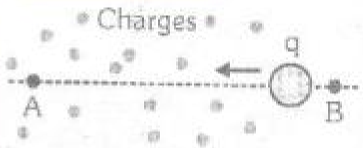
ELECTRICITY

ELECTRICITY

The source of all electricity is charge. As charge is the basis of all electrical phenomena, we need to know the amount of charge on a body. It is measured in coulombs. The coulomb is the SI unit of charge and its symbol is C. Matter is generally made of protons, electrons and neutrons. Each proton carries a charge of 1.6×10^{-19} coulomb, and each negative charge. Neutrons do not carry any net charge. Normally, a body has equal number of protons and electrons, and is therefore, electrically neutral. In certain situations, the balance of charge in a body is disturbed. For example, when a glass rod is rubbed with a silk cloth, some electrons get transferred from the glass rod to the silk. The silk cloth. Which gains electrons, becomes negatively charged. And the glass rod, which is left with more protons than electrons, becomes positively charged. Charged particles or object can exert forces on each other. While like (similar) charges repel each other, unlike charge attract. Another important thing about charged particles is that they can flow, i.e., they can move in a particular direction, this flow of charged particles is called an electric current. Charged particles such as electrons are present in all substances. But they do not flow on their own. For flow of charges, there has to be a potential difference.

POTENTIAL DIFFERENCE AND THE FLOW OF CHARGE



The potential difference between two points A and B is the work done per unit charge in taking a charge from B to a. We express this mathematically as

$$V = V_A - V_B = \frac{W}{q}$$

Here, V is the potential difference between the poets A and B, and V_A and V_B are the potentials at these points.

The potential at infinity is chosen as zero.
If B be the reference point, the potential at B is V_B = O. From Equation, the potential at A is $V_A = W/q$. So, the potential at a point is the work done per unit charge in taking a charge to that point from a chosen reference point. Equation may also be written as

$$W = qV.$$

The work done on the charge q is stored as the electric potential energy (U) of the group of charges. So,

$$U = qV$$

UNIT OF POTENTIAL DIFFERENCE

The unit of potential difference (and potential) is the volt, whose symbol is V. One volt is the potential difference between two points in a current carrying conductor when 1 joule of work is done to move a charge of 1 coulomb from one point to the other.

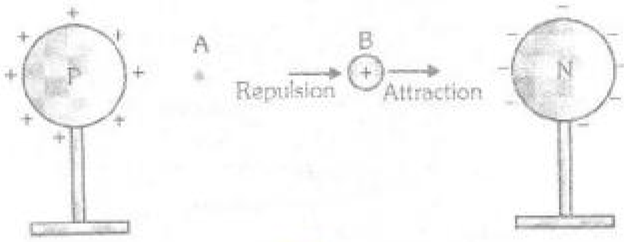
$$\frac{1\ \text{Joule}}{1\ \text{Coulomb}} = 1\ \text{volt or } 1V = 1JC^{-1}$$

The potential difference between two points is sometimes also called the voltage.

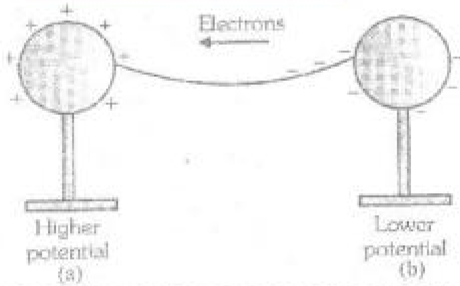
FLOW OF CHARGE

Consider two identical metallic spheres P and N, carrying equal amounts of positive and negative charges respectively. A positive charge is to be taken from B to A. It is attracted by the negatively charged sphere N and

repelled by the positively charged sparer P. So, to move the charge towards A, one has to apply a force on it towards the left. Thus, he work done is positive. Hence, the potential difference $V_A - V_B$ is positive. This means $V_A > V_{B}$.
As one move towards P, the work done increases; so, the potential increases; and on moving towards N, the potential decreases. So, the potential of P is higher than of N. In general, the potential of a positively charged body is taken as higher than of a negatively charged body.



What happens when a free-to-move charge is placed between the spheres? A positive charge will move towards the negatively charged sphere. And a negative charge will move towered the positively charged sphere. That is, a free positive charge moves towards lower potential. And a free negative charge moves towards higher potential
If the two spheres are connected by a metal wire, electrons from the negatively charged sphere (at a lower potential) will flow to the positively charged sphere (at a higher potential). Eventually, the flow of electrons causes the charges on the spheres to become balanced. When that happens, the spheres no longer carry a net charge, and therefore, have equal potential. So, the flow of electrons stops. So we can say that **a potential difference causes charges to flow.**



A CALL PROVIDES A CONSTANT POTENTIAL DIFFERENCE

The potential difference provided by things like charged spheres reduces to zero quickly once charges start to flow. So, we have to use cells to provide constant potential difference for a long time. Cells have chemicals inside. Reactions in the cell cause positive and negative charge to gather separately. This creates a potential difference between the terminals of the cell. The terminal at a higher potential is called the positive terminal and the one at a lower potential is called the negative terminal.
The cells that we commonly use are called dry cells (Figure). In a common dry cell, the small metallic cap at one end is the positive terminal, while the flat metallic plate at the other end is the negative terminal. It provides a potential difference of 1.5 V. A cell is represented by the symbol shown in fig (b). The larger line represents the positive terminal, while the shorter line represents the negative terminal.

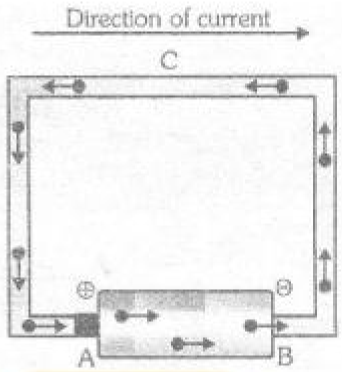
A COMBINATION OF CELLS IS CALLED A BATTERY

Quite often, multiple cells are combined to get a potential difference that is higher than that of a single cell. For example, we connect two 1.5V cells to get a potential difference of 3V (Figure (c)) This is shown using symbols in Figure (d) . in Figure (d).

(a) (b) (c) (d)

ELECTRIC CURRENT

Consider a metallic wire ACB connoted across a cell of potential difference V. Since the end A is connected to the positive terminal, it is at a higher potential than the end B. In metals, some electrons are loosely bound to the atoms, and can move within it. These are called free electros. In the metallic wire, these electrons (negative charges) move from the low-potential side B to the high-potential side A. After reaching A, they enter the cell. The chemical reactions in the cell drive these electrons to the negative terminal. From there, they re-enter the wire at the end B. Thus, there is a continuous flow of electrons in the wire from B to C to A. We say that there is an electric current in the wire. In a metal, the flow of negative charges constitutes the current.



Current in a wire connected to a to a cell

An electric current can also be a flow of positive charges. So, a flow of charge is called an electric current. By convention, the direction of current is taken as the direction of flow of positive charges. Thus, the direction of current is opposite to the direction of flow of negative charges. So, **when a wire is connected to a cell, the current in the wire is from the positive-terminal end to the negative-terminal end.**

MEASUREMENT OF CURRENT

The charge passing per unit time through a given place (area) is the magnitude of the electric current at that place. Thus,

$$i = \frac{Q}{t}$$

Here Q is the charge that passes through a place in time t.

Unit of current From Equation, we find that current is charge divided by time. The SI unit of charge is the coulomb and that of time is the second. The SI unit of current, therefore, is coulomb/second. This unit is called the ampere, whose symbol is A. Thus, if one coulomb of charge passes through a place in one second, the current there is 1 ampere.

CONDUCTOR AND INSULATORS

Materials that conduct electricity easily are called good conductors or simply, conductors, and, materials that do not conduct electricity easily are called insulators.

All metals conduct electricity because they have some loosely bound free electrons, which flow when a potential difference is applied. However, some metals conduct electricity better than others, Silver is the best conductor.

But because of the high cost of silver, electric wires are made of copper, or in some cases aluminum.

Most nonmetallic solids do not conduct electricity. Although diamond and graphite are both forms of carbon (a nonmetal,) graphite is a conductor while diamond is an insulator. Insulators do conduct electricity because their electrons are tightly bound to the atoms. Rubber, plastics, wood glass and porcelain are some examples of insulators. Insulators have many uses. For example, they are used as protective covers on electric wires and electrician's tools. Certain liquids also conduct electricity. While distilled water is an insulator, addition of certain slats, acids or bases allows it to conduct electricity. Under normal circumstances, gases do not conduct electricity.

ELECTRIC CIRCUITS AND MEASURING INSTRUMENTS

A closed path in which a current can flow is called an electric circuit. An electric circuit may have one or more electric elements such as bulbs (or lamps), cells, switches (or plug keys), metal wires, etc. Each element of a circuit has a specific function to play. For example, wires can be used to connect one element to the next. And a plug key or a switch can be used to either complete or break the closed path, thereby starting or stopping the current in the circuit.

Some common circuit elements and their symbols are shown in Figure.

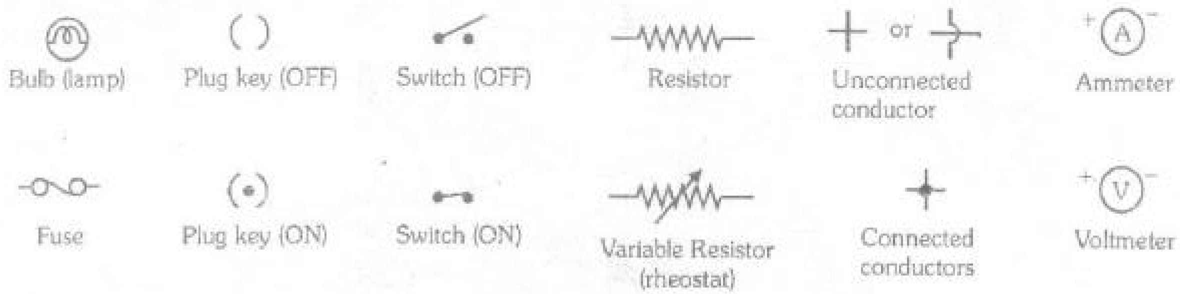


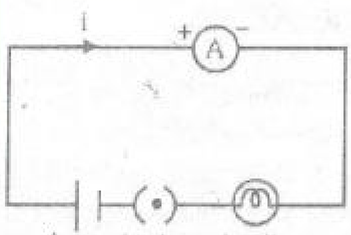
Fig. Some symbols used in circuit diagrams

COMMON MEASURING INSTRUMENTS

The electric current in a circuit is measured by an instrument called the ammeter, and the potential difference between two points in it is measured by a voltmeter (in voltage stabilizers). In these meters, a needle moving over a graduated scale gives the value of the measured quantity. Each meter has two terminals. The terminal marked '+' is connected by a wire to the higher-potential side of a circuit, while the terminal marked '-' is connected to the lower-potential side.

USING AN AMMETER TO MEASURE CURRENT

To measure the current through an element of a circuit, an ammeter is connected in such a way that the current flowing through it also flows through the element. Such a connection is called a series connection. In Figure, the current I flowing through the lamp also flows through the ammeter. The reading of the ammeter gives the current through the lamp. Note that if the ammeter is removed, there will be a gap, and the current through the circuit will stop .

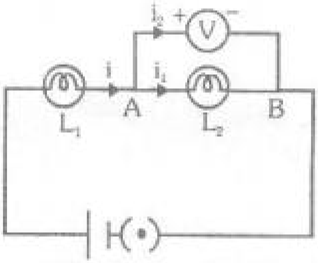


Ammeter in a circuit

Two or more electric elements are said to be connected in series if the current flowing through one also flows through the rest.
An ammeter is always connected in series in a circuit.

USING A VOLTMETER TO MEASURE POTENTIAL DIFFERENCE

Figure shows a circuit that two lamps connected to a cell. We want to measure the potential difference across the lamp L_2, i.e., between the points A and B. As A is on the side of the positive terminal of the cell, its potential is higher than to B. So, the '+' terminal of the voltmeter is connected to A, and the '-' terminal, to B. The reading of the voltmeter gives the potential difference across L_2. The current flowing through the voltmeter is different from those flowing through the other elements of the circuit. Also, even if the voltmeter is removed, the current continues to flow in the circuit. Note that the potential difference across L_2 and the voltmeter is the same. Such a connection is called a parallel connection.



Voltmeter in a circuit

Two or more electric elements are said to be connected in parallel if the same potential difference exists across them.

OHM'S LAW

The electric current through a metallic element or wire is directly proportional to the potential difference applied between its ends, provided the temperature remains constant.

If a potential difference V is applied to an element and a current i passes through it,

$$i \propto V$$

$$\text{or} \quad i = \left(\frac{1}{R}\right)V$$

Thus **Ohm's Law** $\mathbf{V = iR}$

Here R is a constant for the given element (metallic wire) at a given temperature and is called its resistance. It is the property of a conductor to resist the flow of charges through it.

RESISTANCE

From equation, $i = \frac{V}{R}$

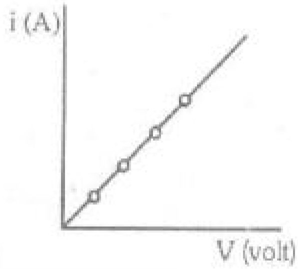
So, for a given potential difference $i \propto \frac{1}{R}$

Thus, for a given potential difference, the current is inversely proportional to the resistance. The higher is the resistance, the lower is the current. If the resistance is doubled, the current is halved. Good conductors have low resistance, while insulators have very high resistance.

UNIT OF RESISTANCE

Potential difference is measured in volts, and current is measured in amperes. From Equation, R = V/i. So, the unit of resistance is volt/ampere. This unit is called the ohm, and its symbol is Ω. We can define one ohm as follows.

If a potential difference of 1 volt is applied across an element, and a current of 1 ampere passes through it, the resistance of element is called 1 ohm,



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

ON WHAT DOES RESISTANCE DEPEND?

The resistance of the conductor depends (i) on its length, (ii) on its area of cross-section, and (iii) on the nature of its material. Resistance of a uniform metallic conductor is directly proportional to its length (ℓ) and inversely proportional to the area of cross-section (A).

$$R \propto \ell \qquad \text{and} \qquad R \propto \frac{1}{A}$$

Combining equations. We get $R \propto \frac{\ell}{A}$ or $R = \rho \frac{\ell}{A}$

where ρ (rho) is a constant of proportionality and is called electrical of the material of the conductor. The SI unit of resistively is Ω m.

SERIES AND PARALLEL CONNECTIONS OF RESISTORS

A conducting material (e.g., a wire) of a particular resistance meant for use in a circuit is called a resistor. A resistor is sometimes simply referred to as a resistance. It is represented by the symbol . Two or more resistors can be connected in series, in parallel or in a manner that is a combination of these two.

SERIES CONNECTION OF RESISTORS

Two or more resistors are said to be connoted in series if current flowing through one also flows through the rest. The total potential difference across the combination of resistors connected in series is equal to the sum of the potential differences across the individual resistors. $V = V_1 + V_2 + V_3$

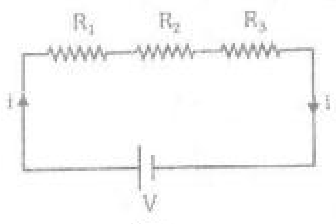
EQUIVALENT RESISTANCE IN SERIES CONCESSION

Figure (a) shows three resistors of resistances R_1, R_2 and R3 connected in series. The cell connected across the combination maintains a potential difference V across the combination. The current through the cell is i. The same current i flows through each resistor.

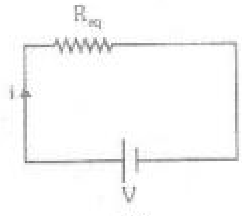
Let us replace the combination of resistors by a single resistor R_{eq} such that current does not change, i.e., it remains i. This resistance is called the **equivalent resistance** of the combination, and its value is given by

Ohm's law as $R_{eq} = V / i$

Thus $V = iR_{eq}$.



(a)



(b)

The potential differences V_1, V_2 and V_3 across the resistors R_1, R_2 and R_3 respectively are given by

Ohm's law as: $V_1 = iR_1$, $V_2 = iR_2$, $V_3 = iR_3$

Since the resistors are in series, $V = V_1 + V_2 + V_3$

Substituting the values of the potential differences in the above equation,

$$iR_{eq} = iR_1 + iR_2 + iR_3$$

or $$iR_{eq} = i(R_1 + R_3)$$

or $$\boxed{R_{eq} = R_1 + R_2 + R_3}$$

Similarly, for n resistors connected in series,

Equivalent resistance of resistors in series: $\boxed{R_{eq} = R_1 + R_2 + R_3 + \dots\dots\dots + R_n}$

PARALLEL CONNECTION OF RESISTORS

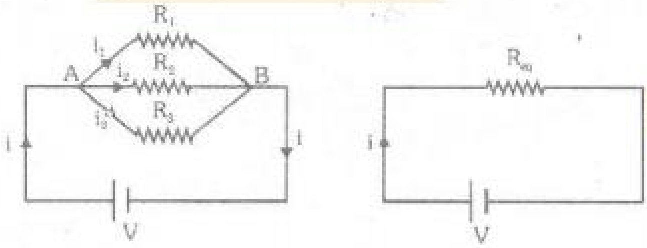
The total current flowing into the combination is equal to the sum of the currents passing through the individual resistors.

$$\boxed{i = i_1 + i_2 + i_3}$$

If resistors are connected in such a way that the same potential difference gets applied to each of them, they are said to be connected in parallel.

EQUIVALENT RESISTANCE IN PARALLEL CONNECTION

Figure (a) shows three resistors of resistances R_1, R_2 and R_3 connected in parallel across the points A and B . The cell connected across these two points maintains a potential difference V across each resistor. The current through the cell is i. It gets divided at A in to three parts i_1, i_2 and i_3. which flow through R_1, R_2 and R_3 respectively.



(a) (b)

Let us replaced the combination of resistors by an equivalent resistor R_{eq} such that the current i in the circuit does not change (Fig). The equivalent resistance is given by Ohm's law as $R_{eq} = V/I$.

Thus,

$$i = \frac{V}{R_{eq}} \text{i}$$

The currents i_1, i_2 and i_3 through the resistor R_1, R_2 and R_3 respectively are given by Ohm's law as

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

Since the resistors are in parallel,

$$i = i_1 + i_2 + i_3$$

Substituting the values of the currents in above equation,

$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

or $$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Similarly, if there are n resistors connected in parallel, their equivalent resistance R_{eq} is given by

Equivalent Resistance of resistors in parallel: $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots\dots\dots\dots + \frac{1}{R_n}$

For two resistances R_1 and R_2 connected in parallel.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2} \qquad \text{or} \qquad R = \frac{R_1 R_2}{R_1 + R_2}$$

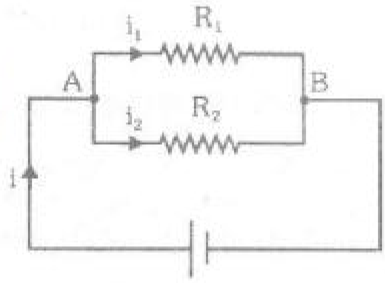
The equivalent resistance in parallel connection is less than each of the resistances.

When a resistance is joined parallel to a comparatively smaller resistance, the equivalent resistance is very close to the value of the smaller resistance.

NOTE: If a resistor connected in series with others is removed or fails, the current through each resistor becomes zero. On the other hand, if a resistor connected in parallel with others fails or is removed, the current continues to flow through the other resistors.

DISTRIBUTION OF CURRENT IN TWO RESISTORS IN PARALLEL

Consider the circuit in fig. The resistors R_1 and R_2 are connected in parallel. The current i gets distributed in the two resistors.



$$i = i_1 + i_2 \qquad \ldots(i)$$

Applying Ohm's law to the resistor R_1

$$V_A - V_B = R_1 i_1 \qquad \ldots(ii)$$

And applying Ohm's law to the resistor R2

$$V_A - V_B = R_2 i_2 \qquad \ldots(iii)$$

From (ii) and (iii), $R_1 i_1 = R_2 i_2$ or $i_2 = \frac{R_1}{R_2} i_1$

Substituting for i_2 in (i), we have

$$i = i_1 + \frac{R_1}{R_2} i_1 = i_1 \left(1 + \frac{R_1}{R_2}\right) = i_1 \frac{R_1 + R_2}{R_2}$$

or

$$i_1 = \frac{R_2}{R_1 + R_2} i$$

Similarly,

$$i_2 = \frac{R_1}{R_1 + R_2} i$$

Thus,

$$\frac{i_1}{i_2} = \frac{R_2}{R_1}$$

The current through each branch in parallel combination of resistors is inversely proportional to its resistance

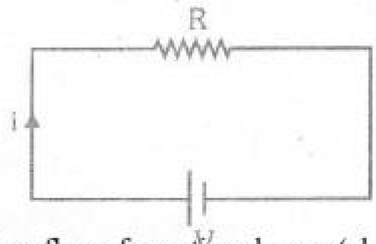
DEVICES IN SERIES AND PARALLEL

You must have seen tiny bulbs strung together for decorating buildings during festivals like Diwali, and occasions like marriages, etc. These bulbs are connected in series, and the mains voltage is applied to the combination. The potential difference (V) of the mains gets divided across the bulbs ($V = V_1 + V_2 + V_3 + \ldots$). So, a small potential difference exists across each bulb, close to that required to make the bulb work. However, the same current flows all the bulbs. So, if one bulb goes bad. The current through it strops. And this stops the current through the rest of the bulbs as well. To make the chain of lights work, we have to find and replace the defective bulb. This problem does not occur with the lights in our house. That is because **in houses, lights, fans, etc., are connected in parallel.** In parallel connection, the same mains voltage gets applied to each device, but the current through each is different. If one of them goes bad, the current in the other branches of the parallel connection does not stop. Another advantage of parallel connection is that, unlike series connection, each device can draw a different current, as per its requirement.

HEATING EFFECT OF ELECTRIC CURRENT

When an electric current passes through a bulb, the filament gets so hot that it glows and emits light. When a current passes through the filament of an electric iron, the iron becomes very not. This increase in temperature is due to what is called 'the heat produced due to current'. Suppose a resistor R is connected to a cell. The cell maintains a potential difference V across the resistor, driving a current i through it.

So, $V = iR$ ...(i)



The current through the resistor is actually a flow of negative charges (electrons). Inside the cell, the negative charges flow from the positive to the negative terminal. The cell does work = QV to take a charge through the potential difference V between its terminals. This increases the energy of the charge by QV. This increased energy gets converted to heat in the resistor. So, the energy appearing as heat is given by

$U = QV$ ...(ii)

The charge that passes through the wire in time is

$Q = it$ ...(iii)

Using (i), (ii) and (iii), we find that the heat produced in the wire in time t is

$U = QV = (it)(iR) = i^2Rt$.

From Equation the heat produced is proportional to the square of the current, if R and t remain constant. So, if the current passing for a given time through a given resistance is doubled, the heat produced becomes four times. Similarly, for a given i and t, the heat produced is proportional to R. If the same current i passes through two resistances in a given time, more heat will be produced in the larger resistance. The heat produced can also be written as.

$$U = i^2Rt = \left(\frac{V}{R}\right)^2$$

or $$U = \frac{V^2}{R}t$$

For a given V and t, the heat produced is inversely proportional to R. So, if the same potential difference is applied across two resistances, more heat will be produced in the smaller resistance.

We have seen above that the increased energy of a charge gets converted to heat in the resistor. The increase in energy comes from the work done by the cell. This uses up the chemical energy of the cell. So, the energy appearing as heat in the resistor ultimately comes at the expense of the chemical energy of the cell.

Not always is the work done by a cell converted to hart immediately after a motor is connected to a cell, the speed of the shaft of the motor increases. A part of the work done by the cell goes into producing the increase in kinetic energy. And a part is used to overcome friction, etc. When the motor achieves a constant speed, its kinetic energy does not change. So the work done by the cell is only used to overcome friction. etc. This appears as heat. That is why the cover over a motor becomes warm on use.

ELECTRIC POWER

Power is the rate of doing work, or the rate at which energy is produced or consumed. The electrical energy produced or consumed per unit time is called electric power. In an electric circuit, the power is

$$P = \frac{U}{t} = \frac{i^2 Rt}{t} = i^2 R$$

Using iR = Vi

P = Vi

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

The energy consumed and power are related as

U = Pt.

UNIT OF POWER

The SI unit of energy is the joule, and that of times is the second. The SI unit of power is therefore joule/ second. This unit is called the watt, whose symbol is W.

APPLICATIONS OF THE HEATING EFFECT OF CURRENT

The heating effect of electric current has many uses. Electric bulbs, room heaters, electric irons, immersion heaters, toasters, electric fuses and a number of other appliances work in this principle. In all of these, a wire of suitable resistance, commonly called the heating element, is connected to the power supply. The current passing through the element produces heat in it, which is used for same specific purpose.

ELECTRIC BULB

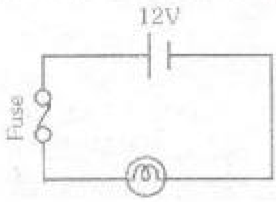
An electric bulb has a simple structure. It consists of a sealed glass bulb that has a tungsten filament connected to two electrical contacts. The bulb is filled with an uncreative gas like argon or nitrogen. To produce white light, the filament has to be heated to about 3000^0 C by passing a currant though it. Obviously, the material of the filament should such that it does not melt at this temperature. Tungsten is used for the filament because its melting point is about 3400^0 C. The sealed glass bulb serves two purposes. First, it protects the filament from oxidation and the effects of humidity. Secondly, the small enclosed volume makes it easier to maintain the required temperature, as without it the loss of heat would be more.

FUSE

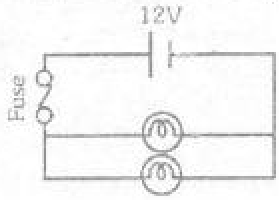
A fuse is a safety device that does not allow excessive current to flow through an electric circuit. It consists of a metallic wire of low melting, fixed between the two terminals of a fuse plug. The fuse plug fits into a fuse socket connoted in the circuit. Fuses are available in various shapes. The fuse plug is used in household wiring. it is made f porcelain.

A fuse is connected in series with an appliance (such as a TV) or a group of appliances (such as the lights and fans in room). So, the current through the fuse is the same as the current through the appliance or the group of appliance. If this current exceeds a safe value, the heat produced in the fuse wire causes it to melt immediately. This breaks the circuit, preventing any damage. Figure shows examples of how a fuse is connected in circuits.

Good-quality fuse wires are made of tin, as it has low melting point. Some fuse wires are made of an alloy of tin and copper. The thickness of the fuse wire depends on the circuit in which it is to be used. If a section of the circuit is meant to carry a maximum of 5A current, the fuse wire should also be able to carry currents up to 5A. Similarly, for wiring meant for 15A, the fuse wire should be thicker, and should be able to carry current up to 15 A.



(a)



(b)

DISADVANTAGES OF THE HEATING EFFECT OF CURRENT

A current always produces some neat, whether we use the heat or not. If the neat produced cannot be utilized, it represents a wastage of energy. A considerable amount of energy is thus wasted in the transmission of electricity from the generating station to out homes. Sometimes, the heat reduced in a device is so much that it can damage the device, unless power proper cooling arrangements are made. To dissipate the heat produced in TV sets, monitors, etc., their cabinets have grills for air to pass. Certain components of computer get so not that they have fans to cool them.

RATING OF ELECTRIC APPLIANCES

Take an electric bulb and see what is written on it. Apart from the name and the symbol of the company. we will find value of power and potential difference. For example, it could be 60W, 220V. It means that 220V should be applied across this bulb, and when 220V is applied, the power consumed will be 60W. We will find similar markings on all electric appliances. For an electric appliance, the values of power and voltage taken together form what is called the rating of the appliance?

From the rating of an appliance, you can easily calculate its resistance by using the equation $P = \frac{V^2}{R}$. Note that higher the power rating, smaller the resistance. So, a 1000W heater has less resistance than a 100W bulb.

We can also calculate the current drawn by an appliance by using relation $i = \frac{P}{V}$.

KILOWATT HOUR

Power is the rate of energy consumes or produced. If 1 joule of energy is used per second, the energy is used at the rate of 1 watt. In other words, if energy is used at the rate of 1 watt, the total energy used in 1 second is 1 joule. How much energy is used in 1 hour if it is used at the rate of 1000 watt?

It is (1000 watt) × (3600 second) = 3, 600,00 joule.

This amount of energy is called 1 kilowatt hour, written in short as kWh. Thus, **1kWh = 3, 600,00j=3.6×10^6J**. The electrical energy used in hosed, factories , etc., is measured in kilowatt hours. The cost of electricity is fixed per kilowatt hour. **One kilowatt hour of electrical energy is called one unit.**

NCERT EXERCISE

1. A piece of wire of resistance R is cut into 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

Ans. Resistance of each one of the five parts $= \frac{R}{5}$

Resistance of five parts connected in parallel is given by

$$\frac{1}{R'} = \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5} \quad \text{or} \quad \frac{1}{R'} = \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} = \frac{25}{R}$$

or $\frac{R}{R'} = 25$

Thus, (D) is the correct answer.

2. 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

Ans. Electrical power, $P = VI = (IR)R = t^2R = V\left(\frac{V}{R}\right) = \frac{V^2}{R}$

Obviously, IR^2 does not represent electrical power in a circuit.

Thus, (B) is the current an answer.

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

Ans. Resistance of the electric bulbs, $R = \frac{V^2}{P}$ ($P = V^2/R$)

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

Power consumed by the bulb when it is operated at 110 V is given by

$$P' = \frac{V'^2}{R} = \frac{(110)^2}{484} = \frac{110 \times 110}{484} = 25W \quad (V' = 100\text{ V})$$

Thus, (D) is the correct answer.

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

Ans. Since both the wires are made of the material and have equal lengths and equal diameters, these have the same resistance. Let it be R.

When connected in series, their equivalent resistance is given by

$$R_s = R + R = 2R$$

When connected in parallel, their equivalent resistance is given by

$$\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R} \text{ or } R_p = \frac{R}{2}$$

Further, electrical power is given by $P = \frac{V^2}{R}$

Power (or heat produced) in series, $P^s = \frac{V^2}{R_s}$

Power (or heat produced) in parallel, $P_p = \frac{V^2}{R_p}$

Thus, $\frac{p_s}{P_p} = \frac{V^2/R_s}{V^2/R_p} = \frac{R_p}{R_s} = \frac{R/2}{2R} = \frac{1}{4}$

or $P_s : Pp :: 1 : 4$

thus, (C) is the correct answer

5. How is voltmeter connected in the circuit to measure potential difference between two points?

Ans. A voltmeter is always connected in parallel across the points between which the P.D. is to be determined.

6. A copper wire has a diameter of 0.5 mm and a resistively of 1.6×10^{-6} ohm cm. How much of this wire would be enquired to make a 10 ohm coil? How much does the resistance change if the diameter is doubled?

Ans. We are given that, Diameter of the wire, $D = 0.5\text{ mm} = 0.5 \times 10^{-3}\text{ m}$

Resistivity of copper, $\rho = 1.6 \times 10^{-3}$ ohm cm $= 1.6 \times 10^{-8}$ ohm m

Required resistance, R = 10 ohm

As $R = \frac{\rho\ell}{A}, \ell = \frac{RA}{\rho} = \frac{R(\pi D^2/4)}{\rho} = \frac{\pi R D^2}{4\rho} [A = \pi r^2 = \pi(D/2)^2 = \pi D^2/4]$

or $\ell = \frac{3.14 \times 10 \times (0.5 \times 10^{-3})^2}{4 \times 1.6 \times 10^{-8}} m = 112.7\ m$

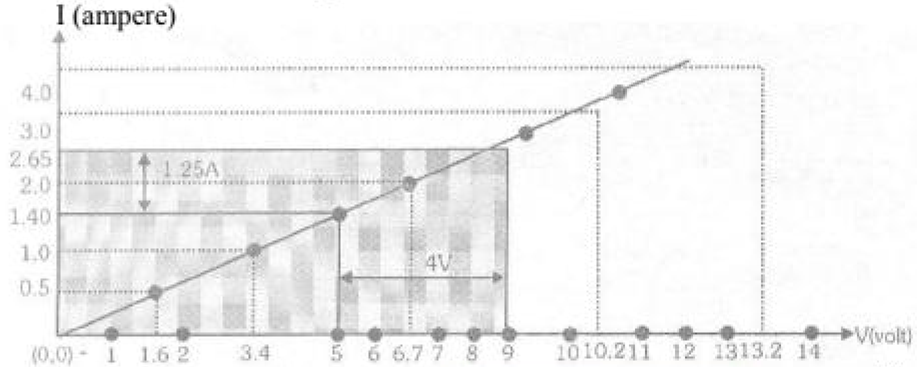
Since, $R = \frac{\rho\ell}{\pi D^2/4} = \frac{r\rho\ell}{\pi D^2} . R \propto 1/D^2$. When D is doubled, R becomes $\frac{1}{4}$ times.

7. The value of current, I, flowing in a given resistor for the corresponding value of potential difference, V, across the resistor are given below:

I (ampere) :	0.5	1.0	2.0	3.0	4.0
V (volt)	1.6	3.4	6.7	10.2	13.2

Plot a graph between V and I and calculate the resistance of resistor.

Ans. The V-I graph is as shown in fig.



For V = 4V (i.e., 9V – 5V), I = 1.25 A (i.e., 2.65 A – 1.40 A). Therefore, $R = \frac{V}{I} = \frac{4V}{1.25A} = 3.2\ \Omega$

The value of R obtained from the graph depends upon the accuracy with which the graph is plotted.

8. When a 12 V battery is connected across an unknown resistor, there is a current of 2.5 mA in the circuit. Find the value of the resistance of the resistor.

Ans. Here, V = 12V, I = 2.5 mA = 2.5×10^{-3} A

Resistance of the resistor $R = \frac{V}{I} = \frac{12V}{2.5 \times 10^{-3} A} = 4800\ \Omega = 4.8\ k\Omega$

9. A battery of 9 V is connected in series with resistors of 0.2Ω, 0.3Ω, 0.4Ω, 0.5Ω and 12Ω. How much current would flow through the 12Ω resistor?

Ans. Since all the resistors are in series, equivalent resistance.

$R_s = 0.2\Omega + 0.3\Omega + 0.4\Omega + 0.5\Omega + 12\Omega = 13.4\Omega$

Current through the circuit, $I = \frac{V}{R_s} = \frac{9V}{13.4\Omega} = 0.67A$

In series, same current (I) flows through all the resistors. Thus, current flowing through 12Ω resistor = 0.67 A

10. How many 176Ω resistors (in parallel) are required to carry 5 A in 220 V line?

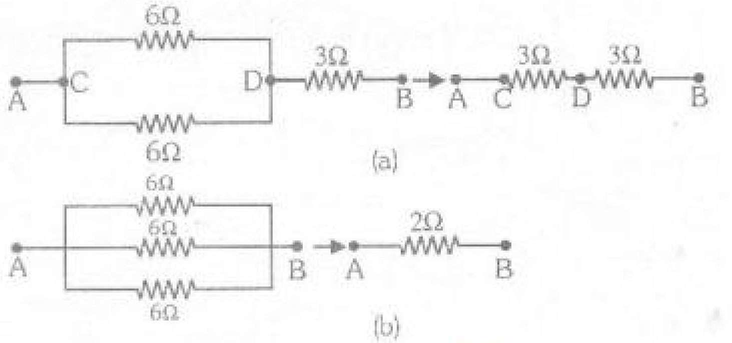
Ans. Here, I = 5A, V = 220 V.

Resistance required in the circuit, $R = \frac{V}{I} = \frac{220V}{5A} = 44\Omega$, resistance of each resistor, r = 176 Ω If n resistors, each of resistance r, are connected in parallel to get the required resistance R, then $R = \frac{r}{n}$ or $44 = \frac{176}{n}$ or $n = \frac{176}{44} = 4$

11. Show how you would three resistors, each of resistance 6Ω, so that the combination has a resistance of (i) 9Ω (ii) 2Ω.

Ans. (i) In order to get a resistance of 9Ω from three resistors , each of resistance 6Ω, we connect two resistors in Parallel combination (or resistance 3Ω) in series with the third resistor as shown in fig.

(ii) In order to get a resistance of 2Ω from three resistors, each of resistance 6Ω, we connect all the three resistors in parallel as shown in fig (b) as equivalent resistance in parallel combination, i.e., R_p is given by $R_p = \frac{6\Omega}{3} = 2\Omega$



12. Several electric bulbs designed to be used on a 220 V electric supply line, are rated 10 W. How many lamps can be connected in parallel with each other across the two wires of 220 V line if the maximum allowable current is 5 A ?

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

Total resistance in the circuit, $R = \frac{220V}{5A} = 44\Omega$

Let n be he number of bulb (each of resistance r) to be connected in parallel to obtain a resistance R.

Clearly, $R = \frac{r}{n}$ or $n = \frac{r}{R} = \frac{48480\Omega}{44\Omega} = 110$

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

Ans. Here, potential difference, V = 220 V

Resistance of each coil, r = 24 Ω

(i) When each of the coils A or B is connected separately, current through each foil, i.e.,

$$I = \frac{V}{r} = \frac{220V}{24\Omega} = 9.2A$$

(ii) When coils A and B are connected in series, equivalent resistance in the circuit,

$R_s = r + r + r = 48\,\Omega$

Current through are series combination, i.e., $I_s = \frac{V}{R_s} = \frac{220V}{48\Omega} = 4.6A$

(iii) When the coils A and B are connected in parallel, equivalent resistance in the circuit,

$$R_p = \frac{r}{2} = \frac{24\Omega}{2} = 12\Omega$$

Current through the parallel combination, i.e., $I_p = \frac{V}{R_p} = \frac{220V}{12\Omega} = 18.3A$

14. Compare the power used in the 2 Ω resistor in each of the following circuits:

(i) a 6V battery in series 1 Ω and 2 Ω resistors, and (ii) a 4 V battery in parallel with 12 Ω and 2 Ω resistors.

Ans. (i) Since 6V battery is in series with 1 Ω and 2 Ω resistors, current in the circuit.

$$I = \frac{6V}{1\Omega + 2\Omega} = \frac{6V}{3\Omega} = 2A$$

Power used in 2 Ω resistor, $P_1 = i^2 R = (2A)^2 \times 2\ \Omega = 8W$

(ii) Since 4 V battery is in parallel with 12Ω and 2Ω resistors, pd across 2Ω resistor, V = 4V. Power used in 2Ω resistor, $P_2 = \frac{V^2}{R} = \frac{(4V)^2}{(2\Omega)} = 8W$

Clearly, $\frac{P_1}{P_2} = \frac{8W}{8W} = 1$

15. Two lamps, one rated 100 W at 220 V, and the other 60 W at 220 V, are connected in parallel to the electric mains supply. What current is drawn from the line if the supply voltage is 220 V?

Ans. Resistance of first lamp, $r_1 = \frac{V^2}{P} = \frac{(220)^2}{100} = 484\Omega$

Residence of the second lamp, $r_2 = \frac{V^2}{P} = \frac{(220)^2}{60} = 806.7\Omega$

Since the two lamps are connected in parallel, the equivalent resistance is given by

$$\frac{1}{R_p} = \frac{1}{r_1} + \frac{1}{r_2} = \frac{r_2 + r_1}{r_1 r_2}$$

or $$R_p = \frac{r_2 r_1}{r_1 + r_2} = \frac{484 \times 806.7}{484 + 806.7} = \frac{390442.8}{1290.7} = 302.6\Omega$$

Current drawn from the line, i.e., $I = \frac{V}{R_p} = \frac{220V}{302.6\Omega} = 0.73A$

16. Which uses more energy, a 250 W TV set in 1 h, or 1200 W toaster in 10 minutes?

Ans. Energy used by 250 W TV set in 1 h = 250 W × 1h = 250 Wh

Energy used by 1200 W toaster in 10 min. (i.e., 1/6 h) = 1200 W ×(1/6) h = 200 Wh

Thus, a 250 W TV set uses more power in 1h than a 1200 W toaster in 10 minutes.

17. An electric heater of resistance 8Ω draws 15 A from the service mains for 2 hour. Calculate the rate at which heat is developed in the heater

Ans. Here, I = 15A, R = 8Ω, t = 2h

Rate at which heat is developed, i.e., electric power , $P = I^2 R = (15)^2 \times 8 = 1800$ W J/s

18. Explain the following:

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

(b) Why are the conductors of electric heating devices, such as 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 cross-sectional area?

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

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

(b) The resistivity of an alloy is generally higher than that of pure metals of which it is made of.

(c) In series arrangement, if any one of the appliances fails or is swathed off, all the other appliances stop working because the same current is passing through all the appliances.

(d) The resistance of wire (R) varies inversely as its cross-sectional area (A) as $R \propto 1/A$.

(e) Copper and Aluminium wires possess low resistivity and as such are generally used for electricity transmission.

EXERCISE – 1 (FOR SCHOOL / BOARD EXAMS)

OBJECTIVE TYPE QUESTIONS

CHOOE THE CORRECT ONE

1. The space around a charge in which its effect can be felt is called its
(A) potential (B) field (C) field intensity (D) potential difference

2. The force acting on a unit positive test charge at a point inside an electric field is called
(A) potential (B) field
(C) field intensity (D) potential difference.

3. Work done in moving a unit positive test charge from infinity to a point inside an electric field, is called
(A) electric potential (B) field
(C) field intensity (D) potential difference.

4. Work done is moving a unit positive test charge from point to other insider an electric field, is called
(A) potential (B) field
(C) field intensity (D) potential difference.

5. Electricity constituted by electric charge at rest on the surface of a conductor, is called
(A) positive electricity (B) negative electricity (C) current electricity (D) static electricity.

6. Electricity constituted by moving electric charges, is called
(A) positive electricity (B) negative electricity (C) current electricity (D) static electricity.

7. Time rate of flow of electric charge measures electric
(A) circuit (B) current (C) potential difference (D) cell.

8. The condition for an electric charge to flow one point to other is that the two points must have electric
(A) circuit (B) current (C) potential difference (D) cell.

9. The device that maintains electric potential difference between two points is called electric
(A) circuit (B) current (C) potential difference (D) cell.

10. The path connecting two points at different potentials, to make the electric charges flow, is called electric
(A) circuit (B) current (C) potential difference (D) cell.

11. The device which measures electric potential difference between two points is called
(A) ammeter (B) voltmeter (C) manometer (D) water meter

12. The device which measures electric current through a conductor is called
(A) ammeter (B) voltmeter (C) manometer (D) water meter

13. Electric current is produced by flow of
(A) electrons (B) protons (C) negative ions (D) positive ions

14. Direction of flow of conventional current is taken from

(A) negative to positive
(B) positive to negative
(C) any of the above two
(D) none of the above two

15. The law which gives a relation between electric potential difference and electric current is called
(A) Faraday's law (B) Oersted's law (C) Ohm's law (D) Newton's law

16. With increase in temperature, resistance of a conductor
(A) decreases
(B) increases
(C) may decreases or increase according to the situation
(D) no particular observation

17. In series combination, total resistance
(A) decreases
(B) increases
(C) may decrease or increases according to the situation
(D) no particular observation

18. In parallel combination, total resistance
(A) decreases
(B) increases
(C) may decrease or increase according to the situation
(D) no particular observation.

19. In series combination, resistance increases due to increase in
(A) temperature
(B) humidity
(C) length
(D) area of cross-section

20. In parallel combination, persistence decreases due to increase in
(A) temperature (B) humidity (C) length (D) area of cross-section

21. Central part of an atom is called
(A) molecule (B) proton (C) ion (D) nucleus.

22. In an atom, particle having no charge, is called
(A) neutron (B) proton (C) electron (D) ion

23. In an atom, particle having a positive charge is called
(A) neutron (B) proton (C) electron (D) ion

24. In an atom, particle having a negative charge, is called
(A) neutron (B) proton (C) electron (D) ion

25. Substances whose atoms have more free electrons, are called
(A) electrolytes (B) conductors (C) insulators (D) semiconductors

26. Substances whose atoms have no free electrons, are called
(A) electrolytes (B) conductors (C) insulators (D) semiconductors

27. Substances whose atoms have only few free electrons, are called
(A) electrolytes (B) conductors (C) insulators (D) semiconductors

28. A neutral body has
(A) both types of positive and negative charges (B) only positive charge
(C) only negative chare (D) no charge at all

29. A body gets positively charged by losing
(A) neutron (B) protons (C) electrons (D) $\alpha-$particles

30. A body gets negatively charged by gaining
(A) neutron (B) protons (C) electrons (D) $\alpha-$particles

31. Time rate of work done or electrical energy developed or consumed by a generator or appliance, is called electrical
(A) current (B) power (C) potential (D) energy

32. The unit of electrical power is
(A) watt (W) (B) ampere (A) (C) joule (J) (D) ohm (Ω)

33. In series combination of electrical appliances, total electrical power
(A) increases
(B) decreases
(C) may increase or decrease according to the situation
(D) no definite observation.

34. In parallel combination of electrical appliances, total electrical power
(A) increases
(B) decreases
(C) may increase or decrease according to the situation
(D) no definite observation.

35. Power voltage rating of an electric bulb is 100 W 200 V. Current drawn by it will be
(A) 1.0 A (B) 0.8 A (C) 0.5 A (D) 0.4 A

36. The total work done by an electrical appliance during its operation, is called electrical
(A) current (B) power (C) potential (D) energy

37. The unit of electrical energy is
(A) watt (W) (B) ampere (A) (C) joule (J) (D) ohm (Ω)

38. Number of joules in 1 kWh is
(A) 3.6×10^7 (B) 3.6×10^6 (C) 3.6×10^5 (D) 3.6×10^4

39. When electric current flow through a conductor the conductor becomes
(A) cold (B) hot (C) liquid (D) vapour

40. When electric current flows through a concoctor
(A) free electrons move
(B) atoms move

(C) atoms attract free electrons
(D) atoms repel free electrons

41. Heating of a current carrying conductor is due to
(A) loss of kinetic energy of moving atoms
(B) loss of kinetic energy of moving electrons
(C) attraction between electrons and atoms
(D) repulsion between electrons and atoms

42. The correct relation between heat produced (H) and electric current (I) flowing
(A) $H \propto I$ (B) $H \propto 1/I$ (C) $H \propto I^2$ (D) $H \propto 1/I^2$.

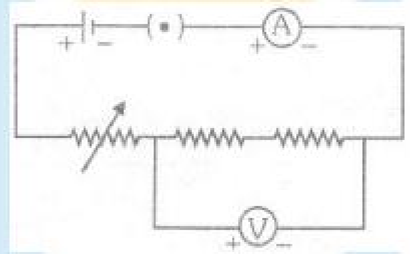
43. In Q. 42, the relation between H and I is called
(A) Newton's law
(B) Faraday's law
(C) Ohm's law
(D) Joule's law

44. In electric heating appliances the material of the heating element is
(A) brass (B) nichrome (C) silver (D) copper.

45. In domestic electric circuits, the cheapest appliance used is
(A) fuse (B) bulb (C) fan (D) television.

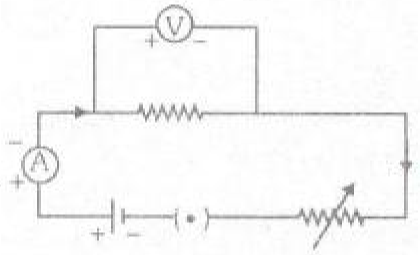
46. An ammeter has 20 divisions between mark 0 and mark 2 on its scale. The least count of the ammeter is
(A) 0.02 A (B) 0.01 A (C) 0.2 A (D) 0.1 A

47. To determine the equivalent resistance of two resistors when connected in series, a student arranged the circuit components as shown in the diagram. But he did not succeed to achieve the objective.



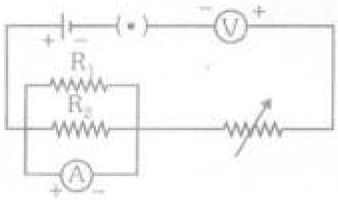
Which of the following mistake has been committed by him in setting up the circuit?
(A) Position of ammeter is incorrect
(B) Position of voltmeter is incorrect
(C) Terminals of voltmeter are wrongly connected
(D) Terminals of ammeter are wrongly connected

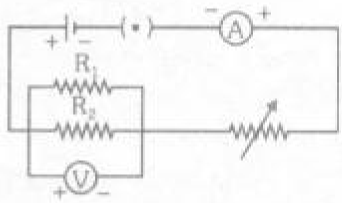
48. Which two circuit components are connected in parallel in the following circuit diagram?

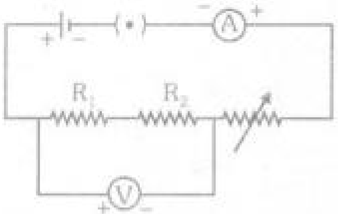


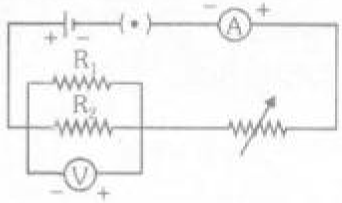
(A) rheostat and voltmeter
(B) voltmeter and resistor
(C) ammeter and resistor
(D) voltmeter and ammeter

49. The correct set up for determining the equivalent resistance of two resistors R_1 and R_2 when connected in parallel is:

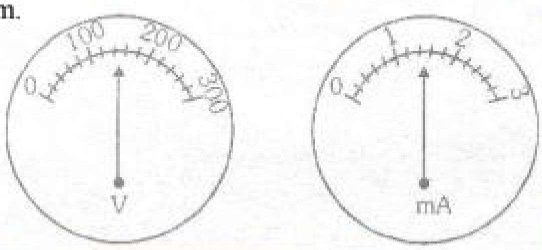
(A)


(B)


(C)


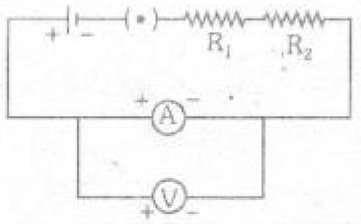
(D)


50. The current flowing though a resistor connected in electrical circuit and the potential difference developed across its ends are shown in the following diagram.



The value of resistance of the resistor in ohm is
(A) 10
(B) 15
(C) 20
(D) 25

51. To determine the equivalent resistance of a series combination of two resistors R_1 and R_2, a student arranges the following set up



Which one of the following statement will be true of this circuit?

(A) incorrect reading for current I as well as potential difference V

(B) correct reading for current I but incorrect reading for potential difference V

(C) correct reading difference V but correct reading for current

(D) correct reading for both current as well as potential difference.

52. In a voltmeter there are 20 divisions between 0 mark and 0.5 mark. The least count of the voltmeter is

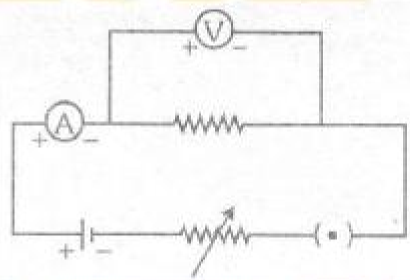
(A) 0.020 V

(B) 0.025 V

(C) 0.050 V

(D) 0.250 V

53. The following circuit diagram shown the experimental set up for the study of dependence of current on potential difference. Which two circuit components are connected in series ?



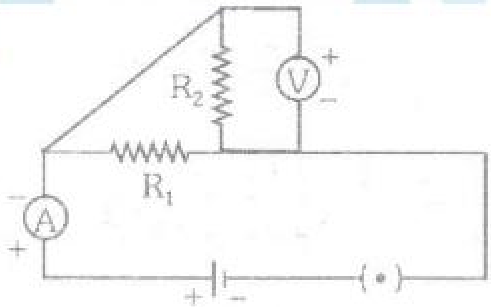
(A) Battery and voltmeter

(B) Resistor and voltmeter

(C) Ammeter and rheostat

(D) Ammeter and voltmeter

54. Which of the circuit components in the following circuit diagram are connected in parallel ?



(A) R_1 and R_2 only

(B) R_2 and V only

(C) R_1 and V only

(D) R_1, R_2 and V only

55. For the circuit diagram shown in figures I and II voltmeter reading would be

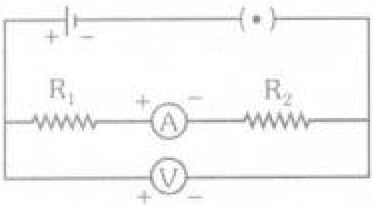
(A) 2 V in circuit (I) and 0 V in circuit (II)

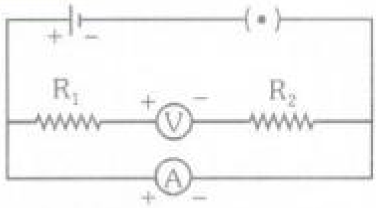
(B) 0 V in both circuits

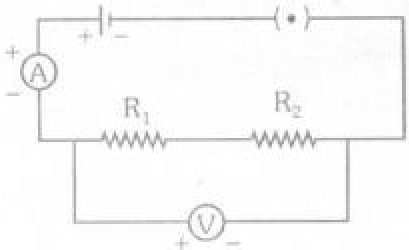
(C) 2 V in both circuits

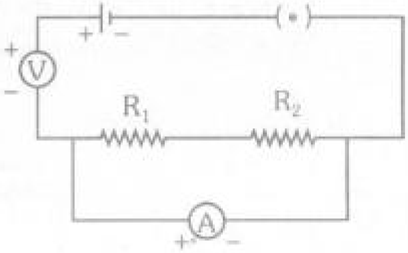
(D) 0 V in circuit (I) and 2 V in circuit (II).

56. In an experiment to determine equivalent resistance of two resistors R_1 and R_2 in series, which one of the following circuit diagrams shows the correct way of connecting the voltmeter in the circuit?

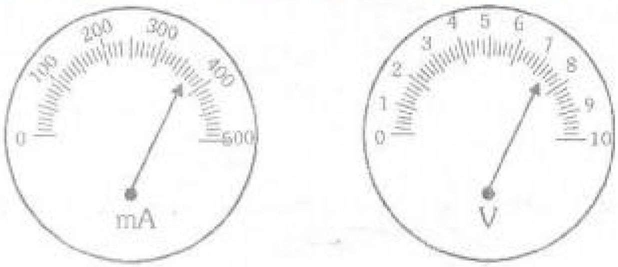
(A)


(B)


(C)


(D)


57. Current following through a conductor and the potential difference across its two ends are as per reading of the ammeter and voltmeter shown below. The resistance of the conductor and could be



(A) 0.02 Ω

(B) 20.0 Ω

(C) 0.024 Ω

(D) 24.0 Ω

58. The following instruments are available in a laboratory

milliammeter A_1 of least count 10 mA and range 0-300 mA

milliammeter A_2 of least count 20 ma and range 0-200 mA

voltmeter V_1 of least count 0.2 V and range 0-5 V

voltmeter V_2 of least count 0.3 V and range 0-3 V

Out of the following pairs of instruments which pair would be the best choice for carrying out the experiment to determine the equivalent resistance of two resistors connected in series?

(A) milliammeter A_1 and voltmeter V_2

(B) milliammeter A_2 and voltmeter V_1

(C) milliammeter A_1 and voltmeter V_1

(D) milliammeter A_2 and voltmeter V_2

EXERCISE – 2 (FOR SCHOOL / BOARD EXAMS)

VERY SHORT ANSWER QUESTIONS

1. Write the unit of electric potential.
2. Define the potential a point.
3. Define the potential difference between two points.
4. A dry cell usually has a small cap at one and end and a flat surface at the other end. Which of the two is at a higher potential?
5. Name the instruments used to measure electric current and potential difference respectively. Which of these is connected in series and which is connected in parallel in a circuit?
6. What is the shape of graph between V and i, where V is the potential difference between the ends of a wire and i is the current in it?
7. Consider the units volt, and ampere. One of them is the same as the product of other two. Which one is this?
8. Name three electrical appliances in which the heating effect of electric current is used.
9. Two bulbs have ratings 100W, 220V and 60W, 220V. Which one has a grater resistance?
10. You have two resistors of resistances 3 Ω and 60 Ω. What resistances can you get by combining the two?
11. Dray a diagram to show two resistors R_1 and R_2 connected in series.
12. Two resistors of 5Ω and 10Ω are connected in series in a circuit . How does the current passing through them compare?
13. A wire of resistance 10Ω is bent to form a closed circle. What is the resistance across a diameter of the circle?

SHORT ANSWER QUESTIONS

14. What is the difference between a conductor and an insulator? Give one example of each.
15. The current in a wire is one ampere. Explain this statement in terms of the charge flowing through the wire.
16. When do you say that the resistance of a wire is 1Ω?
17. Draw a circuit diagram for a circuit in which two resistors A and B are joined in series with a battery, and a voltmeter is connected to measure the potential difference across the resistor A.
18. When are resistors said to be connected in series?
19. When are resistors said to be connoted in parallel?
20. Why is tungsten suitable for making the filament of a bulb?
21. Why is tungsten not used as a fuse wire?
22. Alloys are preferred over metals for making the heating element of heaters. Why?
23. Silver is a better conductor of electricity than copper. Why then do we use copper wire for conducting electricity?
24. State Ohm's law. How can it be verified?
25. When the terminals of a cell are connected to the ends of an iron rod, electric current flows through the rod. When the terminals are connected to the ends of a wooden rod, no current flows. Explain why, when the wooden rod also has a large number of electrons.
26. Define electric current and state its unit. How can Ohm's law be used to define ohm?
27. Deduce the expression for the equivalent resistance of the parallel combination of two resistances R_1 and R_2.
28. Deduce the expression of the equivalent resistance of the two resistances R1 ad R2 connected in series.
29. Derive and expression for the heat produced in time t in a wire of resistance R_1 which is carrying a current it.

FILL IN THE BLANKS

1. The diameter of atom is of the order of ……………………………m.
2. The diameter of nucleus of the order of ……………………………………m.
3. The negative charge on an electron is …………………..C.
4. The sign of charge on a proton is ………………….
5. The value of charge on a neutron is ………………
6. Conductors have …………………….free electrons.
7. Insulators have……………………….free electrons.
8. Semiconductors have……………………..free electrons.
9. The sign of charge on a body which has gained electrons is…………………..
10. The sign of charge on a body which has lost electrons is…………………
11. The charge that produces electric field is called a………………………..charge.
12. The charge that measures the intensity of electric at a point is called a ………………………..charge.
13. Electric potential at a point in an electric field is measured as the …………………..done in bringing, a unit positive test charge from infinity to that point.
14. Static electricity is constituted by electric charges……………….on the surface of a conductor.
15. Current electricity is constituted when the charges……………………..in a conductor.
16. The expression for eclectic current is…………………..
17. The S.I. unit of electric current is ………………………
18. The ratio V/I is called …………………..
19. S.I. unit of resistance is…………………….
20. A voltmeter measures ……………………between two points.
21. An ammeter measures …………………….through a conductor.
22. Resistance increases in ………………combination.
23. Resistance decreases in ……………….combination.
24. In a series combination, resistance increases due to increase in…………………
25. In a parallel combination, resistance decreases due to increase in……………………..
26. Watt is the S.I. unit of electrical ……………….
27. Joule is the S.I. unit of electrical ……………….
28. In series combination, power …………....
29. In parallel combination, power ………………
30. Decrease of power of combination, is due to increase of ………………..
31. Increase of power of combination in due to decrease of ………………...
32. Filament of an electric bulb of low power has …………………….resistance.
33. The power is and electric bulb which takes 0.25 A current at 20 V is ………………W.
34. An electric current heats a conductor due to loss of kinetic energy of …………………
35. For same battery, heating of a wire will…………………if is resistance is increased.

MARK THE STATEMENT TRUE (T) OR FALSE (F)

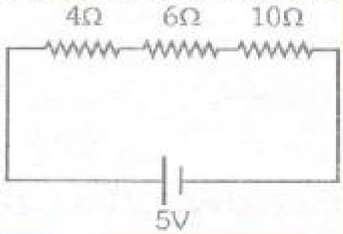
1. An electron has a negative charge of 1.6×10^{-19} C.
2. A neutron has a positive charge of 1.6×10^{-19} C.
3. Conductors have more free electrons.
4. Insulators have few free electrons.
5. Proton has a positive charge.
6. Neutral atom has no charge.
7. A field charge has its own electric field.
8. The field intensity is measured by the field charge.
9. A point insider an electric field has an electric potential.
10. No work is done moving a test charge between two points at different potential.
11. Electric potential is a scalar quantity.
12. Electric field intensity is also a scalar quantity
13. Electric current is due to flow of electrons.
14. In electric current, electros flow from positive (higher) to negative (lower) potential/
15. A voltmeter measures electric potential difference between two poets.
16. A voltmeter has low resistance.
17. An ammeter measures electric current flowing through a resistance.
18. An ammeter has a high resistance.
19. In series combination, total resistance is more than the highest resistance.
20. In parallel combination, total resistance lies in between the lowest and the highest resistance.
21. Electrical power is time rate of production or consumption of electrical energy.
22. Kilo-watt-hour is the unit of electrical power.
23. To increase total power, we connect the appliances in parallel.
24. In house light, connecting the appliances in series will be easier and economical.
25. In parallel a 100W bulb glows more that a 25W bulb.
26. In series, a 25 W bulb glows less than a 100W bulb.
27. A high power bulb takes more current.
28. A high power bulb has more resistance.
29. More bulbs connected in parallel produce more light.
30. More bulbs connected in series produce more light.

NUMERICALS

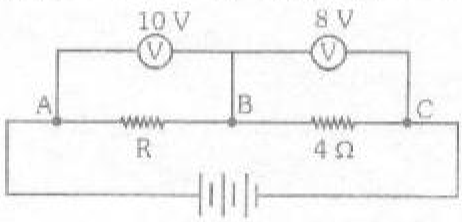
1. How much work will be done in bringing a charge of 5.0 mili-coulombs from infinity to a point P at which the potential is 12V?
2. A particle with a charge of 1.5 coulombs is taken from a point A at a potential of 50V to another point B at a potential of 120 V. Calculate the work done.
3. How many electrons are required to get 1C of negative charge?
4. Calculate the current a wire if 900C of charge passes through it in 10 minutes.
5. How much current will flow through a resistor of resistance $12\,\Omega$ if a battery of 18 V is connected across it?
6. Calculate the resistance of a copper wire of length 1m and area of cross section $2mm^2$. Resistively of copper is $1.7 \times 10^{-8}\,\Omega$ m.
7. A copper wire has a resistance of 0.5 Ω. Another copper wire of the same as the first one is double in length of the first. Find the resistance of the second wire.
8. In an experiment to verify Ohm's law, the current through a resistor and the potential difference across it are measured. From the values given below, plot a graph of i versus V. Show that the data confirms Ohm's law, and find the resistance of the resistor.

   Current (A) **0.1, 0.2, 0.3, 0.4**

   Potential difference (V) **1.2, 2.4, 3.6, 4.8**
9. When a potential difference of 20 V is applied across a resistor, it draws a current of 3A. If 30 V is applied across the same resistor, what will be the current .
10. How will the resistance of a wire change if its diameter (d) is doubled, its length remaining the same?
11. Calculate the potential difference across each resistor in the circuit shown in figure.

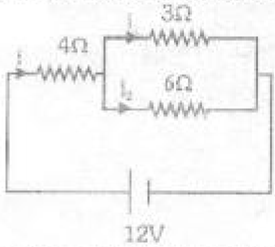


12. Three identical bulbs are connected in parallel with a battery. The current drawn from the battery is 6A. If one of the bulb gets fused, what will be the total current drawn from the battery?
13. A uniform wire of resistance R is cut into three equal pieces. And these pieces are joined in parallel. What is the resistance of the combination?
14. Consider the circuit shown in figure. The voltmeter on the left reads 10 V and that on the right reads 8V. Find **(a)** The current through the resistance R, **(b)** the value of R, and **(c)** the potential difference across the battery.



15. Three resistors of resistances $10\,\Omega$, $20\,\Omega$ and 30 are connected in parallel with a 6V cell. Find (a) The current through each resistor, (b) the current supplied by the cell, and (c) the equivalent resistance of the circuit.

16. Consider the circuit shown in fig. Calculate the current through the $3\,\Omega$ resistor.



17. When two resistors are joined in series, the equivalent resistance is $90\,\Omega$. When the same resistors are joined in parallel, the equivalent resistance is $20\,\Omega$. Calculate the resistance of the two resistors.

18. (a) How will you join three resistance of resistance $4\,\Omega$, $6\,\Omega$ and $12\,\Omega$ to get an equivalent resistance of $8\,\Omega$.

(b) What would be the highest and the lowest equivalent resistances possible by joining these resisrors.

19. How many bulbs of resistance 6 ohms should be joined in parallel to draw a current of 2 amperes from a battery of 3 volts?

20. A current 4A passes through a resistance of $100\,\Omega$ for 15 minutes, Calculate the heat produced in calories.

21. A 12V battery is connected to a bulb. The battery sends a current of 2.5a through it. Calculate

(a) the power delivered to the bulb , and

(b) the energy transferred to the bulb in 5 minutes.

22. A current is passed through a resistor for some time. It produces 400 cal of heat in this period. If the current is doubled, how much heat will be produced for the same duration.

23. Calculate the wattage of an electric heater which draws 5A current connected to a 220V power supply.

24. A bulb draws 24W when connected to a 12V supply. Find the power if it is connected to a 6V supply. (Neglect resistance change due to unequal heating in the two cases.)

25. Two identical resistance R are connected in series with a battery of potential difference V for time t. The resistor are later connoted in patroller and the same battery is connected across the combination for time t. Compare the heat produced in the two cases.

26. A bulb is rated 40W, 220V. Find the current drawn by it when connoted to a 220V supply.

27. A bulb is rated 60W, 240V. Calculate its resistance when it is on. If the voltage drops to 192V, what will be the power consumed and the current drawn?

28. A room has two the lights, a fan and a TV. Each tube light draws 40W. The fan drawn 80W, and the TV draws 60W. On the average, the tube lights are kept on for five hours. The fan for twelve hours and the TV for eight hours every day. The rate for electrical energy is Rs. 3.10 per kWh. Calculate the cost of electricity used in this room in a 30 day month.

29. When a particle of charge $10\,\mu C$ is brought from infinity to a point P, 2.0 mJ of work is done by the external forces. What is the potential at P?

30. Calculate the work done in taking a charge of 0.02C from A to B if the potential at A is 20V, and that at B is 30V.

31. How much charge flows through a wire in 10 minutes if the current through it is 2.5A?

32. A 2V cell is connected to a $1\,\Omega$ resistor. How many electrons same out of the negative terminal of the cell in 2 minutes?

33. The amounts of charge passing through a cell in 4 seconds is 12C. What is the current supplied by the cell?

34. A 6V battery is connected across a $5\,\Omega$ resistor. Calculate the current passing through the resistor.

35. When a 24V battery is connected to a resistor, the current in it is 0.4A. What is the resistance of the resistor ? What would be the current through it when it is connected to a battery of 6V?

36. In an experiment, the current flowing through a resistor and the potential difference across it is measured. The values are given below. Show that these values confirm Ohm's law, and the resistance of the resistor,

i (ampere)	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**
V (volt)	**4.0**	**6.0**	**8.0**	**10.0**	**12**

37. The resistivity of copper is $1.7 \times 10^{-8}\ \Omega m$.

(a) What length of copper wire of diameter 0.1 mm will have a resistance of $34\ \Omega$.

(b) Another copper wire of same length but of half the diameter as the first is taken. What is the ratio of its resistance to that of the first wire?

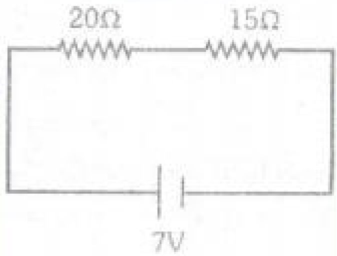
38. Three resistors, each of resistance $12\,\Omega$, are connected in parallel. What is the equivalent resistance?

39. A uniform wire of resistance R is cut into two equal pieces. And these pieces are joined in parallel. What is the resistance of the combination?

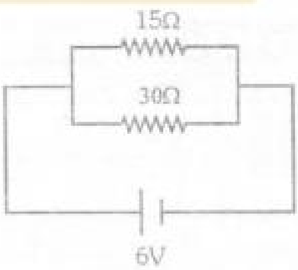
40. You have three resistors of 9 ohms each. By combining them what can be (a) the highest resistance, and (b) the lowest resistance? (c) How can you combine them to get a resistance of $12\,\Omega$?

41. How will you join the resistors of resistance $3\,\Omega$, $6\,\Omega$ and $8\,\Omega$ to get an equivalent resistance of $10\,\Omega$?

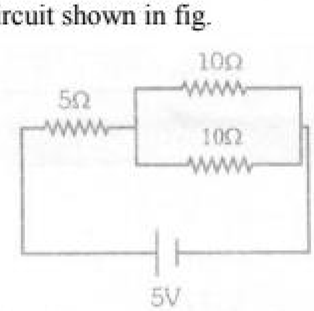
42. Find the current through the circuit shown in fig. Also find the potential difference across the $20\,\Omega$ resistor.



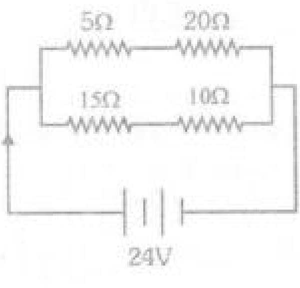
43. Find (a) the equivalent resistance, (b) the current passing through the cell, and (c) the current passing through the $30\,\Omega$ resistor in the circuit shown in fig.



44. Find the current supplied by the cell in the circuit shown in fig.



45. In the circuit shown below, calculate the total resistance of the circuit and the current flowing through it.



46. Fig shows a part of an electric circuit. The reading of ammeter is 3.0A. Find the currents through the $10\,\Omega$ and $20\,\Omega$ resistors.

47. A 12V battery connoted to a bulb drives a current of 2.0A through if. Find the energy supplied by the battery in 10 minutes.

48. A current of 1.5A flows through a wire of $8\,\Omega$. Find the amount of heat produced in 10 seconds.

49. A current of 2A produces 200J of heat in a wire in a given period of time. If the current is increases to 4A how much heat will be produced in the same time?

50. A bulb is rated 5.0V, 100mA. Calculate its rated power and resistance.

51. Calculate the resistance of a bulb rated 40W, 230 V when in ON condition.

52. Calculate the current passing through a bulb rated 60W, 240V when it is connected to a 240V power supply.

53. Two resistors of resistances $10\,\Omega$ and $20\,\Omega$ are joined in series. A potential difference of 12V is applied across the combination. Find the power consumed by each resistor.

54. Two resistors of resistances $10\,\Omega$ and $20\,\Omega$ are joined in parallel. A potential difference of 12V is applied across the combination. Find the power consumed by each resistor.

55. Calculate the energy consumed in kilowatt hours by a 60W fan in 2 hours.

56. A heater draws 1100W at 220W.

(a) Find the resistance of the heater when in ON condition.

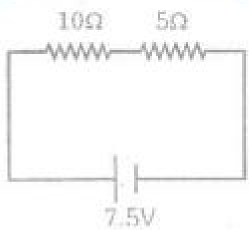
(b) Calculate the kilowatt hours consumed in a week if the heater is used daily for four hours at the rated voltage.

57. A bulb used in a car is rated 12V, 48W. Find the energy consumed in one minute when the bulb is connoted to (a) a 12V battery and (b) a 6V battery.

58. 6×10^7 electrons cross through an area per minute. What is the electric current?

59. A 4V battery is connected to a lamp of resistance $4\,\Omega$. Calculate the current through the lamp.

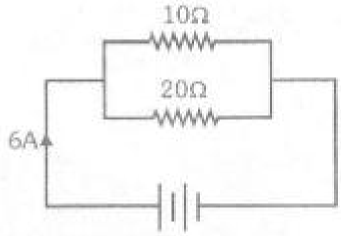
50. Calculate (a) the equivalent resistance, (b) the electric current, and (c) the potential difference across each resistor in circuit shown in Figure.



61. Two resistances of $3\,\Omega$ and $6\,\Omega$ are connected in parallel. Calculate their equivalent resistance.

62. A $1\,\Omega$ Resistor is connected in parallel to a $10\,\Omega$ resistor. Calculate the equivalent resistance.

63. Two resistors of resistances 10Ω and 20Ω are connected in parallel. A battery supplies 6A of current to the combination, as shown in Fig. Calculate the current in each resistor.



64. A 3V battery is connected across a 5Ω resistance. Calculate the heat produced in 5 seconds.

65. An electric kettle is rated 500W, 220 V. It is used to heat water for 30 seconds. Assuming the voltage to be 220V, calculate the heat produced.

ANSWERS — ELECTRICITY

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

EXERCISE - 2

FILL IN THE BLANKS

1. 10^{-10} **2.** 10^{-15} **3.** 1.6×10^{-19} **4.** positive
5. zero **6.** more **7.** No. **8.** few
9. negative **10.** positive **11.** field **12.** fest
13. work **14.** at rest **15.** flow **16.** I = V/R or q/t
17. ampere **18.** resistance **19.** ohm **20.** potential difference
21. current **22.** series **23.** parallel **24.** length
25. area of cross-section **26.** power **27.** energy **28.** decreases
29. increases **30.** resistance **31.** resistance **32.** more
33. 50

TRUE AND FALSE

1. True **2.** False **3.** True **4.** False **5.** True **6.** False **7.** True **8.** False
9. True **10.** False **11.** True **12.** False **13.** True **14.** False **15.** True **16.** False
17. True **18.** False **19.** True **20.** False **21.** True **22.** False **23.** True **24.** False
25. True **26.** False **27.** True **28.** False **29.** True **30.** False **31.** False

NUMERICAL

1. 0.06 J **2.** 105 J **3.** 6.25×10^{18} **4.** 1.5A **5.** 1.5A
6. $8.5 \times 10^{-3}\,\Omega$ **7.** 2.4Ω **8.** 12Ω **9.** 4.5 A **11.** 1V, 1.5V, 2.5V
12. 4A **13.** $\frac{R}{9}$ **14.** 2A, 5Ω, 18V **15.** 5.5 Ω **16.** 1.33A
17. 30Ω **19.** 4 **20.** 3.4×10^{5} cal **21.** 30W, 9000J **22.** 1600 cal
23. 1100W **24.** 6W **26.** $\frac{2}{11}A$ **27.** 38.4W, 0.2A **28.** Rs. 171.12
29. 200 V **30.** 0.2 J **31.** 1500C **32.** 1.5×10^{21} electrons
33. 3A **34.** 1.2A **35.** 60Ω, 0.1A **36.** 4Ω
37. (a) 15.71 m, (b) 4 : 1 (4 times) **38.** 4W **39.** $\frac{R}{4}$
40. (a) 27Ω (b) 3Ω (c) one resistor connected in series to a combination of two resistors in parallel
41. 8Ω resistor connected in series to a parallel combination of 6Ω and 3Ω
42. 0.2A, 4V **43.** (a) 10Ω (b) 0.6A (c) 0.2A **44.** 0.5A **45.** 12.5 W, 1.92 A
46. 2A, 1A **47.** 14,400J **48.** 180J or 43 cal **49.** 800 J
50. 0.5 W 50Ω **51.** 1322.5Ω **52.** 0.25A **53.** 1.6 W, 3.2W **54.** 14.4W, 7.2 W
55. 012 kWh **56.** (a) 44Ω (b) 30.8 kWh **57. (a)** 2880 J (b) 720 J
58. 1.6 mA. **59.** 1A **60.** (a) 15Ω. (b) 0.5A (c) 5V, 2.5V
61. 2Ω **62.** 0.99Ω **63.** 4A, 2A **64.** 9J **65.** 15,000 J

EXERCISE -3 (FOR SCHOOL / BOARD EXAMS)

PREVIOUS YEARS BOARD (CBSE) QUESTIONS

VERY SHORT ANSWER QUESTIONS (CARRYING 1 MARK EACH)

1. Define resistivity of a material. **[2004]**
2. A cylinder of a material is 10 cm long and has a cross-section of 2 cm^2. If its resistance along the length be $20\,\Omega$, what will be its resistivity in number and units? **[2004]**
3. Why is tungsten metal selected for making filaments of incandescent lamps ? **[2005]**
4. A resistance of 10 ohm is bent in the form of a closed circle. What is the effective resistance between the two points at the ends of any diameter of this circle? **[2005]**
5. A wire of resistance $5\,\Omega$ is bent in the form of a closed circle. What is the resistance between two points at the ends of any diameter of the circle? **[2005]**
6. A wire of resistance $20\,\Omega$ is bent in the form of a closed circle. What is the effective resistance between the two points at the ends of any diameter of the circle? **[2005]**
7. Why is much less heat generated in long electric cables than in filaments of electric bulbs? **[2005]**
8. State which has a higher resistance: a 50 W or a 25W lamp bulb and how many times ? **[2005]**
9. What is the power of torch bulb rated at 2.5 V and 500 mA? **[2005]**
10. There are two electric bulbs, (i) marked 60 W, 220 V and (ii) marked 100 W; 220 V. Which one of them has higher resistance? **[2006]**
11. Out of the two, a toaster of 1 kW and an electric heater of 2 kW, which has a greater resistance? **[2006]**
12. What is the SI unit of electrical potential? **[2007]**
13. What is meant by the statement "potential difference between two points A and B in an electric circuit is 1 volt? **[2007]**
14. Why is series arrangement not used for connecting domestic electrical appliances in a circuit **[2008]**
15. Out of 60 W and 40 W lamps, which one has a higher resistance when in use? **[2008]**

SHORT ANSWER QUESTIONS (CARRYING 2 MARKS EACH)

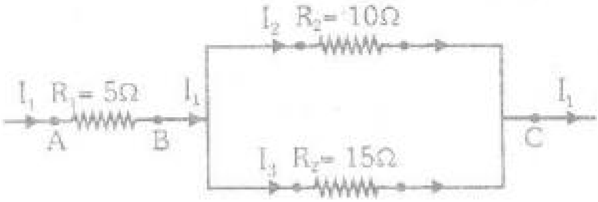
16. An electric bulb draws a current of 0.2 A when the voltage is 220 volts. Calculate the amount of charge flowing through it in one hour. **[2004]**
17. An electric iron draws a current of 0.5 A when the voltage is 200 volts. Calculate the amount of electric charge flowing through it in one hour. **[2004]**
18. An electric appliance draws a current of 0.4 A when the voltage is 200 volts. Calculate the amount of charge flowing through it in one hour. **[2004]**
19. Calculate the amount of charge that would flow in 1 hour through the electric bulb drawing a current of 0.2 A. **[2004]**
20. Calculate the amount of charge that would flow in 2 hours through the element of an electric bulb drawing a current of 0.25 A. **[2004]**
21. Calculate the amount of charge that would flow in 1 hour through the element of an electric iron drawing a current of 0.4 A. **[2004]**
22. Derive the relation $R = R_1 + R_2 + R_3$ when resistors are joined in series **[2005]**
23. (i) Draw a circuit diagram to show how two resistors are connected in series. **[2006]**
    (ii) In a circuit if the two resistors of $5\,\Omega$ and $10\,\Omega$ are connected in series, how does the current passing through the two resistors compare?
24. A bulb is rated at 5.0 V, 100 mA. Calculate its (i) power and (ii) resistance. **[2006]**

25. An electric iron has a rating of 750 W, 220V. Calculate [2007]
(ii) current passing through it, and (ii) its resistance, when in use.

26. An electric lamp in marked 100W, 220V. It is used for 5 hours daily. Calculate [2007]
(i) its resistance while glowing (ii) energy consumed in kWh per day.

SHORT ANSWER QUESTIONS (CARRYING 3 MARKS EACH)

27. Three resistors are as shown in Fig. Through a resistor of 5 ohm, a current of 1 ampere is flowing .



(a) What is the potential difference across AB and across AC ?
(b) What is the current through the other two resistors?
(c) What is the total resistance?

28. An electric bulb is rated at 200 V-100 W. What is its resistance? Five such bulbs burn for 4 hours. What is electrical energy consumed? Calculate the cost if the rate is 50 paise unit. [2003]

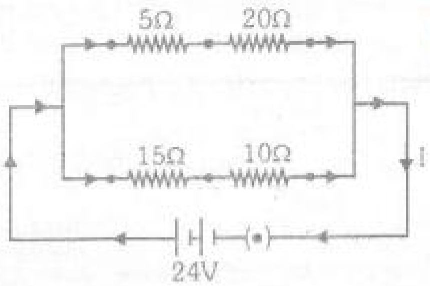
29. State the formula co-relating the electric current flowing in a conductor and the voltage applied across it. Also show this relationship by drawing a graph .
What would be the resistance of a conductor if the current flowing through it is 0.35 ampere when the potential difference across it is 1.4 volt. [2004]

30. (i) State the formula showing how the current I in a conductor varies when the potential difference V applied across it is increased stepwise [2004]
(ii) Show this relationship also on a schematic graph.
(iii) Calculate the resistance of a conductor if the current flowing through it is 0.2 ampere when the applied potential difference is 0.8 volt.

31. When a potential difference of 1.2 volt is applied across a conductor, the current flowing through it is 0.25 ampere. Calculate the resistance of the conductor. [2004]

32. A torch bulb is rated 5.0 V and 500 mA. Calculate its (i) power (ii) resistance and (iii) energy consumed when it is lighted for 4 hours. [2005]

33. If a 12 V battery is connected to the arrangement of resistance given in Fig. (with 5Ω replaced by 10Ω , 15Ω replace by 5Ω and 10Ω replaced by 25Ω). Calculate (i) the total effective resistance of the arrangement and (ii) the total current flowing in the circuit. [2005]

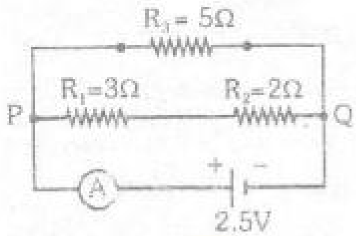


34. Two electric lamps of 100 W and 25 W respectively are joined to a supply of 200V. Calculate the total current flowing through the circuit. [2005]

35. Two identical resistors, each of resistance 2 Ω, are connoted in turn (i) in series, and (ii) in parallel to a battery of 12V. Calculate the ratio of power consumed in the two cases. **[2005]**

36. Two identical resistors, each of resistance 10Ω are connected (i) series, and (ii) in parallel, in turn to a battery of 10 V. Calculate the ratio of power consumed in the combination of resistors in the two cases. **[2005]**

37. In the given circuit, calculate (i) total resistance of the circuit, and (ii) current shown by the ammeter. **[2005]**

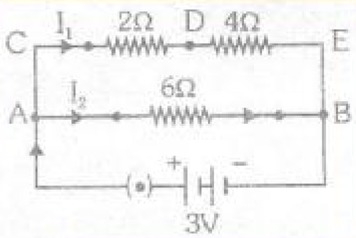


38. (i) Draw a schematic diagram of a circuit consisting of a battery of five 2 V cells, a 5Ω resistor, a 10Ω resistor and a 15Ω resistor, and a plug key, all connected in series . **[2006]**

(ii) Calculate the current passing through the above circuit when is closed.

39. In a household, 5 tube lights of 40 W each are used for 5 hours and an electric press of 500 W for 4 hour each day. Calculate the total energy consumed by the tube lights and press in a month of 30 days. **[2006]**

40. In the circuit shown in Fig. calculate: (a) total resistance in arm CE, (b) total current drawn from the battery , and (c) current in each arm, i.e. , AB and CE of the circuit. **[2006]**



41. (a) What is meant by 'Electric Resistance' of a conductor? **[2007]**

(b) A wire of length L and resistance R is stretched so that its length is doubled and area of cross, section is halved. How will its : (i) resistance change ? (ii) resistivity change ?

42. (a) State Ohm's law. **[2007]**

(b) Draw a schematic diagram of the circuit for studying Ohm's law.

43. Two lamps. One rated 60 W at 220 V and the other 40 W at 220 V, are connected in parallel to the electric supply at 220 V. **[2008]**

(a) Draw a circuit diagram to show the connections.

(b) Calculate the current drawn from the electric supply.

(c) Calculate the total energy consumed by the two lamps together when they operate for one hour.

44. (a) Distinguish between the terms ' overloading' and 'short-circuiting' as used in domestic circuits. **[2008]**

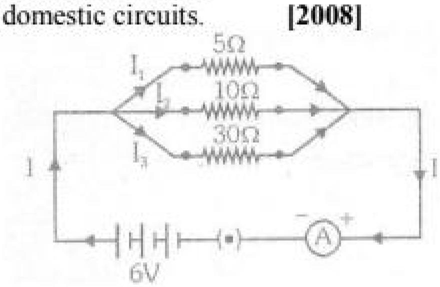
(b) Why are the coils of electric toasters made of an alloy than a pure metal?

45. For the circuit shown in Fig. calculate **[2008]**

(a) the value of current through each resistance

(b) the total current in the circuit

(c) the total effective resistance of the circuit.



LONG ANSWER QUESTIONS (CARRYING 5 MARKS EACH)

46. (a) Express Ohm's law by a mathematical formula. **[2004]**

(b) Draw a circuit diagram to verify Ohm's law.

(c) Resent the relationship between the voltage applied across a conductor and the current flowing through it graphically.

47. State Ohm's law. Express it mathematically. Define SI unit of resistance. Derive and expression for the equivalent resistance of three resistors R_1, and R_2 connected in series (or in parallel). **[2004]**

48. (a) Express Ohm's law both a mathematical formula and by a graph line . **[2004]**

(b) State SI units of (i) resistance and (ii) resistivity.

(c) What will be the equivalent resistance of two resistors R_1 and R_2 (i) connected in series and (ii) connected in parallel

49. (a) What is meant by saying that potential difference between two points is 1 volt ? Name a device that helps to measure the potential difference a conductor. **[2008]**

(b) Why does the connection cord of an electric heater not glow hot while the heating element does ?

(c) Electrical resistivities of some substances at 20^0C are given below :

Silver	$1.60 \times 10^{-8} \Omega$ m
Copper	$1.62 \times 10^{-8} \Omega$ m
Tungsten	$5.20 \times 10^{-8} \Omega$ m
Iron	$10.0 \times 10^{-8} \Omega$ m
Mercury	$94.0 \times 10^{-8} \Omega$ m
Nichrome	$100 \times 10^{-6} \Omega$ m

Answer the following questions in relation to them:

(i) Among silver and copper, which one is better conductor? Why?

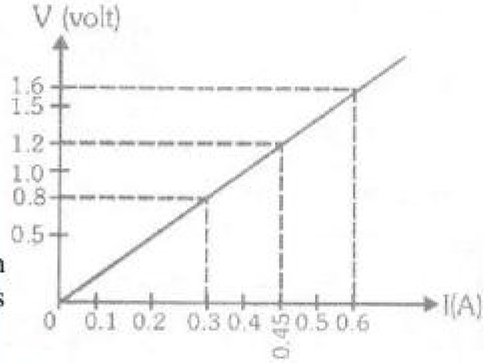
(ii) Which material would you advise to be used in electrical heating devices? Why?

50. (a) Name an instrument that measures electric current in a circuit. Define the unit of electric current **[2008]**

(b) What do the following symbols mean in circuit diagram?

(i) 

(ii) 



(c) An electric circuit consisting of a 0.5 m long nichrome wire XY, an ammeter, a voltmeter, four cells of 1.5 V each and a plug key was set up.

(i) Draw a diagram of this electric circuit to study the relation between the potential difference maintained between the points 'X' and 'Y' and the electric current flowing through XY.

(ii) Graph shown Fig. was plotted between V and I values.

What would be the value of V/I ratios when the potential difference is 0.8 V, 1.2 V and 1.6 V respectively ?
What conclusion do you draw from these values?

EXERCISE – 4 (FOR OLYMPIADS)

1. If a charged body attracts another body, the charge on the other body :-
(A) must be negative (B) must be positive
(C) must be zero (D) may be negative or positive or zero

2. 1 MeV is equal to:
(A) 1.6×10^{-19} J (B) 1.6×10^{-14} J (C) 1.6×10^{-13} J (D) 1.6×10^{-13} J

3. A man has five resistors each of value $\frac{1}{5}\Omega$. What is the maximum resistance he can obtain by connecting them ?
(A) 1 Ω (B) 5Ω (C) $\frac{1}{2}\Omega$ (D) $\frac{1}{5}\Omega$

4. Materials which allow larger currents to flow through them are called:
(A) Insulators (B) Conductors (C) Semiconductors (D) Alloys

5. If I is the current through a wire and e is the charge of electrons, then the number of electrons in t seconds will be given by:
(A) $\frac{Ie}{t}$ (B) Ite (C) e/It (D) It/e

6. Conventionally, the direction of the current is taken as –
(A) the direction of flow to negative charge (B) the direction of flow of atoms
(C) the direction of flow of molecules (D) the direction of flow of positive charge

7. The unit of specific resistance is :-
(A) ohm (B) mho (C) ohm-metre (D) ohm per metre

8. If the length of a wire is doubled and its cross-section is also doubled, then the resistance will –
(A) increase eight times (B) decrease four times
(C) become four times (D) remain unchanged

9. A suitable unit for expressing the strength of electric field is –
(A) V / C (B) C / m (C) N / C (D) C/ N

10. 1 volt equals :-
(A) 1 joule (B) 1 joule per coulomb
(C) 1 coulomb per metre (D) 1 newton per coulomb

11. 1 Vm^{-1} equals –
(A) 1 NC^{-1} (B) 1 NC^{-2} (C) 1 Jm^{-1} (D) I Jm^{-2}

12. The reciprocal of resistance is conductance. If the unit of resistance is ohm, the unit of conductance will be –
(A) ohm (B) volt (C) mho (D) ohm $metre^{-1}$

13. Good conductors have many loosely bound –
(A) atoms (B) molecules (C) protons (D) electrons

14. One ampere equals :-
(A) 10^{6} μA (B) 10^{-6} μA (C) 10^{-3} μA (D) 10 A

15. How many electrons constitute a current of one microampere?
(A) 6.25×10^{6} (B) 6.25×10^{12} (C) 6.25×10^{9} (D) 6.25×10^{15}

16. If a wire of resistance $1\,\Omega$ is stretcher to double its length, then the resistance will become :-

(A) $\frac{1}{2}\Omega$ (B) 2Ω (C) $\frac{1}{4}\Omega$ (D) 4Ω

17. The SI unit of specific resistance is:

(A) ohm m (B) ohm m^{-1} (C) ohm m^2 (D) $(ohm)^{-1}$

18. The effective resistance of a circuit containing resistances in parallel is –

(A) equal to the sum of the individual resistances

(B) smaller than any of the individual resistance

(C) greater than any of the individual resistances

(D) sometimes grater and sometimes smaller than the individual resistances

19. Electric intensity is

(A) a scalar quantity (B) a vector quantity

(C) neither scalar nor vector (D) sometimes scalar and sometimes vector

20. Electric potential is

(A) A scalar quantity (B) a vector quantity

(C) neither scalar nor vector (D) sometimes scalar and sometimes vector

21. In Coulomb's law, the constant of proportionality k has the units –

(A) N (B) Nm^2 (C) NC^2 / m^2 (D) Nm^2 / C^2

22. The variable resistance is called:

(A) resistor (B) rheostat (C) open switch (D) none of these

23. How much work is done in moving a charge of two coulombs from a point at 118 volts to a point at 128 volts ?

(A) 10 J (B) 20 J (C) $\frac{1}{10}$ J (D) None of these

24. The law that governs the force between electric charges is called –

(A) Ampere's law (B) Coulomb's law (C) Faraday's law (D) Ohm's law

25. A charge q is placed at the center of the line joining two equal charges Q. The system of the three charges will be in equilibrium, if q is equal to -

(A) $-\frac{Q}{2}$ (B) $-\frac{Q}{4}$ (C) $+\frac{Q}{4}$ (D) $+\frac{Q}{2}$

26. Two small spheres each carrying a charge q is placed r mere apart. If one of the spheres is taken around the other one in a circular path of radius r, the work done will be equal to. ≈

(A) Force between them × r (B) Force between them × 2π r

(C) Force between them $/ 2\pi r$ (D) Zero

27. The force between two electrons separated by distance r varies as:-

(A) r^2 (B) r (C) r^{-1} (D) r^{-2}

28. When the distance between the charged particles is halved, the force between them becomes –

(A) One-fourth (B) Half (C) Double (D) Four times

29. There are two charge +1 μC and +5 μC. The ratio of the forces action on them will be –

(A) 1 : 5 (B) 1 : 1 (C) 5 : 1 (D) 1 : 25

30. Which one of the following is the unit of electric field intensity?

(A) V × metre (B) V / joule (C) V × joule (D) V / metre

31. A charge q_1 exerts some force on second charge q_2. if third charge q_3 is brought near, the force of q_1 exerted on, q_2 :-
(A) Decreases
(B) Increases
(C) Remains unchanged
(D) Increases if q_3 is of the same sign as q_1 and decreases if q_3 is of opposite sign

32. If the charge is moved against the coulomb force of an electric field –
(A) Work is done by the electric field
(B) Energy is used from some outside force
(C) The strength of the field is decreased
(D) The energy of the system is decreased

33. The ratio of the forces between two small spheres with constant charge (a) in air (b) in a medium of dielectric constant K is -
(A) 1 : K (B) K : 1 (C) 1 : K^2 (D) K^2 : 1

34. Two charges are placed at a distance. If a glass slab is placed between them, force between them will be
(A) Zero (B) Increased (C) Decreased (D) Remains same

35. Electric intensity and electric potential are related with each other by the relation –
(A) $V = \frac{dE}{dx}$ (B) $E = \frac{dV}{dx}$ (C) $E = \frac{dV}{dx}$ (D) E = potential × distance

36. If a unit positive chare is taken from one point to another over an equipotential surface then –
(A) Work is done on the charge
(B) Work is done by the charge
(C) Work done is constant
(D) No work is done

37. Electric lines of force about negative point charge are –
(A) Circular, anticlockwise
(B) Circular, clockwise
(C) Radial, inward
(D) Radial, outward

38. Electric intensity at a place due to a, charge conductor is a –
(A) Scalar quantity
(B) Vector quantity
(C) Neither scalar vector
(D) None of these

39. If a glass rod is rubbed with silk, it acquires a positive charge because –
(A) Protons are added to it
(B) Electrons are added to it
(C) Protons are removed from it
(D) Electrons are removed from it

40. The magnitude of electric field intensity E is such that, an electron placed in it would experience an electrical force equal to its weight is given by -
(A) mge (B) $\frac{mg}{e}$ (C) $\frac{e}{mg}$ (D) $\frac{e^2}{m^2}.q$

41. Two resistors of resistance R_1 and R_2 having $R_1 > R_2$ are connected in parallel. For equivalent resistance R, the correct statement is -
(A) $R > R_1 + R_2$
(B) $R_1 > R < R_2$
(C) $R_2 < R < (R_1 + R_2)$
(D) $R < R_1$

42. If a 0.1% increases in length due to stretching, the percentage increases in its resistance will be –
(A) 0.2% (B) 2% (C) 1% (D) 0.1%

43. Two unequal resistances are connected in parallel. Which one of the statement is correct –
(A) The current flowing is same in both
(B) More current will flow from higher resistance piece
(C) The potential drop is same in both
(D) The conductivity of lower resistance is less

44. When the length and area of cross-section both are doubled, then its resistance-
(A) Will become half
(B) Will be doubled
(C) Will remain the same
(D) Will become four times

45. A galvanometer can be converted into an ammeter by connecting –
(A) Low resistance in series
(B) High resistance in parallel
(C) Low resistance in parallel
(D) High resistance in series

46. There are 8 equal resistances R. Two are connected in parallel; such four groups are connected in series, the total resistance
(A) R / 2
(B) 2R
(C) 4R
(D) 8R

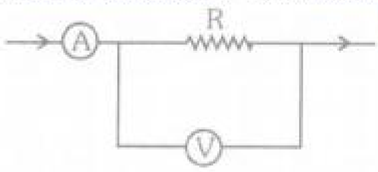
47. In a conductor 4 coulombs of charge flows for 2 seconds. The value of electric current will be –
(A) 4 V
(B) 4 A
(C) 2 A
(D) 2 V

48. In a conductor, the flow of current is:
(A) Flow of molecules
(B) Flow of free electrons
(C) Flow of positive charge
(D) Flow of ions

49. Three resistances of magnitude 2, 3 and 5 ohm are connected in parallel to a battery of 10 volts and of negligible resistances. The potential difference across $3\,\Omega$ resistance will be –
(A) 2 V
(B) 3 V
(C) 5 V
(D) 10 V

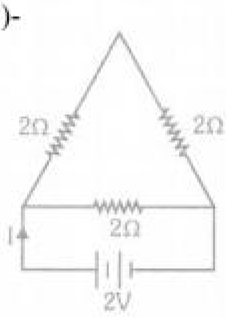
50. Which of the following have highest conductivity?
(A) Cu
(B) Insulator
(C) Semiconductor
(D) All are equal

51. In the circuit shown below, the ammeter A reads 5A and the voltmeter V reads 20 V (Fig.). The correct value of resistance R is :-



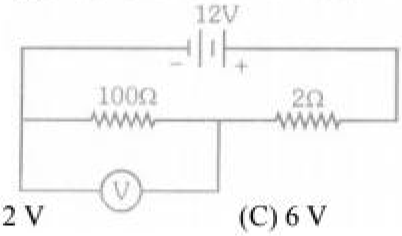
(A) exactly $4\,\Omega$
(B) slightly greater than $4\,\Omega$
(C) slightly less than $4\,\Omega$
(D) zero

52. What is the current in the circuit shown (Fig.)-



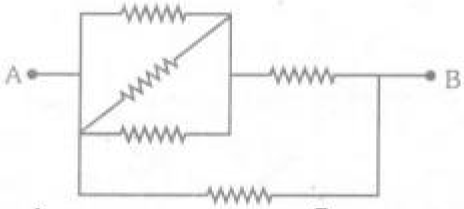
(A) 1.5 A
(B) 0.5 A
(C) 2.5 A
(D) none these

53. In the circuit shown in Fig., the reading of the voltmeter V will be :-



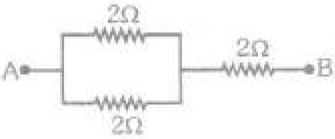
(A) 4 V
(B) 2 V
(C) 6 V
(D) 3 V

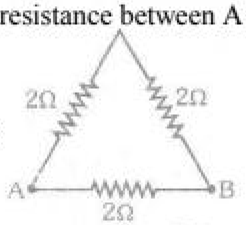
54. Five identical resistance coils are connected in the network as shown in fig. and ht resistance measured between A and B is $1\,\Omega$. Then the individual coils must have a resistance of:-

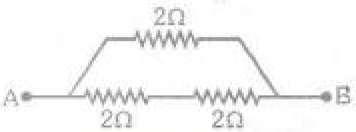


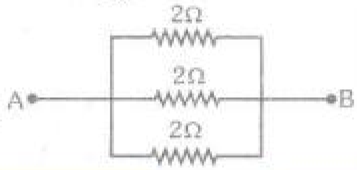
(A) $1\,\Omega$ (B) $\frac{1}{4}\,\Omega$ (C) $\frac{7}{4}\,\Omega$ (D) $\frac{4}{7}\,\Omega$

55. Which of the following networks yields maximum effective resistance between A and B?

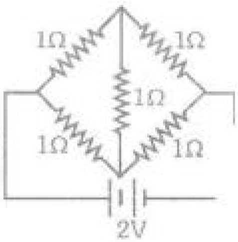
(A)


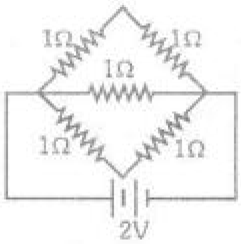
(B)


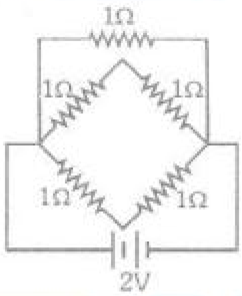
(C)


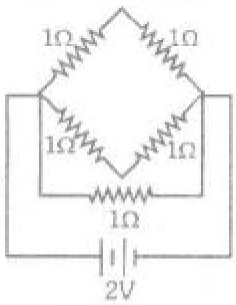
(D)


56. What of the following network yields minimum current?

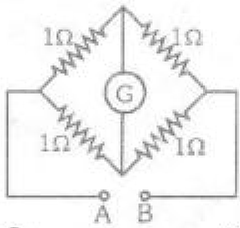
(A)


(B)


(C)


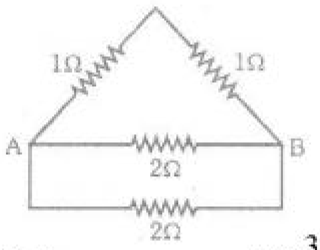
(D)


57. What is the total resistance between A and B in the given network (Fig.)? Given the resistance of the galvanometer as $40\,\Omega$.



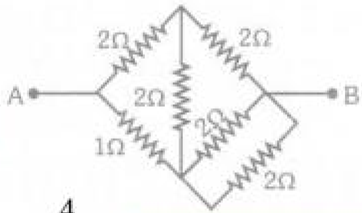
(A) $1\,\Omega$ (B) $2\,\Omega$ (C) $\frac{1}{2}\,\Omega$ (D) None of these

58. What is the resistance between A and B in the given network (Fig.)?



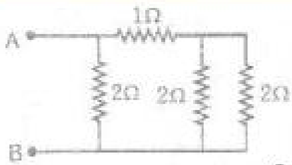
(A) 2Ω (B) 2Ω (C) $\frac{3}{2}\,\Omega$ (D) $\frac{2}{3}\,\Omega$

59. What is the resistance between A and B in the given network [Fig.]?



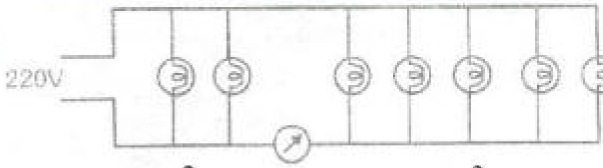
(A) $\frac{3}{4}\,\Omega$ (B) $\frac{4}{3}\,\Omega$ (C)2 Ω (D) $\frac{1}{2}\,\Omega$

60. The equivalent resistance between A and B (Fig.) will be:-



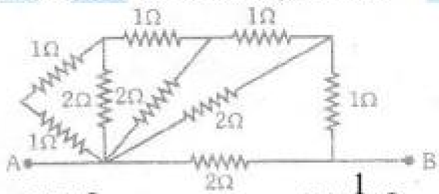
(A) 7Ω (B) 2Ω (C) $\frac{5}{3}\,\Omega$ (D) 1Ω

61. Seven identical lamps of resistance 220Ω each are connected to a 220 V line as shown in Fig. Then the reading in the ammeter will be :-



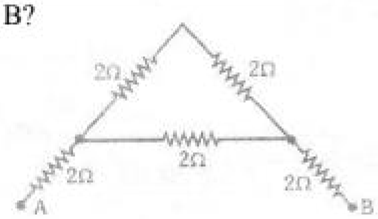
(A) $\frac{1}{10}A$ (B) $\frac{2}{5}A$ (C) $\frac{3}{10}A$ (D) $\frac{1}{2}A\,\Omega$

62. What is the resistance between A and B in the following circuit?



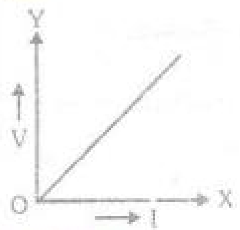
(A) 1Ω (B) 2Ω (C) $\frac{1}{2}\,\Omega$ (D) $\frac{3}{2}\,\Omega$

63. What is the resistance between A and B?



(A) $\frac{3}{4}\,\Omega$ (B) $\frac{4}{3}\,\Omega$ (C) $\frac{16}{3}\,\Omega$ (D) infinity

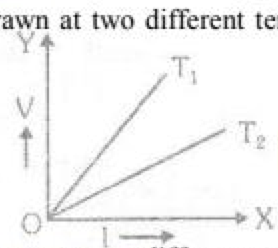
64. The slope of voltage (V) versus current (I) is called:-



(A) resistance (B) conductance (C) resistivity (D) conductivity

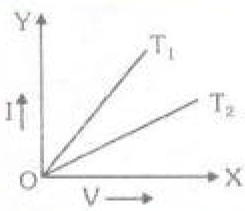
65. For a metallic conductor, current versus voltage graph is drawn at two different temperatures T_1 and T_2. From the graph it follows:-

(A) $T_1 = T_2$
(B) $T_1 > T_2$
(C) $T_1 < T_2$
(D) None of these

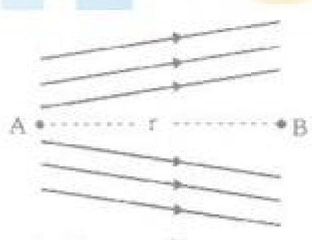


66. For a metallic conductor, voltage versus current graph is drawn at two different temperatures T_1 and T_2. From the graph follows :-

(A) $T_1 = T_2$
(B) $T_1 > T_2$
(C) $T_1 < T_2$
(D) None of these

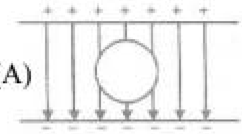
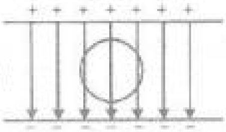
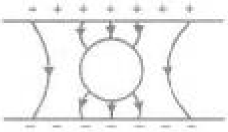
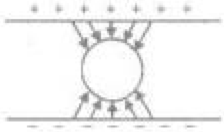


67. Figure shows the electric lines of force emerging from a charged body. If the electric field at A and B are E_A and E_B respectively and if the displacement between A and B is r, then –

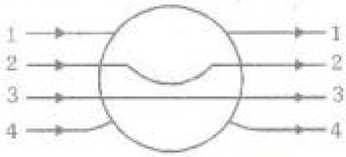


(A) $E_A > E_B$ (B) $E_A < E_B$ (C) $EA = \frac{E_B}{r}$ (D) $E_A = \frac{E_B}{r^2}$

68. An uncharged sphere of metal is placed in between two charged plates as shown. The lines of force look like

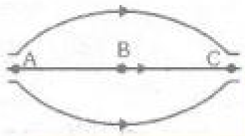
(A)  (B)  (C)  (D) 

69. A metallic solid sphere is placed in a uniform electric field. The lines of force follow the path (s) shown in figure as –



(A) 1 (B) 2 (C) 3 (D) 4

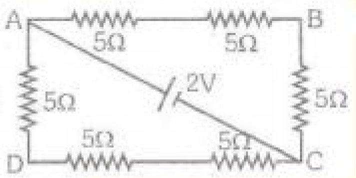
70. The figure shows some of the electric field lines corresponding to an electric field. The figure suggests



(A) $E_A > E_B > E_C$ (B) $E_A = E_B = E_C$

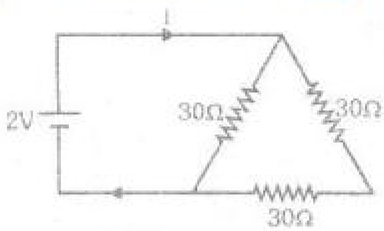
(C) $E_A = E_C > E_B$ (D) $E_A = E_C < E_B$

71. The potential difference between points A and B of adjoining figure is



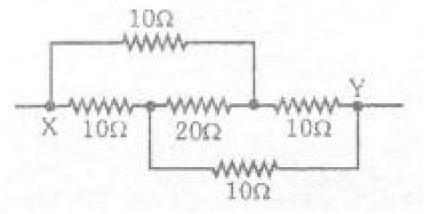
(A) $\frac{2}{3}$ V (B) $\frac{8}{9}$ V (C) $\frac{4}{3}$ V (D) 2 V

72. The current in the adjoining circuit will be –



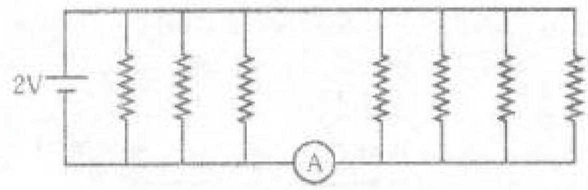
(A) $\frac{1}{45}A$ (B) $\frac{1}{15}A$ (C) $\frac{1}{10}A$ (D) $\frac{1}{5}A$

73. In the circuit shown five resistances are connected. The equivalent resistance between the two points X and Y will be -



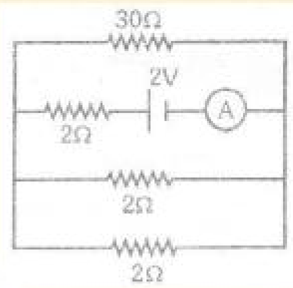
(A) 10Ω (B) 20Ω (C) 22Ω (D) 50Ω

74. Seven resistances each of 20Ω are connected with 2 volt battery as shown in figure. The reading of ammeter will be :-



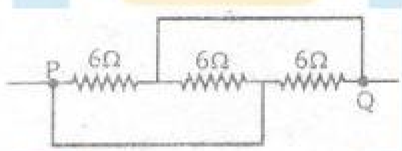
(A) 1 / 10A (B) 3 / 10A (C) 4 / 10A (D) 7 / 10A

75. The reading of the ammeter as per figure shown is :-



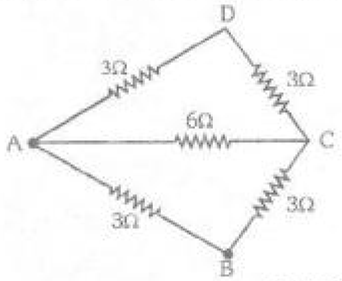
(A) $\frac{1}{8}$ A (B) $\frac{3}{4}$ A (C) $\frac{1}{2}$ A (D) 2A

76. The resultant resistance between P and Q as per the figure shown is :-



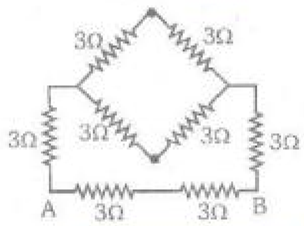
(A) 2Ω (B) 3Ω (C) 6Ω (D) 18Ω

77. The effective resistance between the points A and B in the figure is :-



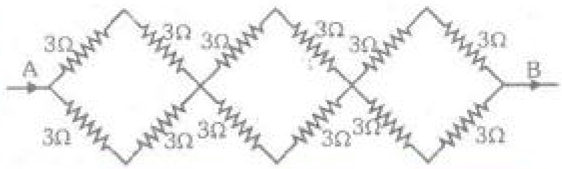
(A) 5 Ω (B) 2 Ω (C) 3 Ω (D) 4 Ω

78. Equivalent resistance between A and B will be –



(A) 2 Ω (B) 18 Ω (C) 6 Ω (D) 3.6 Ω

79. In the network of resistors shown in the adjoining figure, the equivalent resistance between A and B is :-



(A) 54 Ω (B) 18 Ω (C) 36 Ω (D) 9 Ω

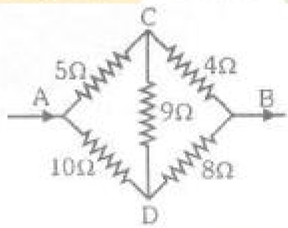
80. Five resistors are connected as shown in the diagram. The equivalent resistance between A and B is –

(A) 6 Ω

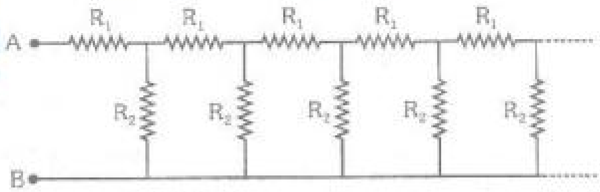
(B) 9 Ω

(C) 12 Ω

(D) 15 Ω



81. An infinite sequence of resistance is shown in the figure. The resultant resistance between A and B will be when $R_1 = 1\,\Omega$ and $R_2 = 2\,\Omega$:-



(A) Infinity (B) 1 Ω (C) 2 Ω (D) 1.5 Ω

82. The resistance wires are made of the material having:-

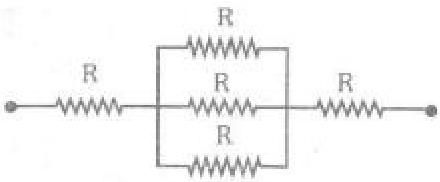
(A) Low specific resistance and low temperature coefficient of resistance.

(B) High specific resistance and low temperature coefficient of resistance.

(C) Low specific resistance and high temperature coefficient of resistance.

(D) High specific resistance and high temperature coefficient of resistance.

83. The resistance between points A and B Fig. is:-



(A) $\frac{7}{3}R$ (B) 3 (C) 5 R (D) $\frac{4}{3}R$

84. Two wires of same material and same mass have their lengths in the ration 1 : 2. Their electrical resistances are in the ratio

(A) 1 : 1 (B) 1 : 2 (C) 2 : 1 (D) 1 : 4

85. A 24 V potential difference is applied across a parallel combination or four 6-ohm resistors. The current in each resistor is

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

86. Three resistors in parallel have an effective resistance of 1 ohm. When they are connected in series their resistance is 9 ohm. The resistance of each resistor is :

(A) 4, 4, 1 ohm (B) 6, 2, 1 ohm (C) 3, 3, 3, ohm (D) 2, 3, 4 ohm

87. 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

88. A 12 V car battery has an internal resistance of 0.2 ohm. What P.D. must be applied across its terminals by a battery has in order that the charging current be 5 A ?

(A) 13 V (B) 12 V (C) 11.4 V (D) 10.6 V

89. Four 20 ohm resistors are connected together to form a square. The resistance between opposite corners will be :-

(A) 20 ohm (B) 22 ohm (C) 24 ohm (D) 24.8 ohm

90. The cost of electricity is about 30 paise per unit for household use. This unit is the same as

(A) ohm (B) ampere (C) volt (D) kilowatt-hour

91. A fuse wire should have

(A) low resistance and low melting point (B) low resistance and high melting point.

(C) high resistance and low melting point. (D) high resistance and high melting point.

92. Two lamps X and Y are connected in series. The lamp X glows lights than Y. Then

(A) the resistance of X is greater than the resistance of Y.

(B) the resistance of X is lesser than the resistance of Y.

(C) the resistance of X is equal to the resistance of Y.

(D) there is no relation between the resistances of X and Y.

93. A one-ohm and half-ohm resistor is connected in parallel across a 3 volt battery. Total energy given out per second is

(A) 27 J (B) 9 J (C) 4.5 J (D) 3 J

94. 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

95. Two electric lamps each of 100 watts 220 V 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

96. A galvanometer can be converted into' a voltmeter by connecting

(A) A high resistance in series with the galvanometer

(B) A high resistance in parallel with the galvanometer

(C) A low resistance in series with the galvanometer

(D) A low resistance in parallel with the galvanometer

97. A rheostat can be used in an electrical circuit as a

(A) standard resistance (B) potential divider (C) heat controller (D) on-off switch

98. Alternating current rather than direct current is normally used for the transmission of power over long distances because

(A) it can be rectified (B) it is easier to generate

(C) loss of energy can be minimized. (D) no question of polarity arises with electrical equipments.

99. A conductor has a positive charge of 3.2×10^{-7} coulombs.

(A) The conductor has 3.2×10^{7} electrons in excess.

(B) The conductor has 2×10^{26} electrons in excess.

(C) The conductor is deficient with 3.2×10^{7} electrons

(D) The conductor is deficient with 2×10^{26} electrons

110. Two bulbs of rating 220 V, 50 W and 220 V. 110 V, 110 W are put in series across 220 V mains. Then :

(A) both bulbs will glow equally (B) neither bulb will glow

(C) 100 W bulb will glow brighter (D) 50 W bulb will glow brighter

ANSWERKEY — Exercise -4

Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Ans.	D	C	A	B	D	D	C	D	C	B	A	C	D	A	B
Que.	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Ans.	D	A	B	B	A	D	B	B	B	B	D	D	D	B	D
Que.	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**
Ans.	C	B	B	D	C	D	C	B	D	C	D	A	C	C	C
Que.	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	B	C	B	D	A	B	A	A	C	A	A	A	D	B	D
Que.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**
Ans.	D	A	C	A	B	C	A	C	D	C	D	C	A	C	A
Que.	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
Ans.	A	B	D	D	A	C	B	A	C	B	C	C	A	A	D
Que.	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**					
Ans.	A	B	A	D	D	A	B	C	D	D					