the circuit shown, find :

(a) the equivalent resistance between points A and B.

(b) the current through the battery.



Sol. Given : $R_1 = 12\Omega,\ R_2 = 12\Omega,\ R_3 = 6.0\ \Omega,\ V = 12V$

Find : (a) R_p (b) I

(a) The three resistors are in a parallel combination.

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{12\Omega} + \frac{1}{12\Omega} + \frac{1}{6.0\Omega} = \frac{1}{12\Omega}\frac{1}{12\Omega} + \frac{2}{12\Omega} = \frac{4}{12\Omega} = \frac{1}{3.0\Omega}$$

So, $R_p = 3.0\ \Omega$. Or using $R_p = \frac{RR}{R+R} = \frac{R}{2}$ for the two 12 ohm resistors in parallel, $R_{p1} = \frac{12\Omega}{2} = 6\Omega$

Now the two 6.0Ω resistances are in parallel and the equivalent resistance is $R_p = \frac{6.0\ \Omega}{2} = 3.0\ \Omega$

(b) From Ohm's law, $I = \frac{V}{R} = \frac{V}{R_p} = \frac{12V}{3.0\Omega} = 4.0A$

SELF CHECK

Q.1 A 4Ω resistance wire is doubled on it. Calculate the new resistance of the wire.

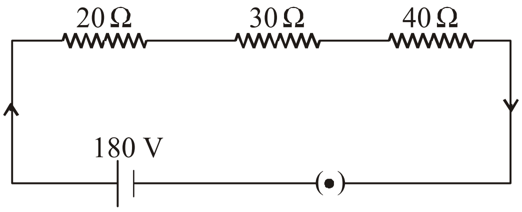
Q.2 Find the potential difference required to pass a current 0.2 A in a wire of resistance 20Ω.

Q.3 A wire of 3 ohm resistance and 10 cm length is stretched to 30 cm. length. Assuming that it has a uniform cross-section what will be its new resistance ?

Q.4 Two resistors having 5Ω and 10 Ω resistance are connected in parallel. Find their equivalent resistance.

Q.5 A combination consists of three resistors in series. Four similar sets are connected in parallel. If the resistance of each resistor is 2 ohm, find the resistance of the combination.

Q.6 Three resistance of 20Ω , 30 Ω and 40 Ω ohms are joined in connected circuit as shown in figure. Find out the value of equivalent resistance and current flowing in the circuit.



Q.7 Show how you would connect three resistors, each of resistance 6Ω, so that the combination has a resistance has a resistance of (i) 9Ω (ii) 4Ω.

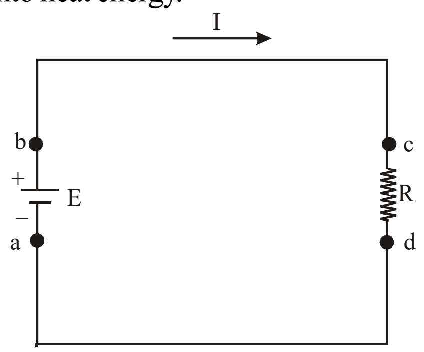
ANSWER

(1) 1Ω **(2) 4V** **(3) 27Ω** **(4) 3.3 Ω**
(5) 1.5 Ω **(7) 2 ampere**

HEATING EFFECT OF ELECTRIC CURRENT AND ELECTRIC POWER

If a battery is used to establish an electric current in a conductor, there is a continuous transformation of chemical energy stored in the battery to kinetic energy of the charge carriers. This kinetic energy is quickly lost as a result of collisions between the charge carriers. This kinetic energy is quickly lost as a result of collisions between the charge carriers and the lattice ions, resulting in an increase in the temperature of the conductor. Therefore, we see that the chemical energy stored in the battery is continuously transformed into heat energy.

Consider a simple circuit consisting of a battery whose a terminals are connected a resistor R, as shown in figure.



The positive terminal of the battery (the longer plate) is at the higher potential, while the negative terminal (the shorter plate) is at the lower potential. Now imagine following a positive quantity of charge ΔQ moving around the circuit from point a through the battery resistor and back to a. Point a is a reference point that is grounded, and its potential is taken to be zero.

As the charge moves from a to b through the battery, its electrical potential energy increases by an amount VΔQ (where V is the potential at b) while the chemical potential energy in the battery decreases by the same amount. However, as the charge moves from c to d through the resistor, it loses this electrical potential energy as it undergoes collisions with atoms in the resistor, thereby producing thermal energy. Note that if we neglect the resistance of the interconnecting wires there is no loss in energy for paths bc and da. When the charge returns to point a, it must have the same potential energy (zero) as it has at the start.

The rate at which the charge ΔQ loses potential energy in going through the resistor is given by

$\frac{\Delta U}{\Delta t} = \frac{\Delta Q}{\Delta t} V = IV$, where I is the current in the circuit. Of course, the charged regains this energy when it passes through the battery. Since the rate at which the charge loses energy equals the power P lost in the resistor, we have $P = IV$ .... (1)

In this case, the power is supplied to a resistor by a battery. However, eq. (1) can be use to determine the power transferred to any device carrying a current I and having a potential difference V between its terminals.

Using eq. (1) and the fact that V = IR for a resistor, we can express the power dissipated in the alternative forms

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

When I is in amperes, V in volts, and R in ohms, the SI unit of power is the watt (W). The power lost as heat in a conductor of resistance R is called joule heating.

Watt is a small unit of power, its other bigger units are Kilowatt, Megawatt and Horsepower.

$1 \text{ KW} = 1000 \text{ W} = 10^3 \text{ W}$
$1 \text{ MW} = 1000000 \text{ W} = 10^6 \text{ W}$
$1 \text{ hp} = 746 \text{ W}$

If 100W – 220V is written on the bulb then it means that the bulb will consume 100 joule in one second if used at the potential difference of 220 volts.

The value of electricity consumed in houses is decided on the basis of the total electric energy used. Electric power tells us about the electric energy used per second not the total electric energy.

The total energy used in a circuit = power of the electric circuit × time

If the power is in watt and time is in second, then the electric energy will be in joule or watt × second.

As the watt × sec. is a small unit of energy, electric energy is measured in Kilowatt Hour (KWh)

1 Kilowatt hour (KWh) = 1000 Watt hour

= 1000 × 60 × 60 Watt sec.

= 36000000 Joule = 3.6×10^6 Joule

1 Kwh is called the 1 unit.

The electricity department uses this unit in the electric bills. If the 100 watt bulb or any other electric appliance is used for an hour then the total electric energy consumed is 1 KWh or 1 unit.

Example 17 :

An immersion rod of 1500 W is used everyday for 3 hours to boil water. If the rate of 1 unit of electric energy is Rs. 2.5 then what will be the total cost of the electricity used in 30 days ?

Sol. Electric energy used in a day = 1500 × 3 Wh = 4500 Wh

Electric energy used in 30 days = 4500 × 30 Wh = 135000 Wh

Total energy in KWh unit = $\frac{135000}{1000}\text{KWh} = 135\text{ KWh}$ or unit

Hence the total cost of the electricity = 135 × 2.50 Rs. = 337.50 Rs.

Example 18 :

An electric heater is rated 750 W – 200V. Calculate (i) resistance of the heating element (ii) current flowing through it.

Sol. P = 750 W, p.d. = 200V, R = ?, I = ?

$$P = \frac{V^2}{R} \quad \therefore \quad R = \frac{V^2}{P} \quad \therefore \quad R = \frac{200 \times 200}{750} = 53.33\ \Omega$$

$$R = \frac{V}{I} \quad \therefore \quad I = \frac{V}{R} = \frac{200}{53.33} = 3.75\text{ A}$$

Example 19 :

The resistance of a wire of length 100 cm and of uniform area of cross-section 0.020 cm^2, is found to be 2.0 ohm. Calculate sp. resistance of wire.

Sol. $\ell = 100$ cm., a = 0.020 cm^2, R = 2.0 Ω.

Sp. resistance $\rho = \frac{Ra}{\ell} = \frac{2.0 \times 0.020}{100} = 0.0004\ \Omega - \text{cm}$

PRACTICAL APPLICATION

The heat generated when current passes through a resistive material is used in many common devices. The material through which the current passes is surrounded by an insulating substance in order to prevent the current from flowing through the cook to the earth when he or she touches the pan. A material that is a good conductor of heat surrounds the insulator.

Hair dryer, in which a fan blows air past heating coils. In this case the warm air can be used to dry hair, but on a broader scale this same principle is used to dry clothes and to heat buildings.

A final example of a household uses the heating effect of electric currents is the steam iron. A heating coil warms the bottom of the iron and simultaneously turns water to steam, which is sprayed from jets located in the bottom of the iron. Other practical application includes heater, toaster, electric kettle. Let us consider another application.

FUSE

The selection of wires used in electric circuits is such that it can carry a current of given magnitude without much loss. If excess current passes through the circuit, the electric wires can become very hot and can catch fire.

There are two reasons for the excess current in the circuit then the allowed unit (1) overloading and (2) short circuit.

The current in a given circuit depends on the power rating of electric appliances used in it. If the total power of electric appliances increases, the current passes through the circuit is more than the allowed limit and it is called the overloading. Sometimes phase and neutral wires come into direct contact with each other because of fault or damage in the wires. In such situation, the resistance of the circuit become almost zero and more current started passing through it. This is called short circuit.

The wire becomes very hot because of this and there is a sparking where the short circuit takes place this causes a fire. The fuse is an important device to protect the circuit and to prevent the accident from the overloading and short circuit. Fuse is a thin wire made an alloy of low melting point and low resistance. When the current exceeds the allowed limit in the circuit, the fuse wire melts due to the heating and the circuit gets disconnected, resulting into zero current in the circuit. Because of this the possibility of fire or accident is prevented.

Separate fuses are used for different circuits in the houses. Fuse wire is always connected to the phase wire. Once the fuse wire is damaged, it is replaced for normal flow of current.

ADDITIONAL EXAMPLES

Example 1 :

On what factors does the resistance of a conductor depend ?

Sol. The resistance of a conductor depends : (i) on its length, (ii) on its area of cross-section (iii) on the nature of its material and (iv) on temperature of the conductor.

Example 2 :

Explain the following.(a) Why is the tungsten used almost exclusively for filament of electric lamps?

(b) Why are the conductors of electric heating devices, such as bread-toasters and electric irons, made of an alloy rather than a pure metal?

(c) Why is the series arrangement not used for domestic circuits?

(d) How does the resistance of a wire vary with its area of cross-section?

(e) Why are copper and aluminium wires usually employed for electricity transmission?

Sol. (a) They have less resistivity. (b) It has more resistivity and less temperature coefficient of resistance.

(c) (i) All appliances need same potential. (ii) All appliances can be individually operated.

(d) $R \propto 1/\text{area}$

(e) They are very good conductors of electricity.

Example 3 :

An immersion heater having 50Ω resistance is connected to 250V mains. Find the time required to heat 2 kg of water from 34°C to 100°C, assuming there is no loss of heat energy (Sp. heat cap. of water = 4×10^3 J/kg°C)

Sol. Current passing through the heater $I = \frac{V}{R} = \frac{250}{50} = 5A$

Heat produced = I^2Rt and Heat required = $mC\theta$. Heat produced = $5^2 \times 50 \times t$

$mC\theta = 2 \times 4 \times 10^3 \times (100 - 35) = 8 \times 10^3 \times 65$

Since $5^2 \times 50 \times t = 8 \times 10^3 \times 65$

$\therefore\ t = \frac{520 \times 1000}{1250} = 416\ s = 6\ min\ 56\ s$

Example 4 :

Calculate the current flowing through a nichrome wire, immersed in 100g of oil at 20°C, such that final temperature of oil rises to 80°C in five minutes, when the supply of emf is 10V.
[Sp. heat capacity of oil is 0.85 $Jg^{-1}°C^{-1}$]

Sol. I = ?, p.d. = 10V, t = 5 min = 300s ; m = 100 g, S.H.C. = 0.85 $Jg^{-1}°C^{-1}$, $\theta_R = (80-20) = 60°C$

Energy produced in wire = I × V × t = I × 10 × 300 Vs

Energy absorbed by oil = $mc\theta_R$ = 100 × 0.85 × 60 J

∴ By the law of conservation of energy

$$I \times 10 \times 300 = 100 \times 0.85 \times 60 \Rightarrow I = \frac{100 \times 0.85 \times 60}{10 \times 300} = 1.7\ A$$

Example 5 :

What is the operating resistance of a 100-watt household light bulb ? The operating line voltage of household electricity is 120V.

Sol. Given : P = 100 W, V = 120 V, Find R. From $P = \frac{V^2}{R}$,

We have $R = \frac{V^2}{P} = \frac{(120V)^2}{100W} = 144\ \Omega$

Example 6 :

On a 220V power line the powers of two electric bulbs are 60W and 30W separately. Find the powers of their parallel and series combinations when connected on the same line.

Sol. The resistance of the 220V-60W bulb is $R_1 = \frac{V^2}{P_1} = \frac{(220)^2}{60}\Omega$

The resistance of the 220V-30W bulb is $R_2 = \frac{V^2}{P_2} = \frac{(220)^2}{30}\Omega$

When the bulbs are connected in parallel, their equivalent resistance is

$$R = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{\frac{(220)^2}{60} \times \frac{(220)^2}{30}}{\frac{(220)^2}{60} + \frac{(220)^2}{30}} = \frac{(220)^2}{90}\Omega$$

The power of the parallel combination is $P = \frac{V^2}{R} = \frac{(220V)^2}{\{(220)^2/90\}\Omega} = 90W$

When the bulbs are connected in series, their equivalent resistance is

$$R' = R_1 + R_2 = \frac{(220)^2}{60} + \frac{(220)^2}{30} = (220)^2 \times \frac{1}{20}\Omega.$$

The power is $P' = \frac{V^2}{R'} = \frac{(220V)^2}{\{(220)^2 \times 1/20\}\Omega} = 20W$

Example 7 :

An electric kettle has coils A and B. When coil A is switched on, the water boils in 10 minutes, and when coil B is switched on, the water boils in 20 minutes. Calculate the time taken by the water to boil if the coils connected in (a) series and in (b) parallel are switched on.

Sol. Let R_1 and R_2 be the resistances of the coils A and B respectively, and t_1 and t_2 the time-intervals taken by the water to boil when A and B are switched on turn by turn. If W be the heat energy required to boil the water, then

$$W = \frac{V^2 t_1}{R_1} = \frac{V^2 t_2}{R_2} \text{ where V is supply voltage. This gives } \frac{R_2}{R_1} = \frac{t_2}{t_1} \quad \text{............ (1)}$$

Here $t_1 = 10$ min and $t_2 = 20$ min. $\therefore \frac{R_2}{R_1} = \frac{20}{10} = 2$ or $R_2 = 2R_1$

(a) When the coils are connected in series, the equivalent resistance is $R = R_1 + R_2 = R_1 + 2R_1 = 3R_1$.

If t be the time taken by the water to boil, then from eq. (1), we have $\frac{R}{R_1} = \frac{t}{t_1}$; $t = 3t_1 = 30$ min. $[\because R / R_1 = 3]$

(b) When the coils are connected in parallel, the equivalent resistance is

$$R' = \frac{R_1 R_2}{R_1 + R_2} = \frac{R_1(2R_1)}{R_1 + 2R_1} = \frac{2}{3} R_1$$

If t' be the time taken by the water to boil, then from eq. (1) , we have

$$\frac{R}{R_1'} = \frac{t'}{t_1} \quad \text{or} \quad t' = \frac{2}{3} t_1 = \frac{20}{3} \text{min} \qquad [\because R'/R_1 = 2/3]$$

Example 8 :

For driving a current of 3 ampere for 5 minutes in an electric circuit, 1200 joule of work is to be done. Find the emf of the source in the circuit.

Sol. The charge flown in the circuit is given by : $q = i \times t$

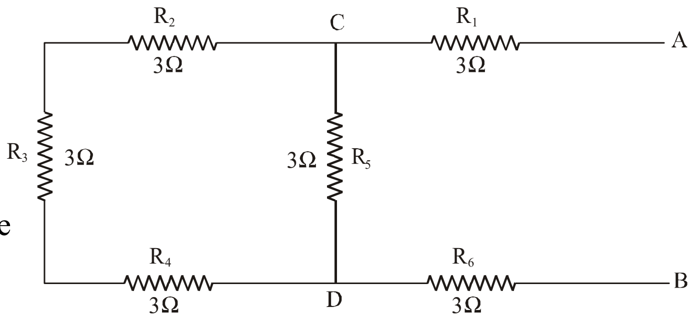
Here current i = 3A and time t = 5 min = 5 × 60s $\therefore$ q = (3A) × (5 × 60s) = 900C

The emf E is measured by the work done in flowing a unit charge.

$$\therefore \quad E = \frac{W}{q} = \frac{1200J}{900C} = 1.33 \text{ V}$$

Example 9 :

For the combination of resistors shown in figure, find the equivalent resistance between (i) C and D (ii) A and B.



Sol. **(i)** The resistors R_2, R_3, R_4 are in series. They can be replaced by an equivalent resistance R', where

$R' = R_2 + R_3 + R_4 = 3 + 3 + 3 = 9\Omega$.

The resistance R_5 (= 3Ω) and R' (=9Ω) are in parallel, between the points C and D. The equivalent resistance between C and D is R'', where $\frac{1}{R''} = \frac{1}{3} + \frac{1}{9}$ or $\frac{1}{R''} = \frac{3+1}{9} = \frac{4}{9}$ or $\frac{1}{R''} = \frac{4}{9} = 2.25\ \Omega$

Thus the equivalent resistance between C and D is 2.25 Ω

(ii) Now the resistor R1 = (3Ω). R'' (= 2.25Ω) and R_6 (= 3Ω) are in series between the points A and B.

The equivalent resistance between A and B is : $R = R_1 + R'' + R_6 = 3 + 2.25 + 3 = 8.25\Omega$

Example 10 :

Two bulbs A and B are rated 100W, 120V and 10W, 120V respectively. They are connected across a 120V source in series. Calculate the current through each bulb. Which bulb will consume more energy ?

Sol. Resistance of bulb A (rating 100W, 120V) is $R_1 = \frac{V^2}{P_1} = \frac{(120)^2}{100} = 144\ \Omega$

Resistance of bulb B (rating 10W, 120V) is $R_2 = \frac{V^2}{P_2} = \frac{(120)^2}{10} = 1440\ \Omega$

When they are connected in series,
Total resistance, $R = R_1 + R_2 = 144 + 1440 = 1584\Omega$

Current in the circuit $I = \frac{V}{R} = \frac{120}{1584} = 0.076A$

Same current passes through each bulb.
Power consumed in the bulb A is $P_1 = I^2R_1$.
Power consumed in the bulb B is $P_2 = I^2R_2$.
Since $R_1 < R_2$ $\therefore$ $P_1 < P_2$.
Hence the bulb B (rated 10W, 120V) consumes more energy than the bulb A (rated 100W, 120V) when they are connected in series.

Example 11 :

Two copper wires A and B of length 30m and 10m have radius 2mm and 1 mm respectively. Compare the resistance of the two wires. Which will have less resistance ?

Sol. From the relation $R = \rho\frac{\ell}{a}$; Resistance of wire A is $R_A = \rho\frac{30}{\pi\,(2\times10^{-3})^2}$

Resistance of wire B is $R_B = \rho\frac{10}{\pi\,(1\times10^{-3})^2}$; On dividing $\frac{R_A}{R_B} = \frac{30}{10}\left(\frac{1\times10^{-3}}{2\times10^{-3}}\right)^2 = \frac{3}{4}$

Thus the wire A has less resistance.

Example 12 :

There are 5 rooms in a house. Each room has a 100W bulb and a 40W tube light. If every day the bulb is used for 1 hour and tube light is used for 5 hours in each room then what will be the cost of total electric energy consumed in 30 days when 1 unit of electric energy costs Rs. 2.5

Sol. Energy used every day in 5 bulbs = 5 × 100 × 1 Wh = 500 Wh
Energy used everyday in 5 tube lights = 5 × 40 × 5 Wh = 1000 Wh
Total energy used everyday by bulb and tube light = (500 + 1000) Wh = 1500 Wh

Total energy used in 30 day = 1500 × 30 Wh = 45000 Wh = $\frac{45000}{1000}$ KWh = 45 KWh (unit)

Cost of the total energy used = 45 × 2.50 Rs. = 112.50 Rs.

Example 13 :

Define the unit of current.

Sol. The SI unit of electric current is ampere (A). When 1 coulomb of electric charge flows through any cross-section of a conductor in 1 second, the electric current flowing through it is said to be 1 ampere.

$$1\ \text{ampere(A)} = \frac{1\ \text{coulomb (c)}}{1\ \text{sec ond (s)}}$$

Example 14 :

Calculate the number of electrons constituting one coulomb of charge.

Sol. Charge on an electron = 1.6×10^{-19} C $\because$ If is 1.6×10^{-19} C, the no. of electron = 1

$\therefore$ If charge is 1C, then no. of electrons = $\frac{1}{1.6 \times 10^{-19}} = \frac{1}{1.6} \times 10^{19} = 0.625 \times 10^{19} = 6.25 \times 10^{18}$

Example 15 :

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

Sol. Energy = charge × potential difference = 1 × 6 = 6 joule

Example 16 :

(a) How much current will an electric bulb draw from a 220 V source, if the resistance of the bulb filament is 1200 Ω ? (b) How much current will an electric heater coil draw from a 220 V source, if the resistance of the heater coil is 100 Ω ?

Sol. (a) We are given V = 220 V; R = 1200 Ω. From Eq. R = V/I , The current I = 220 V/1200 Ω = 0.18 A.

(b) We are given, V = 220 V, R = 100 Ω.From Eq. R = V/I, we have the current I = 220 V/100 Ω = 2.2 A.

The difference of current drawn by an electric bulb and electric heater from the same 220 V source.

Example 17 :

Resistance of a metal wire of length 1 m is 26 Ω at 20°C. If the diameter of the wire is 0.3 mm, what will be the resistivity of the metal at that temperature?

Sol. R = 26 Ω, d = 0.3 mm = 3×10^{-4} m, l = 1 m. resistivity of the given metallic wire is $\rho = (RA/l) = (R\pi d^2/4l)$.

Substitution of values in this gives $\rho = 1.84 \times 10^{-8}\ \Omega$ m

The resistivity of the metal at 20°C is 1.84×10^{-8} Ω-m. This is the resistivity of manganese.

Example 18 :

If 3.0×10^{15} electrons flow through a section of a wire of diameter 2.0 mm in 4.0 s, what is the electric current in the wire ?

Sol. Given n = 3.0×10^{15} electrons, t = 4.0s, d = 2.0 mm, Find I

The charge in 3.0×10^{15} electrons is q = ne = (3.0×10^{15} electrons) (1.60×10^{-19} C/electrons) = 4.8×10^{-4}

So, $I = \frac{q}{t} = \frac{4.8 \times 10^{-4}\ C}{4.0\ s} = 1.2 \times 10^{-4}\ A = 0.12\ mA$

Example 19 :

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

Sol. Resistance, $R \propto 1/A$

The resistance of a conductor is inversely proportional to its area of cross-section. A thick wire has a greater area of cross-section whereas a thin wire has a smaller area of cross section. Thus, a thick wire has less resistance and a thin wire has more resistance. Therefore, current will flow more easily through a thick wire.

Example 20 :

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

Sol. The current is directly proportional to potential difference and current is inversely proportional to resistance. i.e., I=V/R. Let the resistance remains constant. If the potential difference is halved, the current also gets halved.

Example 21 :

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

Sol. Coils of electric toasters and electric irons are made of an alloy rather than a pure metal because
(i) the resistivity of an alloy is much higher than that of pure metal, and (ii) an alloy does not undergo oxidation easily even at high temperature.

Example 22 :

(a) Which among iron and mercury is a better conductor ? (b) Which material is the best conductor ?

Sol. (a) Among iron and mercury, iron is better conductor of electricity because resistivity for iron ($10.0 \times 10^{-8}\ \Omega$-m) is less than that of mercury ($94.0 \times 10^{-8}\ \Omega$-m).
(b) We know that a good conductor of electricity should have a low resistivity and a poor conductor of electricity will have a high resistivity. Silver has the lowest resistivity of $1.60 \times 10^{-8}\ \Omega$-m, which means that silver offers the least resistance to the flow of current through it. So, silver is the best conductor of electricity.

Example 23 :

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

Sol. $R_l = 100\ \Omega$, $R_t = 50\ \Omega$, $R_f = 500\Omega$, V = 220 volt,

I drawn by, l amp = $I_\ell = \dfrac{V}{R_\ell} = \dfrac{220}{100} = 2.2\text{A}$, toaster = $I_t = \dfrac{220}{50} = 4.4\text{A}$, Water filter = $I_f = \dfrac{220}{500} = 0.44\text{A}$

Total current drawn = 7.04 A, Current to be drawn by iron = 7.04 A

Resistance of electric iron = $R_1 = \dfrac{V}{I} = \dfrac{220}{7.04} = 31.25\Omega$

Example 24 :

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

Sol. (i) Devices can be operated individually. (ii) Faculty devices can be identified easily.

Example 25 :

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

Sol. (a) Highest – By connecting the resistors in series.

So R = 4 + 8 + 12 + 24 = 48 Ω

(b) Lowest – By connecting the resistors in parallel.

So, $$R = \frac{64}{6+3+2+1} = \frac{24}{12} = 2\Omega$$

CONCEPT MAP

ELECTRICITY

* **Charge:** One of the fundamental properties of elementary particles is called charge. It produces electric and magnetic phenomena.
  Types of charges:
  (i) Positive charge (ii) Negative charge
  • Opposite charges attract each other.
  • Like charges repel each other.
* **Coulomb's law :** The force between two electric charges at rest is directly proportional to the product of the magnitudes of the charges and is inversely proportional to the square of the distance between them.

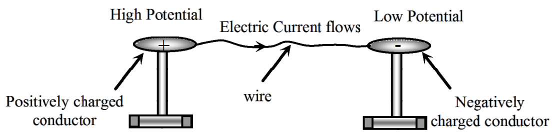
According to coulomb's law

$$F = K\frac{q_1 q_2}{r^2}$$

$\rightarrow q_1$ and q_2 are two electric charges
$\rightarrow K \rightarrow$ constant of proportionality.
$\rightarrow r$ is the distance between two charges.

* **Principle of Conservation of electric charge**
  • Total electric charge in an isolated system is conserved.
  • Electric charge can neither be created nor be destroyed.

* **Electrostatic potential:** Work done in bringing a unit positive charge from infinity to any point is called as the electrostatic potential at that point.
* **Potential difference :** V = W/Q
  • S.I. unit of potential difference is volt (V)
  • It is a scalar quantity
  • It is measured by voltmeter.
* **Electric current :** Electric current is a flow of electric charges in a conductor such as metal wire.
  Current : I = Q/t



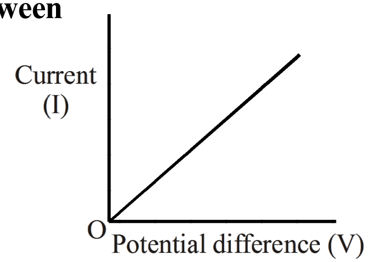
• S.I. unit is Ampere (A)
• Current is a scalar quantity
• Current is measured by Ammeter.
• Current always flows from higher potential to lower potential.

* **Ohm's Law**
  According to Ohm's law, at constant temperature, the current flowing through a conductor is directly proportional to the potential difference across its ends.

$I \propto V$ or $V = R \times I$
$R \rightarrow$ Resistance; $V \rightarrow$ Potential difference
$I \rightarrow$ current

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

* **Graph between V and I**



Since the **'current - potential difference'** graph is a straight line, we conclude that current is directly proportional to potential difference. [For ohmic devices]

* **Factors affecting the resistance of a conductor**
  (i) Length of conductor i.e. $R \propto \ell$
  (ii) Area of cross section of the conductor i.e $R \propto 1/A$
  (iii) Nature of material of the conductor.
  (iv) Temperature of the conductor.
  ▪ Resistance of all pure metals increases on increasing the temperature.
  ▪ Resistance decreases on lowering the temperature.

CONCEPT MAP

ELECTRICITY

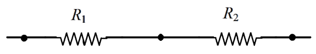
* **Resistivity**
By combining the relations in points (i) and (ii) $R = \frac{\rho \times \ell}{A}$
Where ρ is a constant known as resistivity of the material of the conductor. It is also known as specific resistance.

$$\text{Resistivity}(\rho) = \frac{R \times A}{\ell}$$

$R \rightarrow$ Resistance of conductor
$A \rightarrow$ Area of cross section of conductor
$\ell \rightarrow$ length of the conductor

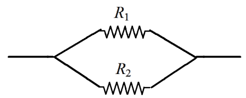
- SI unit of resistivity is ohm-meter which is written in symbols as Ω m

* **Combination of resistances(or resistors)**
→ When two or more resistances are connected end to end consecutively they are said to be connected in series.



Series Combination

→ When two or more resistances are connected between the same two points, they are said to be connected in parallel



Parallel Combination

* **Law of combination of resistance in series :** The combined resistance of any number of resistances connected in series is equal to the sum of the individual resistances

$$R = R_1 + R_2 + R_3 + \text{..........}$$

* **Law of combination of resistance in parallel :** The reciprocal of the combined resistance of a number of resistances in parallel is equal to the sum of the reciprocals of all the individual resistances

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

* **Types of Material on the basis of their electric conductivity**

1. **Conductors :**Those substances through which electricity can flow are called conductors
2 **Insulators** Those substances through which electricity cannot flow are called insulators
3 **Superconductors** The phenomenon of loss of electrical resistance by a substance on cooling it an extremely low temperature is known as supper conductivity and the substance under these conditions are called superconductors.

* **Electric power :** Electrical power is the electrical work done per unit time.

$$\text{Electrical power} = \frac{\text{Work done by electric current}}{\text{time taken}}$$

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

- SI unit of power is watt.

* **Electrical energy -**According to law of conservation of energy,
Work done by electric current
= Electric energy consumed. Hence,
Electric energy = Power × Time i.e,

$E = P \times t$

- Commercial unit of electrical energy is **Kilowatt-hour (KWh)**
1 KWh=36,00,000 Joules=3.6×10^6 Joules

* **Heating effects of current**
The heating effect of current is obtained by the transformation of electrical energy into heat energy.
Heat produced, $H = I^2 \times R \times T$

QUESTION BANK

EXERCISE - 1

Q.1 What are the factors on which resistance depends ?

Q.2 Which combination have maximum value of equivalent resistance ?

Q.3 If one coulomb charge flows in a circuit for one second then what will be the value of current in the circuit.

Q.4 Define one ohm resistance.

Q.5 Write Ohm's law. Explain it by giving diagram of an electric circuit.

Q.6 Write the expression for the equivalent resistance R of three resistors R_1, R_2 and R_3 joined in (i) parallel, (ii) series.

Q.7 Define the term current and state its SI unit.

Q.8 Define the term resistance.

Q.9 How does the resistance of a metallic wire depend on its temperature ? Explain the reason to your answer.

Q.10 A lamp draws a current of 0.5A when it is connected to a 230 V supply. What is the resistance of the filament of the lamp ?

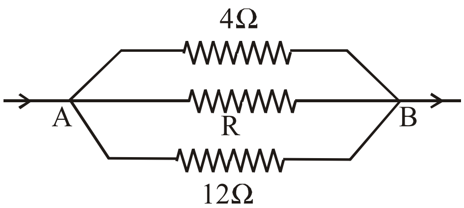
Q.11 A circuit consists of a 1Ω wire in series with a parallel arrangement of 6Ω and 3Ω with a P.D. of 12V is connected across the whole circuit. Draw the circuit diagram and calculate the main current in the circuit.

Q.12 A 4Ω resistance wire is bent in the middle by 180° and both the halves are twisted with each other. Find its new resistance.

Q.13 Two resistors of 15Ω and 30Ω are connected in parallel. What resistance should be connected in series of the combination to get an equivalent resistance of 20Ω ?

Q.14 There are three bulbs marked 40W-110V, 40W-110V and 80W-110V. How should they be mutually joined so that on being connected to a supply of 220V they glow with normal brightness ?

Q.15 The equivalent resistance between the point A and B in the adjoining circuit is 2 Ω. Determine the value of R.



Q.16 Join three resistances of 2 ohm each such that the total resistance of the circuit is 3 ohm.

Q.17 Name a device that helps to maintain a potential difference across a conductor. What is meant by saying that the potential difference between two points is 1 V ?

Q.18 A 60W auto lamp allows 5 amps to pass through it. Find
(i) The p.d. across its terminal.
(ii) the resistance of the filament of the lamp
(iii) energy consumed in 2 hours

Q.19 An electric bulb is connected to a 220V generator. The current is 0.50V. What is the power of the bulb ?

Q.20 What uses more energy, a 250 W TV set in 1 hr. or a 1200W toaster in 10 minutes ?

Q.21 A copper wire has diameter 0.5 mm and resistivity of 1.6×10^{-8} Ωm. What will be the length of this wire to make its resistance 10Ω? How much does the resistance change if the diameter is doubled ?

Q.22 Name two devices which use the heating effect of current.

Q.23 Why is the filament of an electric bulb not made of carbon?

Q.24 Obtain an expression for the (i) electrical energy (ii) electrical power, spent in flow of current through a conductor.

Q.25 How is a fuse put in an electric circuit ? State the purpose of using a fuse in a circuit.

Q.26 60W-220V is written on a bulb. What does it mean ?

Q.27 What is the electric power ? Derive a formula for it ?

Q.28 How does an electric circuit is kept safe with fuse ?

Q.29 A 60-W bulb is switched on in a room. A 240-W heater is also turned on in the same room. The voltage of the mains is 120V and the resistance of the connecting leads is 6Ω. What is the change in the voltage at the bulb when the heater is turned on.

Q.30 Calculate the cost of electric bill of a house for the month of March. The following appliances were used in the house for the duration shown respectively. The cost of electrical energy is 50 paise per unit.
6 – 100 W lamps 4h each ; 5 – 60 W lamps 5h each ; 1 – 750 W iron 2 h ; 1 – 2 kW geyser 2h

Q.31 An electric iron consumes energy at a rate of 840W when heating is at the maximum rate and 360W when the heating is at the minimum. The voltage is 220V. What are the current and the resistance in each case

Q.32 A hot plate of an electric oven connected to a 220V line has two resistance coils A and B, each of 24Ω resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases ?

Q.33 Three resistors of 20 ohm, 30 ohms and 50 ohm resistance are joined in series. Across this combination a source of 150 volts is connected then determine the current in each resistor and potential difference across their ends.

Q.34 A heating coil is immersed in a calorimeter of heat capacity 50 $J°C^{-1}$ containing 1.0 kg of a liquid of specific heat capacity 450 $J\,kg^{-1}\,°C^{-1}$. The temperature of liquid rises by 10°C when 2.0 A current is passed for 10 minutes. Find (i) the resistance of the coil (ii) the potential difference across the coil. State the assumption used in your calculations.

Q.35 A geyser is rated 1500W, 250V. This geyser is connected to 250V mains. Calculate : (i) the current drawn, (ii) the energy consumed in 50 hours. (iii) the cost of energy consumed at Rs. 220 per kWh.

Q.36 When a potential difference of 2 volt is applied across the ends of a wire of 5m length, a current of 1A is found to flow through it. Calculate : (i) the resistance per unit length of the wire (ii) the resistance of 2m length of this wire (iii) the resistance across the ends of the wire it is doubled on itself.

Q.37 Name the instrument used to measure electric current.

Q.38 Write the unit of electrical resistance.

Q.39 Name the best conductor of electricity.

Q.40 In domestic wiring do we connect various distribution circuits in series ?

Q.41 What do you mean by a 'fuse' ?

Q.42 What do you mean by a circuit diagram ?

Q.43 Name the term used to represent the values of the voltage and wattage (power) of an electrical appliance taken together.

Q.44 Draw a schematic diagram of a current consisting of a battery of three cells of 2V each, a 5Ω resistor, an 8Ω resistor and a 12Ω resistor and a plug key, all connected in series.

EXERCISE - 2

FILL IN THE BLANKS

Q.1 Kilowatt is the unit of electrical .... but kilowatt-hour is the unit of electrical ....

Q.2 Energy spent in kilowatt-hour = $\frac{\text{volt} \times \text{.........} \times \text{..........}}{1000}$

Q.3 A fuse is a short piece of wire of high .... and low ....

Q.4 Fuse wire has a .... melting point and is made of an alloy of ....and .... If the current in a circuit rises too high, the fuse wire ....

Q.5 A fuse is connected in .... to the .... wire.

Q.6 The colour coding of wires is .... for earth .... for live and .... for neutral.

Q.7 Electric energy is produced by the .... of charges.

Q.8 The rate of flow of electric charge is called ....

Q.9 Current is measured with an instrument called a (an).................

Q.10 Energy converted per unit charge is measured with an instrument called a (n)....................

Q.11 If there is no current, a voltmeter connected across a resistor will register.

Q.12 Between any two points in a circuit, the sum of all .... is the same through any pathway.

Q.13 Combined resistance is the sum of separate resistances provided that the various conductors are connected in ....

Q.14 In a parallel circuit, each circuit element has the same ....

Q.15 Copper is a preferred material for making wire because of its low.......................

TRUE-FALSE STATEMENTS –

Q.16 The filament resistance of glowing bulb is greater, to its resistance when it is not glowing ?

Q.17 The quantity of charge flowing past a point multiplied by time is a current.

Q.18 The resistivity of all pure metals increases with the rise in temperature.

Q.19 Ohm's law is a relation between the power used in a circuit to the current and the potential difference.

Q.20 Direction of current is taken opposite to the direction of flow of electrons.

Q.21 A cell generates a potential difference across its terminals

Q.22 The equivalent resistance of several resistors in series is equal to the sum of their individual resistances.

Q.23 The commercial unit of electrical energy is kilowatt hour (kWh).

Q.24 In parallel combination, the reciprocal of equivalent resistance is the sum of the reciprocal of individual resistance.

EXERCISE - 3

Q.1 A cylindrical rod is reformed to twice its length with no change in its volume. If the resistance of the rod was R, the new resistance will be –

(A) R (B) 2R (C) 4R (D) 8R

Q.2 What is the current through a 5.0 ohm resistor if the voltage across it is 10V –

(A) zero (B) 0.50 A (C) 2.0 A (D) 5.0 A

Q.3 A wire carries a steady current of 1.0 A over a period of 20s. What total charge passes through the wire in this time interval –

(A) 200 C (B) 20 C (C) 2.0 C (D) 0.20 C

Q.4 The length of a wire is doubled and the radius is doubled. By what factor does the resistance change–

(A) 4 times as large (B) twice as large (C) unchanged (D) half as large

Q.5 A 1500 watt heater is connected to a 120 volt source for 2.0 h. How much heat energy is produced –

(A) 1.1×10^7 J (B) 1.8×10^5 J (C) 9.0×10^4 J (D) 3.0×10^3 J

Q.6 A circular conductor is made of a uniform wire of resistance 2×10^{-3} ohm/metre and the diameter of this circular conductor is 2 metres. Then the resistance measured between the ends of the diameter is (in ohms) –

(A) $\pi \times 10^{-3}$ (B) $2\pi \times 10^{-3}$ (C) $4\pi \times 10^{-3}$ (D) 4×10^{-3}

Q.7 A 24V potential difference is applied across a parallel combination of four 6 ohm resistor. The current in each resistor is –

(A) 1 A (B) 4 A (C) 16 A (D) 36 A

Q.8 Two electric lamps each of 100 watts 220V are connected in series to a supply of 220 volts. The power consumed would be –

(A) 100 watts (B) 200 watts (C) 25 watts (D) 50 watts

Q.9 Three resistances of 2, 3 and 5Ω are connected in parallel to a 10V battery of negligible internal resistance. The potential difference across the 3Ω resistance will be –

(A) 2V (B) 3V (C) 5V (D) 10V

Q.10 Two unequal resistances are connected in parallel. Which of the following statement is true –

(A) current in same in both (B) current is larger in higher resistance

(C) voltage-drop is same across both (D) voltage-drop is lower in lower resistance

Q.11 You are given n identical wires, each of resistance R. When these are connected in parallel, the equivalent resistance is X. When these will be connected in series, then the equivalent resistance will be –

(A) X/n^2 (B) n^2X (C) X/n (D) nX

Q.12 A piece of wire of resistance R is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is R', then the ratio R/R' is –
(A) 1/25 (B) 1/5 (C) 5 (D) 25

Q.13 An electric bulb is rated 220V and 100W. When it is operated on 110V, the power consumed will be –
(A) 100W (B) 75W (C) 50W (D) 25W

Q.14 2 ampere current is flowing through a conductor from a 10 volt emf source then resistance of conductor is
(A) 20 Ω (B) 5 Ω (C) 12 Ω (D) 8 Ω

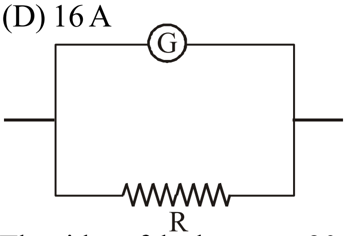
Q.15 Charge on an electron is 1.6×10^{-19} coulomb. Number of electrons passing through the wire per second on flowing of 1 ampere current through the wire will be–
(A) 0.625×10^{-19} (B) 1.6×10^{-19} (C) 1.6×10^{-19} (D) 0.625×10^{19}

Q.16 20 coulomb charge is flowing in 0.5 second from a point in an electric circuit then value of electric current in amperes will be –
(A) 10 (B) 40 (C) 0.005 (D) 0.05

Q.17 Three resistors of 4.0 Ω, 6.0 Ω and 10.0 Ω are connected in series. What is their equivalent resistance–
(A) 20 Ω (B) 7.3 Ω (C) 6.0 Ω (D) 4.0 Ω

Q.18 The following three appliances are connected to a 120 volt house circuit : (A) computer and printer, 3.50W, (B) coffee pot, 650W, and (C) microwave, 900W. If all were operated at the same time what total current would they draw –
(A) 0.063 (B) 2.9 A (C) 5.4 A (D) 16 A

Q.19 In the following simple circuit, G is a galvanometer and R is a resistor. What is this arrangement likely to be used to measure in a circuit –



(A) voltage (B) current
(C) resistance (D) power

Q.20 A letter 'A' is constructed of a uniform wire of resistance 1 ohm per cm. The sides of the letter are 20 cm. and the cross piece in the middle is 10 cm. long. The resistance between the ends of the legs will be–
(A) 32.4 ohm (B) 28.7 ohm (C) 26.7 ohm (D) 24.7 ohm

Q.21 If it takes 8 minutes to boil a quantity of water electrically, how long will it take to boil the same quantity of water using the same heating coil but with the current doubled –
(A) 32 minutes (B) 16 minutes (C) 4 minutes (D) 2 minutes

Q.22 A wire of resistance R is cut into ten equal parts which are then joined in parallel. The new resistance is –
(A) 0.01 R (B) 0.1 R (C) 10 R (D) 100 R

Q.23 When a current I flows through a resistance R for time t, the electrical energy spent is given by –
(A) IRt (B) I^2Rt (C) IR^2t (D) I^2R/t

Q.24 Kilowatt-hour is the unit of –
(A) potential difference (B) electric power (C) electrical energy (D) charge

Q.25 When main switch of the house circuit is put off, it disconnects the –
(A) live wire (B) neutral wire (C) earth wire (D) live and neutral wires

Q.26 According to international convention of colour coding in a wire –
(A) live is red, neutral is black and earth is green (B) live is red, neutral is green and earth is black
(C) live is brown, neutral is blue and earth is black (D) live is red, neutral is black and earth is green

Q.27 An electric bulb is filled with –
(A) hydrogen (B) oxygen and hydrogen (C) ammonia (D) nitrogen and argon

Q.28 The unit of resistivity is –
(A) ohm (B) ohm/m (C) ohm × m (D) mho

Q.29 For which of the following substances, resistance decreases with temperature –
(A) copper (B) mercury (C) carbon (D) platinum

Q.30 If a wire is stretched to make its length three times, its resistance will become –
(A) three times (B) one-third (C) nine times (D) one-ninth

Q.31 The resistivity of a wire depends on –
(A) length (B) area of cross-section (C) material (D) all the above three factors

Q.32 Which of the following statements does not represent Ohm's law –
(A) current/potential difference = constant (B) potential difference/current = constant
(C) potential difference =current × resistance (D) current = resistance × potential difference

Q.33 When current is passed through an electric bulb, its filament glows, but the wire leading current to the bulb does not glow because –
(A) less current flows in the leading wire as compared to that in the filament
(B) the leading wire has more resistance than the filament
(C) the leading wire has less resistance than the filament
(D) filament has coating of fluorescent material over it

Q.34 From a power station, the power is transmitted at a very high voltage because –
(A) it is generated only at high voltage
(B) it is cheaper to produce electricity at high voltage
(C) electricity at high voltage is less dangerous
(D) there is less loss of energy in transmission at high voltage

Q.35 When a fuse is rated 8A, it means –
(A) it will not work if current is less than 8A (B) it has a resistance of 8 ohm
(C) it will work only if current is 8A (D) it will burn if current exceeds 8A

Q.36 Fuse wire is made of –
(A) platinum (B) copper (C) aluminium (D) alloy in tin and lead

Q.37 Which is not a device based on the heating effect of electricity –
(A) heater (B) toaster (C) refrigerator (D) press

Q.38 Which of the following terms does not represent electrical power in a circuit?
(A) I^2R (B) IR^2 (C) VI (D) V^2/R

Q.39 Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then parallel in a circuit across the same potential difference. The ratio of heat produced in series and parallel combinations would be–
(A) 1 : 2 (B) 2 : 1 (C) 1 : 4 (D) 4 : 1

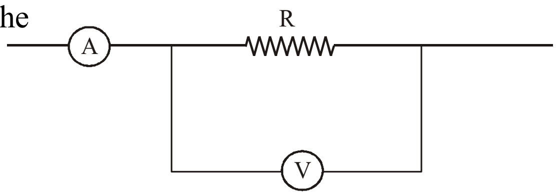
Q.40 Two electric bulbs whose resistance are in the ratio of 1:2 are connected in parallel to a constant voltage source. The ratio of the power dissipated in them will be –
(A) 1 : 4 (B) 1 : 2 (C) 1 : 1 (D) 2 : 1

Q.41 Cost of electricity for home use in Rs. 1.50 per unit. This unit is –
(A) 1 ampere (B) 1 volt (C) 1 joule (D) 1 kilowatt hour

Q.42 A wire of resistance 12 ohms is bent in the form of a circular ring. The effective resistance between the two points on any diameter of the circle is –
(A) 24 ohm (B) 12 ohm (C) 6 ohm (D) 3 ohm

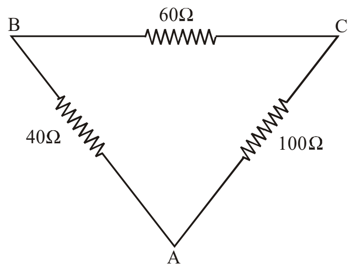
Q.43 Ampere-second stands for the unit of –
(A) power (B) charge (C) emf (D) energy

Q.44 In the circuits shown below the ammeter A reads 4 amp. and the voltmeter V reads 20 volts. The value of the resistance R is –



(A) slightly more than 5 ohms
(B) slightly less than 5 ohms
(C) Exactly 5 ohms
(D) None of the above

Q.45 Three resistors are connected to form the sides of a triangle ABC as shown.The resistance of side AB is 40 ohms, of side BC 60 ohms and of side CA 100 ohms. The effective resistance between the point A and B in ohms is –



(A) 50 (B) 64
(C) 32 (D) 100

Q.46 Which one of the following is bad conductor of electricity–
(A) acid (B) coal (C) distilled water (D) human body

Q.47 On which one of the following the emf of a cell does not depend –
(A) The nature of the metal of electrodes (B) The size of the plates
(C) Nature of the electrolyte (D) The nature of electrodes

Q.48 If one micro-amp. current is flowing in a wire, the number of electrons which pass from one end of the wire to the other end in one second is –
(A) 6.25×10^{12} (B) 6.25×10^{15} (C) 6.25×10^{18} (D) 6.25×10^{19}

Q.49 The primary cell which is used in daily life is –
(A) Leclanche cell (B) Dry cell (C) Daniel cell (D) Simple voltaic cell

Q.50 Which one of the following primary cells has emf 1.08 volts and which remains fairly constant –
(A) Daniel cell (B) Simple voltaic cell (C) Leclanche cell (D) Dry cell

Q.51 Coulomb is equal to –
(A) 1 amp × 1 sec (B) 1 amp/1 sec (C) 1 joule × 1 amp (D) 1 joule/1 sec

Q.52 Which one of the following is non-ohmic resistance –
(A) mercury (B) copper (C) nichrome (D) bulb of a torch

Q.53 Which one of the following is the definition of specific resistance –
(A) It is resistance of a wire of length 1 cm. and volume 2c.c.
(B) It is resistance of a wire of volume 1 c.c.and mass 1gm.
(C) It is the resistance of a wire 1 cm length and 1 sq. cm cross section
(D) It is the resistance of a wire of volume 1 c.c. and potential difference 1 volt.

Q.54 The unit for specific resistance is –
(A) ohm × second (B) ohm × cm (C) ohm (D) ohm/cm

Q.55 Two wires of resistance R_1 and R_2 are joined in parallel. The equivalent resistance of the combination is –
(A) $R_1R_2/R_1 + R_2$ (B) $R_1 + R_2$ (C) $R_1 \times R_2$ (D) R_1/R_2

Q.56 If the temperature of a conductor is increased, its resistance will –
(A) not increase (B) increase (C) decrease (D) change according to the whether

Q.57 The unit for electric conductivity is –
(A) ohm per cm (B) ohm × cm (C) ohm per second (D) mho

Q.58 Primary cell are connected in parallel to –
(A) Increase voltage (B) decrease capacity
(C) decrease internal resistance (D) make electric current constant

Q.59 In a closed circuit drawing current from cell, the emf of a cell is always –
(A) Less than potential difference (B) More than potential difference
(C) Half of the potential difference (D) Double of the potential difference

Q.60 The filament of an electric bulb is of tungsten because –
(A) Its resistance is negligible (B) It is cheaper
(C) Its melting point is high (D) Filament is easily made

EXERCISE - 4

MATCH THE COLUMN–

Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **column I** have to be matched with statements (p, q, r, s) in **column II**.

Q.1 Column II gives nature of temperature coefficient of resistance for materials written in column I.

Column I	**Column II**
(A) Metal	(p) Zero
(B) Insulator	(q) positive
(C) Semi-conductor	(r) negative
(D) Alloys	(s) unknown

Q.2 A voltmeter and an ammeter are connected in series to an ideal cell of emf E. The voltmeter reading is V and the ammeter reading is I.

Column I	**Column II**
(A) Voltmeter resistance	(p) E – V
(B) Potential difference across ammeter	(q) V/I
(C) Voltmeter resistance plus ammeter resistance	(r) E/I
(D)Potential difference across voltmeter	(s) V

Q.3 Column II gives name of material use for device given in column I

Column I	**Column II**
(A) Resistance of resistance box	(p) Tungsten
(B) Fuse wire	(q) maganin
(C) Bulb	(r) tin-leadalloy
(D) Potentiometer wire	(s) nichrome

Q.4 Column II gives order of resistivity for materials in column I

Column I	**Column II**
(A) Semi-conductor	(p) 3×10^{3} Ω-m
(B) Conductor	(q) 10^{-8} Ω-m
(C) Insulator	(r) 10^{16} Ω-m
(D) Super conductor	(s) 1 Ω-m

ASSERTION & REASON TYPE

Each question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason). Each question has 5 choices (A), (B), (C), (D) and (E) out of which ONLY ONE is correct.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement -1 is True, Statement-2 is False. (D) Statement -1 is False, Statement-2 is True.
(E) Statement -1 is False, Statement-2 is False.

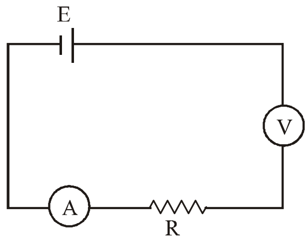
Q.5 **Statement 1 :** When a battery is short-circuited, the terminal voltage is zero.
Statement 2 : In the situation of a short-circuit, the current is zero

Q.6 **Statement 1 :** The equation V = Ri does not apply to those conducting devices which do not obey Ohm's law.
Statement 2 : V = Ri is a statement of Ohm's law.

Q.7 **Statement 1 :** The emf of a battery equal the potential difference between its terminals when the terminals are not corrected externally.
Statement 2 : Terminals potential difference can be greater than emf of cell.

Q.8 **Statement 1 :** A resistor of resistance R is connected to an ideal battery. If the value of R is decreased, the power dissipated in the circuit will decrease.
Statement 2 : The power dissipated in the circuit is directly proportional to the resistance of the circuit.

Q.9 **Statement 1 :** All electric devices shown in the circuit are ideal. The reading of each of ammeter (A) and voltmeter (V) is zero.



Statement 2 : An ideal voltmeter draws almost no current due to very large resistance, and hence (V) and (A) will read zero.

EXERCISE - 5

PREVIOUS YEARS COMPETITION PROBLEMS

Q.1 How much energy in kilowatt hour is consumed in operating ten 50 watt bulbs for 10 hours per day in a month (30 days)
(A) 1500 (B) 5000 (C) 15 (D)150

Q.2 Three resistances 4Ω each of are connected in the form of an equilateral triangle. The effective resistance between two corners is–
(A) 8Ω (B) 12Ω (C) 3/8 Ω (D) 8/3 Ω

Q.3 A current of 2A passing through conductor produces 80J of heat in 10 seconds. The resistance of the conductor is –
(A) 0.5Ω (B) 2Ω (C) 4Ω (D) 20Ω

Q.4 Two wires of same metal have the same length but their cross-sections area in the ratio 3 : 1. They are joined in series. The resistance of the thicker wire is 10Ω. The total resistance of the combination will be –
(A) 40 Ω (B) 40/3 Ω (C) 5/2 Ω (D) 100 Ω

Q.5 A heating coil is labelled 100W, 220V. The coil is cut in half and the two pieces are joined in parallel to the same source. The energy now liberated per second is –
(A) 200 J (B) 400 J (C) 25 J (D) 50 J

Q.6 What is immaterial for an electric fuse wire –
(A) Its specific resistance (B) Its radius (C) Its length (D) Current flowing through it

Q.7 A certain piece of silver of given mass is to be made like a wire. Which of the following combination of length (L) and the area of cross-sectional (A) will lead to the smallest resistance –
(A) L and A (B) 2L and A/2 (C) L/2 and 2A
(D) Any of the above, because volume of silver remains same

Q.8 If R_1 and R_2 are respectively the filament resistance of a 200 watt bulb and 100 watt bulb designed to operate on the same voltage, then –
(A) R_1 is two times R_2 (B) R_2 is two times R_1 (C) R_2 is four times R_1 (D) R_1 is four times R_2

Q.9 A (100W, 200V) bulb is connected to a 160V power supply. The power consumption would be –
(A) 64 W (B) 80 W (C) 100 W (D) 125 W

Q.10 A galvanometer having a resistance of 8 ohm is shunted by a wire of resistance 2 ohm. If the total current is 1 amp, the part of it passing through the shunt will be –
(A) 0.25 amp (B) 0.8 amp (C) 0.2 amp (D) 0.5 amp

Q.11 Three equal resistors connected in series across a source of e.m.f. together dissipate 10 watt. If the same resistors are connected in parallel across the same e.m.f., then the power dissipated will be –
(A) 10 watt (B) 30 watt (C) 10/3 watt (D) 90 watt

Q.12 A 5°C rise in temperature is observed in a conductor by passing a current. When the current is doubled the rise in temperature will be approximately –
(A) 16°C (B) 10°C (C) 20°C (D) 12°C

Q.13 A certain wire has a resistance R. The resistance of another wire identical with the first except having twice its diameter is

(A) 2R (B) 0.25 R (C) 4R (D) 0.5 R

Q.14 The resistance of a wire is R. If the length of the wire is doubled by stretching, then the new resistance will be –

(A) 2R (B) 4R (C) R (D) R/4

Q.15 For driving a current of 2A for 6 minutes in a circuit, 1000 J of work is to be done. The e.m.f. of the source in the circuit is

(A) 1.38 V (B) 1.68 V (C) 2.04 V (D) 3.10 V

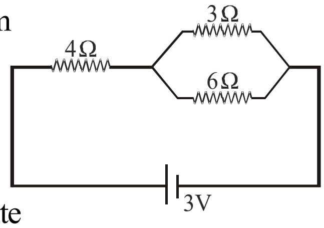
Q.16 The resistance of a wire is 10 Ω. Its length is increased by 10% by stretching. The new resistance will now be

(A) 12 Ω (B) 1.2 Ω (C) 13 Ω (D) 11 Ω

Q.17 What length of the wire of specific resistance 48×10^{-8} Ω-m is needed to make a resistance of 4.2 Ω (diameter of wire = 0.4 mm)

(A) 4.1 m (B) 3.1 m (C) 2.1 m (D) 1.1 m

Q.18 The potential drop across the 3Ω resistor is –



(A) 1V (B) 1.5V

(C) 2V (D) 3V

Q.19 The resistance of an ideal voltmeter is –

(A) zero (B) very low (C) very large (D) Infinite

Q.20 Two electric bulbs, one of 200 volt 40 watt and the other 200 volt 100W are connected in a house wiring circuit

(A) They have equal currents through them

(B) The resistance of the filaments in both the bulbs is same

(C) The resistance of the filament in 40 watt bulb is more than the resistance in 100 watt bulb

(D) The resistance of the filament in 100 watt bulb is more than the resistance in 40 watt bulb

Q.21 A 25W, 220V bulb and a 100W, 220V bulb are connected in parallel across a 440V line –

(A) Only 100 watt bulb will fuse (B) Only 25 watt bulb will fuse

(C) Both bulbs will fuse (D) None of the bulbs will fuse

Q.22 The potential difference in open circuit for a cell is 2.2 volts. When a 4 ohm resistor is connected between its two electrodes the potential difference becomes 2 volts. The internal resistance of the cell will be –

(A) 1 ohm (B) 0.2 ohm (C) 2.5 ohm (D) 0.4 ohm

Q.23 Masses of 3 wires of same metal are in the ratio 1 : 2 : 3 and their lengths are in the ratio 3 : 2 : 1. The electrical resistances are in ratio –

(A) 1 : 4 : 9 (B) 9 : 4 : 1 (C) 1 : 2 : 3 (D) 27 : 6 : 1

Q.24 The resistance of a conductor increases with –

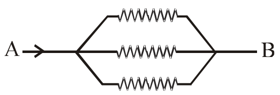
(A) Increase in length (B) Increase in temperature

(C) Decrease in cross-sectional area (D) All of these

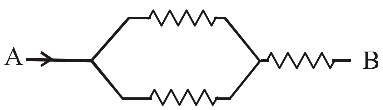
Q.25 When a 12Ω resistor is connected in series with a moving coil galvanometer then its deflection reduces from 50 divisions to 10 divisions. The resistance of the galvanometer is –

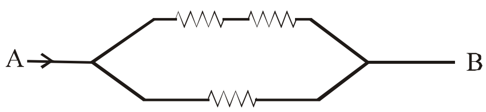
(A) 24 ohm (B) 36 ohm (C) 3 ohm (D) 60 ohm

Q.26 Arrange the order of power dissipated in the given circuits, if the same current is passing through all three resistance and each resistor is r –

(I) 

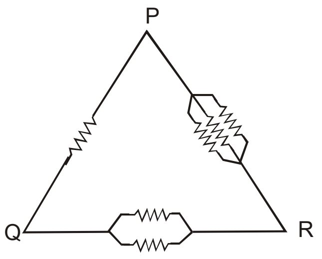
(II) 

(III) 

(IV) 

(A) $P_2 > P_3 > P_4 > P_1$ (B) $P_3 > P_2 > P_4 > P_1$ (C) $P_4 > P_3 > P_3 > P_1$ (D) $P_1 > P_2 > P_3 > P_4$

Q.27 Six equal resistances are connected between points P, Q and R as shown in the figure. Then the net resistance will be maximum between –



(A) P and Q
(B) Q and R
(C) P and R
(D) any two points

Q.28 We have two wires A and B of same mass and same material. The diameter of the wire A is half of that B. If the resistance of wire A is 24 ohm then the resistance of wire B will be –
(A) 12 ohm (B) 3.0 ohm (C) 1.5 ohm (D) None of the above

Q.29 The material of fuse wire should have –
(A) A high specific resistance and high melting point (B) A low specific resistance and low melting point
(C) A high specific resistance and low melting point (D) A low specific resistance and high melting point

Q.30 The electric resistance of a certain wire of iron is R. If its length and radius are both doubled, then –
(A) The resistance will be doubled and the specific resistance will be halved
(B) The resistance will be halved and the specific resistance will remain unchanged
(C) The resistance will be halved and the specific resistance will be doubled
(D) The resistance and the specific resistance, will both remain unchanged

Q.31 A battery is charged at a potential of 15V for 8 hours when the current flowing is 10A. The battery on discharge supplies a current of 5A for 15 hours. The mean terminal voltage during discharge is 14V. The "Watt-hour" efficiency of the battery is –
(A) 82.5% (B) 80% (C) 90% (D) 87.5%

Q.32 Three electric bulbs of rating 60W each are joined in series and then connected to electric mains. The power consumed by these three bulbs will be –
(A) 180 W (B) 60 W (C) 20 W (D) 20/3 W

Q.33 When a wire of uniform cross-section a, length ℓ and resistance R is bent into a complete circle, resistance between any two of diametrically opposite points will be –
(A) R/4 (B) R/8 (C) 4R (D) R/2

Q.34 Which of the following has a negative temperature coefficient –
(A) C (B) Fe (C) Mn (D) Ag

Q.35 The reciprocal of resistance is –
(A) Conductance (B) Resistivity (C) Voltage (D) None of the above

Q.36 A solenoid is at potential difference 60V and current flows through it is 15 ampere, then the resistance of coil will be –
(A) 4 Ω (B) 8 Ω (C) 0.25 Ω (D) 2 Ω

Q.37 The resistance of a discharge tube is –
(A) Ohmic (B) Non-ohmic (C) Both (A) and (B) (D) Zero

Q.38 In a hydrogen discharge tube it is observed that through a given cross-section 3.13×10^{15} electrons are moving from right to left and 3.12×10^{15} protons are moving from left to right. What is the electric current in the discharge tube and what is its direction –
(A) 1mA towards right (B) 1mA towards left (C) 2mA towards left (D) 2mA towards right

Q.39 If a wire of resistance 20 ohm is covered with ice and a voltage of 210 V is applied across the wire, then the rate of melting of ice is –
(A) 0.85 g/s (B) 1.92 g/s (C) 6.56 g/s (D) All of these

Q.40 Masses of three wires of copper are in the ratio of 1 : 3 : 5 and their lengths are in the ratio of 5 : 3 : 1. The ratio of their electrical resistances are –
(A) 1 : 3 : 5 (B) 5 : 3 : 1 (C) 1 : 15 : 125 (D) 125 : 15 : 1

EXERCISE - 6

PREVIOUS YEARS BOARD QUESTIONS

Q.1 What is the S.I. unit electric potential?

Q.2 What is meant by the statement " Potential difference between points A and B in an electric field is l volt"?

Q.3 There are two electric bulbs (i) Marked 60 W, 220 V and (ii)Marked 100 W, 220 V. Which one of two has a higher resistance?

Q.4 Out of the two, a toaster of l k W and an electric heater of 2kw, which has a greater resistance?

Q.5 Name a meatal which offers higher resistance to the passage of electricity other than copper.

Q.6 Which has a higher resistance: a 50 W lamp bulb or a 25 W lamp bulb and how many times?

Q.7 Why is tungsten metal selected for making filaments of incandescent lamp bulbs?

Q.8 A wire of resistance 10Ωis bent in the form of a close circle. What is the effective resistance between the two points at the ends of any diameter of the circle?

Q.9 Define the term resistivity of a material.

Q.10 Calculate the resistance of a conductor, if the current flowing through it is 0.2 A when the applied potential difference is 0.8 volt.

Q.11 A cylinder of a material is 10 cm long and has a cross-section of $2cm^2$. If its resistance along the length be 20Ω, what will its resistivity value be in number and units?

Q.12 Which has greater resistance l kW electric heater or a 100 W filament bulb both marked for 220 V?

Q.13 A heater joined in parallel with a 60 W bulb is replaced by a 100 W bulb, Will the rate of heat produced by the heater be more or less or remains the same ?

Q.14 Nichrome and copper wires of same length and same radius are connected in series. Current l is passed through then. Why does the nichrome wire get heated first?

Q.15 Two bulbs are marked 60 W, 220 V and 100 W, 220V. These are connected in parallel to 220 V main. Which one of the two will glow brighter ?

Q.16 A toaster produces more heat than a light bulb when connected in a parallel to the 220 V mains. Which of the has greater resistance?

Q.17 Two bulbs whose resistances are in the ratio 1 : 2, are connected in parallel to a source of constant voltage. What will be the ratio of power dissipation of these?

Q.18 Two wires, one of manganin and the other of copper have equal lengths and resistances. Which one of these wires will be thicker?

Q.19 Two wire A and B are of the same metal, have the same are of cross-section and have their lengths in the ratio of 2: 1 What will be the ratio of currents flowing through them respectively when the same potential difference is applied across length of each of them?

Q.20 (a) What is the function of an earth wire in electrical instruments? Why is it necessary to earth to earth the metallic electric appliances?

(b) Explain what is short circuiting and overloading in an electric and overloading in an electric supply.

(c) What is the usual capacity of the fuse wire in the line to feed:

(i) light and fans ? (ii) appliances of 2 kW or more power ?

Q.21 How much current will an electric heater rated l kW draw when connected to 250 V?

Q.22 A student obtains resistances 3,4,12 and 16 Ω using only two metallic resistance wires are either separately or joined together. What is the value of resistance of each of these wires?

Q.23 An electric iron has a rating of 750 W, 220 V. Calculate (i) Current passing through it, and (ii) Its resistance, when in use.

Q.24 An electric iron has a rating of 1000 W, 220 V. When in use calculate for it.

(i) Current passing through it. (ii) Its resistance.

Q.25 An immersion heater has a rating of 2 kW, 220 V. While in use calculate
(i) Current passing through it, and (ii) Its resistance.

Q.26 An electric lamp is marked 100 W, 220 V. It is used for 5 hours daily. Calculate
(i) Its resistance while glowing (ii) Energy consumed in kWh per day.

Q.27 An electric lamp is marked 40 W, 220 V. It is used for 4 hours daily calculate
(i) Its resistance while glowing (ii) Energy consumed in k Wh per day.

Q.28 An electric lamp is marked 25 W, 220 V. It is used for 10 hours daily. Calculate
(i) Its resistance while glowing (ii) Energy consumed in k Wh per day.

Q.29 A bulb is rated at 5.0 volt, 100 mA. Calculate its (i) Power and (ii) Resistance.

Q.30 What is the difference between direct and alternating current ? Write one important advantage of using alternating current.

Q.31 A torch bulb is rated 3V and 600 mA. Calculate its resistance if it is lighted for 4 hours.

Q.32 An electric bulb draw a current of 0.2 A When the voltage is 220 Volts. Calculate the amount of electric charge flowing through it in one hour.

Q.33 In a factory, an electric bulb of 500 W is used for 2 hours and electric bulb of 500 W is used for 2 hours and electric motor of 0.5 horse power is used for 5 hours everyday. Calculate the cost of using the bulb and motor for 30 days if cost of electrical energy is three rupees per unit.

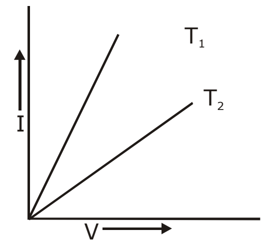
Q.34 State Ohm's law. Express it mathematically. Define S.I. unit of resistance.

Q.35 Define the term resistivity of a conductor. Give its S.I. unit.

Q.36 Define resistivity and state its S.I. unit. Does it vary value with temperature?

Q.37 A heater coil is rated 100 W, 200 V. It is cut into two identical parts. Both parts are connected together in parallel to the same source of 200V.Calculate the energy liberated per second in the new combination.

Q.38 V-I graph for a metallic wire at two different temperatures T_1 and T_2 as shown in the following figure. Which of the two temperatures is higher and why?



Q.39 Calculate the energy supplied by 100 kW of power in one hour

Q.40 A 60 W electric lamp gives off energy in the form of light at a rate of 7.5 joule per second. What percentage of energy does the lamp transform into light energy?

ANSWER KEY

EXERCISE - 1

(10) 460Ω **(11)** 4A **(12)** 1Ω **(13)** 10Ω **(15)** 6 Ω

(18) (i) 12 volts (ii) Resistance = 2.4Ω (iii) 0.12 kWh **(19)** P = VI = 220V × 0.50 A = 110 J/s = 110 W

(20) 250W TV set in 1 hours. **(21)** 122.7 m, 1/4 minutes.

(30) Rs. 145.70 **(31)** (a) 57.60 Ω. (b) 134.15 Ω. **(32)** 9.2 A, 4.6 A, 18.3 A

(33) 1.5 ampere, 30 volts, 45 volts, **(34)** (i) 2.08 Ω (ii) 4.16 V

(35) (i) 6A (ii) 75 kWh (iii) Rs. 165 **(36)** (i) 0.4Ω/m (ii) 0.8 Ω (iii) 1

(37) Ammeter **(38)** Ohm. **(39)** Silver **(40)** No **(43)** Rating. **(44)** 6V

EXERCISE - 2

(1) power, energy **(2)** ampere, hour **(3)** resistance, melting point

(4) low, lead, tin, melts **(5)** series, live **(6)** Green, red, black

(7) separation **(8)** current **(9)** ammeter

(10) voltmeter **(11)** zero **(12)** potential difference

(13) series **(14)** potential difference **(15)** resistivity
(16) True **(17)** False **(18)** True
(19) False **(20)** True **(21)** True
(22) True **(23)** True **(24)** True

EXERCISE - 3											
Q	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
A	C	C	B	D	A	C	B	D	D	C	B
Q	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
A	D	D	B	D	B	A	D	B	C	D	A
Q	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
A	B	C	D	D	D	C	C	C	C	D	C
Q	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**
A	D	D	D	C	B	C	D	D	D	D	A
Q	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**
A	C	C	B	A	B	A	A	D	C	B	A
Q	**56**	**57**	**58**	**59**	**60**						
A	B	D	C	B	C						

EXERCISE - 4

(1) (A) $\rightarrow$ q , (B) $\rightarrow$ t (C) $\rightarrow$ r (D) $\rightarrow$ p **(2)** (A) $\rightarrow$ q , (B) $\rightarrow$ p, (C) $\rightarrow$ r, (D) $\rightarrow$ s
(3) (A) $\rightarrow$ q, (B) $\rightarrow$ r (C) $\rightarrow$ p (D) $\rightarrow$ q **(4)** (A) $\rightarrow$ q, (B) $\rightarrow$ r (C) $\rightarrow$ p (D) $\rightarrow$ q
(5) (C) **(6)** (E) **(7)** (B) **(8)** (E) **(9)** (E)

EXERCISE - 5											
Q	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
A	D	D	B	A	B	C	C	B	A	B	D
Q	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
A	C	B	B	A	A	D	A	C	C	C	D
Q	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
A	D	D	C	A	A	C	C	B	D	C	A
Q	**34**	**35**	**36**	**37**	**38**	**39**	**40**				
A	A	A	A	B	A	C	D				

EXERCISE - 6

(1) Volt or joule/coulomb. **(2)** 1 joule. **(3)** 60 W **(11)** 4Ω-cm **(21)** 4 ampere
(22) 12Ω and 4Ω since in parallel they give 3Ω and in series they give 16Ω **(23)** (i) 3.4 A. (ii) 64.5Ω
(24) (i) 4.5A. (ii) 48.4Ω **(25)** (i) 9 A. (ii) 24.2ΩR **(26)** (i) 484Ω (ii) 0.5 k Wh.
(27) (i) 1210Ω (ii) 0.16 k Wh. **(28)** (i) 1936Ω (ii) 0.25 kWh. **(29)** (i) 0.5 W (ii)5Ω
(31) 5Ω **(32)** 720 C **(33)** Rs. 258. **(37)** 400Ω joule
(39) 3600×10^5 joule **(40)** 12.5%