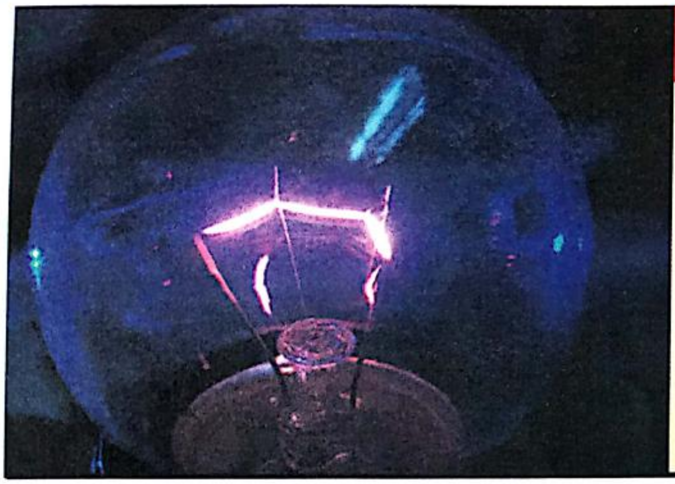


8

Electricity

Theme : In this theme the aim is that children will develope the ability to estimate consumption of electricity by knowing the power rating of appliances used. They will also appreciate and understand the need and importance of taking certain precautions and using of safety devices to protect themselves and others against electrical hazards. Previous learning stressed on electricity due to charges in motion, *i.e.* current electricity. However, objects can be charged, where charges are static, not in motion. This is known as static electricity. This leads to many phenomena in nature, like lightning and thunder during rainy season. How an object that is charged may be detected using a simple device known as an electroscope.

In this chapter you will learn to

- describe household consumption of electricity.
- identify live wire, neutral wire and earth wire in terms of their energy and path they travel.
- describe safety components (fuses, circuits breakers).
- describe phenomenon of static electricity.
- explain conservation of charges.
- describe conduction and working of an electroscope.
- describe a lightning conductor.
- identify dangers of electricity.
- conduct scientific experiments keeping in mind all the parameters.
- study the impact of energy consumption and drawn conclusions from the same and suggest alternate approaches.
- learn the use of safety precautions while dealing with electrical appliances.

LEARNING OBJECTIVES

- Revising previous concepts learnt by children.
- Building on children's previous learning.
- Calculating energy consumption using household electricity bills by children.
- Helping children identify live, neutral and earth wires.
- Demonstrating safety components and their uses.
- Demonstrating static electricity.
- Demonstrating induction and conduction.
- Engaging children in activities related to static electricity.
- Demonstrating the construction and working of an electroscope.

KNOWING CONCEPTS

- Household consumption of electric energy (kilowatt hour).
- Identify live wire, neutral wire and earth wire in terms of their energy and path they travel.
- Safety components (fuses/circuit breakers (qualitative approach only)/grounding).
- Static electricity.
  - Conservation of charges.
  - Induction.
  - Conduction.
  - Electroscope (Gold leaf electroscope).
- Lightning conductor.

(A) HOUSEHOLD ELECTRICITY

INTRODUCTION

In our daily life, we all use electricity in different ways such as to light our home, school, office etc. to run fan, television, heater, radio and all other electrical appliances. The different sources of electricity are : cells (or battery), mains, electric generator (or dynamo) and solar cells. In earlier classes, we have read the use of cells (or battery) in torches, watches, calculators, remote controls etc. In this chapter, we shall study the use of mains as a source of electricity for household purposes.

The cell or battery provides us current which remains constant with time. This current is called direct current (or D.C.). The mains and electric generator provide us the alternating current (A.C.) which changes its magnitude and polarity with time. Generally we use A.C. of frequency 50 Hz in which the polarity is 50 times positive and 50 times negative in each one second.

ELECTRICAL ENERGY AND POWER CONSUMED IN A CIRCUIT

In class VII, we have read that current from a cell flows in a circuit due to the motion of electrons in the metallic wires used in that circuit. A cell has a potential difference (or voltage) between its electrodes namely the anode and cathode. Potential difference is defined as the work done in moving a unit charge from one electrode to another electrode. It is expressed in the unit volt (symbol V) after the name of the scientist Alessandro Volta.

We have defined current as the rate of flow of charges in a unit time. It is measured in ampere (symbol A) after the name of the scientist Andre Marie Ampere.

In Fig. 8.1, suppose a current I flows through a conductor of resistance R for time t, when a source of potential difference V is connected across its ends. We are to find the amount of electrical energy supplied by the source.

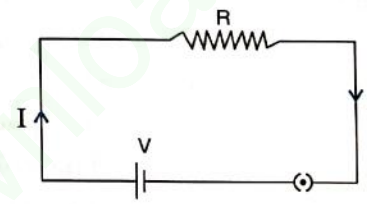


Fig. 8.1 Current flowing in a resistance

By definition, potential difference is the work done in moving a unit charge, so work needed to move a charge Q through a potential difference V is

$$\boxed{W = QV}$$

But current $I = \dfrac{\text{charge } Q}{\text{time } t}$

$$\therefore \quad \boxed{Q = It}$$

Hence,

$$W = VIt$$

This gives the electrical energy W supplied by the source (battery or mains) in providing the current I for time t in the conductor under a potential difference V.

Now power is the rate of doing work. So power supplied by the source

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

Thus, power (in watt)

= (potential difference in volt) × (current in ampere)

Thus 1 W = 1 V × 1 A

or 1 watt = 1 volt × 1 ampere.

• TRANSMISSION OF POWER FROM THE POWER GENERATING STATION TO THE CONSUMER

Electric power is generated at the power generating stations which are usually located very far from the areas where it is consumed. At the generating station, the electric power is generated at 11 kV. The voltage generated has alternating frequency of 50 Hz (*i.e.* its polarity at the terminals changes 100 times a second, 50 times + and 50 times –). The voltage of the power generated at the generating station is first raised from 11 kV to 132 kV to reduce loss of energy in transmission due to heating of line wires and then is transmitted to the grid sub station. At the grid sub station, its voltage is reduced from 132 kV to 33 kV before it is sent to main substation where its voltage is further reduced to 11 kV. Once reduced, the power is supplied to the city substation where its voltage is further reduced to 220 V before it is supplied to the consumer.

SUPPLY OF POWER TO A HOUSE

To supply electric power to a house from the city substation, either the overhead wires or cable on poles or an underground cable is used. The cable has three wires : (i) live (or phase) wire (L), (ii) neutral wire (N), and (iii) earth wire (E). The neutral and the earth wires are connected together at the local substation so that the neutral and earth wires are at the same potential (*i.e.* at 0 V). The live wire, also called the phase wire, is at 220 V and it carries current from the source to the distribution board, while the neutral wire is for the return path of current. The earth wire passes the current to the earth.

Do You Know ?

(1) A.C. voltage is raised up by using a step up transformer while it is lowered down with a step down transformer.

(2) D.C. voltage can neither be increased nor decreased by any device. This is why D.C. power is not used in household circuits.

(3) In household circuits, we use A.C. power at 220 volts.

COLOUR CODING OF LIVE, NEUTRAL AND EARTH WIRES

In the cable, the live, neutral and earth wires have insulations of different colours so that they can be easily distinguished.

Live wire is red or brown.

Neutral wire is black or light blue.

Earth wire is green or yellow.

To summarize, the voltage, colours and the purpose of the three wires are given below.

Wire	Colour	Voltage	Purpose
Live	Red or brown	220 V	To carry current from source to the appliance
Neutral	Black or light blue	0 V	To provide the return path from appliance to source
Earth	Green or yellow	0 V	To provide connection to earth

CONNECTION FROM POLE TO THE DISTRIBUTION BOARD

To connect the cable from pole to the meter in a house, first a fuse of high rating (= 50 A) is connected in the live wire at the pole or just before the meter. This fuse is called the company fuse or pole fuse. Only the electric supply company staff are authorized to handle it. The rating of the fuse depends on the load for which connection is taken from the company. After the company fuse, the cable is connected to an electric meter. The electric meter is usually mounted on the front or outside wall of the house. From the meter, connections are made to the distribution board through a main fuse and a main switch. The main fuse is connected to the live wire, while the main switch is connected to the live and neutral wires.

COMMERCIAL UNIT OF ELECTRICAL ENERGY

Electrical energy is generally measured in a unit called B.O.T (Board of Trade) unit or kWh, (*i.e.*, kilowatt hour).

1 kilowatt hour is defined as the amount of energy consumed when an electrical appliance of power 1 kilowatt is used for 1 hour.

The energy consumed in our houses, shops, factories etc. is measured in kWh.

Since, $\text{Power} = \dfrac{\text{Energy}}{\text{Time}}$

$\text{Energy} = \text{Power} \times \text{Time}$

i.e. Energy (in kWh)

$= \text{Power (in kW)} \times \text{time (in h)}$

Hence, $1 \text{ kWh} = 1 \text{ kW} \times 1 \text{ h}$

$= (1000 \text{ W}) \times (60 \times 60 \text{ s})$

$= 36{,}00{,}000 \text{ J}$

$= 3{\cdot}6 \times 10^6 \text{ J}$

Electric meter : The electric meter is also called the kWh meter because it measures the amount of electric energy consumed by the consumer in the unit kWh (called kilo watt hour) for which the electricity bill is paid by him to the electricity board.

Fig. 8.2 shows a kWh meter. The main part of the meter is the armature A which is connected to the main line (Fig. 8.3). When any electrical appliance is put on, the electric current flows which rotates the armature. The counter fixed on the armature reads the number of rotations.

Fig. 8.2 kWh meter

Then five dials on the counter read electricity consumption directly in kWh units as shown in Fig. 8.3. These five dials from right to left measure the energy in (i) units, (ii) tens, (iii) hundreds, (iv) thousands and (v) ten thousands respectively. In Fig. 8.3, the reading on the meter is 49180 kWh.

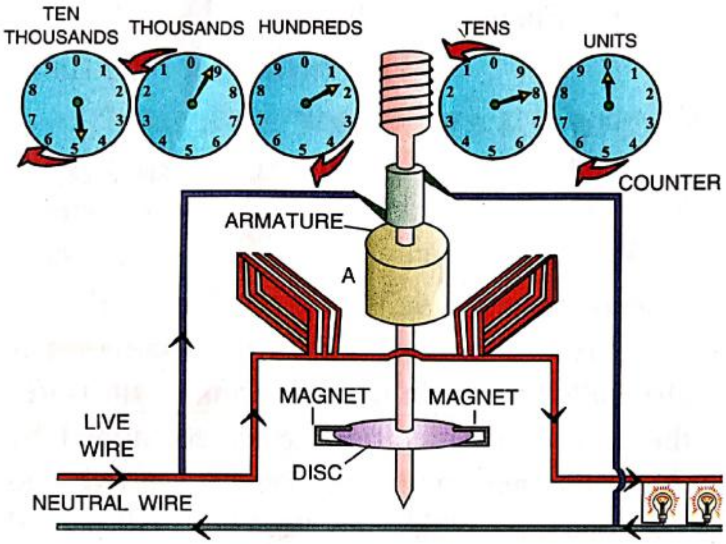


Fig. 8.3 Working of a household meter

Nowadays, the old meters are being replaced by electronic digital meters which are totally different from the meters shown above. The following activity will make clear how the electrical energy consumed in a given time is measured by the electric meter.

ACTIVITY 1

To find the consumption of electricity in a month and pay the electricity bill.

Fig. 8.4 (a) shows the reading on dials of the meter on the first day of a month and Fig. 8.4(b) shows the reading on the last day of the month. You are to find the initial reading, final reading, the electrical energy consumed in the month and the electricity bill at a rate of ₹ 6·25 per kWh.

The initial reading is 49180 kWh and the final reading is 50625 kWh. The total consumption of

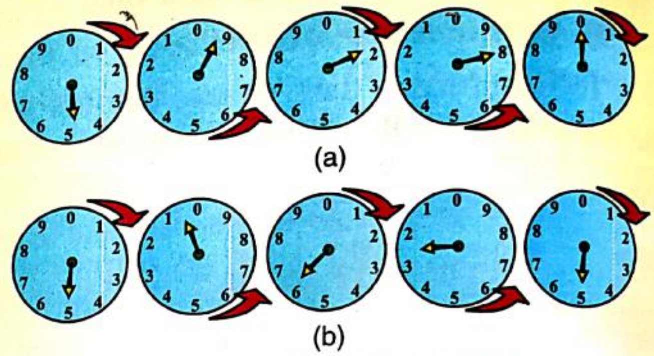


Fig. 8.4 (a) Initial reading in kWh meter (b) Final reading in kWh meter

electricity in the month is 50625 kWh – 49180 kWh = 1445 kWh *i.e.* the electricity consumed is 1445 units. The rate of electricity per unit is ₹ 6.25 *i.e.* the bill will be 1445 × ₹ 6.25 = ₹ 9031.25 only.

ELECTRIC FUSE (A SAFETY DEVICE)

The electric fuse is a device which is used to limit the current in an electric circuit. It safeguards the circuit and the appliances connected in the circuit from being damaged if the current in the circuit exceeds the specified value due to voltage fluctuations or short circuiting. Fig. 8.5 shows an electric fuse arrangement commonly used in our household circuits. It consists of a fuse wire F which is stretched between the two metal terminals T_1 and T_2 in a porcelain holder. The holder fits into a porcelain socket.

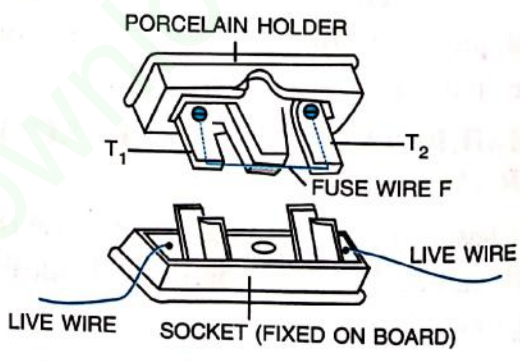


Fig. 8.5 Electric fuse

The fuse wire is a short and thin piece of wire of a material of low melting point.

Generally, the fuse wire is made of an alloy of lead and tin, 50% of each metal.

Purpose of fuse : If the insulation on the wire of cable used in wiring (or used with an appliance) breaks, the live wire comes in contact with the neutral wire which results in a short circuit. Maximum current then passes through the wires which can cause burning of the wires due to the excessive heat. Similarly, due to voltage fluctuations, sometimes high current flows through the wires that can cause burning of wires. To prevent this damage, a fuse is connected to the live wire of the circuit. When there is a short circuit, the fuse wire gets heated up to the extent that it melts. As a result, a gap is produced in the live wire and the circuit becomes incomplete or breaks. No current then flows and the appliance or the circuit is saved. After removing the fault in the circuit or the appliance, a new fuse wire is fixed between the terminals T_1 and T_2 in the holder to complete the circuit again.

Note : Nowadays the domestic gadgets such as oven, geyser, press, referigriator, air conditioner etc. are provided with a cartridge type fuse in its line wire.

CHARACTERISTICS OF A FUSE

1. It is a short wire with a low melting point. The fuse wire is made of an alloy of lead and tin. It melts at about 200°C.
2. Fuse wire is connected in series with the live wire. Its temperature rises much faster than the connecting copper wires as an excessive current flows because its resistance is higher than that of the connecting copper wires.
3. The thickness of fuse wire depends on the current rating of it. Higher the rating, thicker is the wire. It means that 15 A fuse is thicker than the 5 A fuse. The heating of fuse wire does not depend on its length.

Note : An ordinary copper wire must not be used as the fuse wire because its melting point is much high.

These days miniature circuit breakers (MCB) are used. They switch off the circuit in a very short time (nearly 25 milli seconds) in case of short circuiting.

MINIATURE CIRCUIT BREAKER (MCB)

A miniature circuit breaker (Fig. 8.6) is an automatic switch that is nowadays used to protect the household wiring from the excessive flow of electric current in a circuit. When the current flow is in excess, the MCB automatically falls down to break the electric circuit. It is reset (*i.e.* raised up) after the fault is rectified.

Fig. 8.6 MCB

HOUSEHOLD ELECTRICAL CIRCUITS

In your house, you notice that each electrical appliance can be used separately. You can light a bulb without running the fan, or you can light the bulb in one room without lighting the bulbs in the other rooms. Further, you can notice that if one bulb fuses or one appliance fails, it does not affect the working of the other appliances in the house. All the appliances work at the same voltage equal to the voltage of mains (= 220 V). Now the question arises how are the various appliances connected in the circuit ? To answer this question, perform the following two experiments.

Experiment 1 : Take two torch bulbs. Mark them as A and B. Connect the two bulbs to a cell through a switch as shown in Fig 8.7. The bulbs are said to be connected in series. Close the switch. You will see that both the bulbs glow.

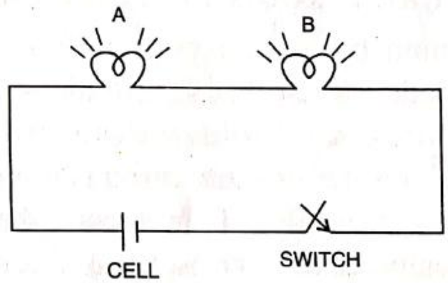


Fig. 8.7 Both the bulbs glow when switch is closed

Now swtich off and take out the connections of the bulb B as shown in Fig. 8.8. Again close the switch. You will see that the bulb A does not glow. The reason is that the circuit is now incomplete.

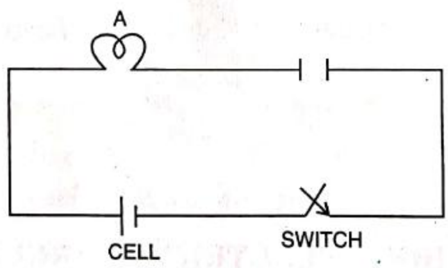


Fig. 8.8 The bulb A does not glow because the circuit is incomplete

Now replace the bulb B by a fused bulb as shown in Fig. 8.9. Close the switch. You will again find that the bulb A does not glow since the circuit is incomplete.

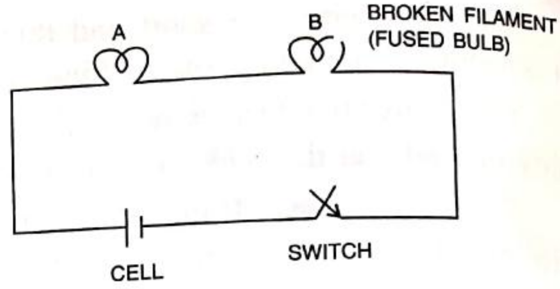


Fig. 8.9 The bulb A does not glow since the circuit is incomplete

Experiment 2 : Connect the two bulbs marked A and B through the switches S_1 and S_2 to a cell as shown in Fig. 8.10. The bulbs are said to be connected in parallel. Close both the switches S_1 and S_2. You will find that both the bulbs glow.

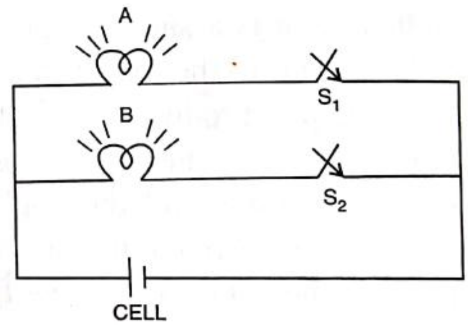


Fig. 8.10 Both the bulbs glow when switches S_1 and S_2 both are closed

Now close only the switch S_1 and leave the switch S_2 open (Fig. 8.11). You will find that the bulb A glows, but the bulb B does not glow.

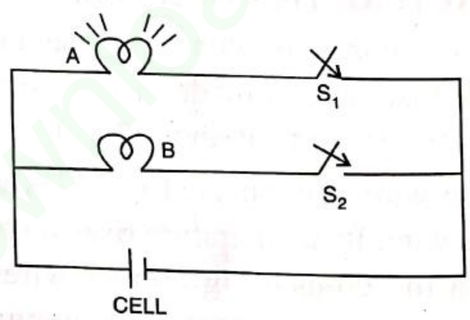


Fig. 8.11 Only the bulb A glows when the switch S_1 is closed

Then close only the switch S_2 and leave the switch S_1 open (Fig. 8.12). You will find that the bulb B glows, but the bulb A does not glow.

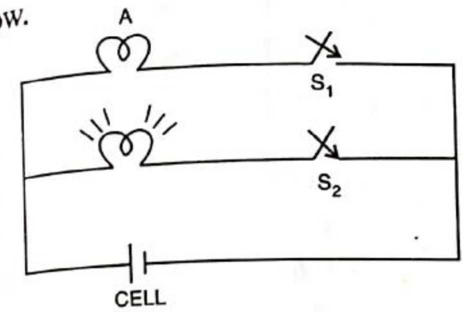


Fig. 8.12 Only the bulb B glows when the switch S_2 is closed

Now replace the bulb B by a fused bulb (Fig. 8.13). Close both the switches S_1 and S_2. You will find that the bulb A still glows, but the bulb B being fused, does not glow.

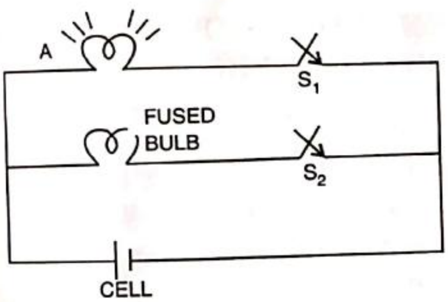


Fig. 8.13 The bulb A still glows when both switches are closed

From the above experiments, you conclude that in series connection, if one of the bulbs is removed or it is fused, the other bulb does not glow on closing the switch, but in parallel connection, a bulb glows irrespective of whether the other bulb glows or not (or it is fused).

Thus, it is clear that all the electrical appliances in our home, offices, schools, factories are connected in parallel. Each appliance has an independent path for current and works at the same voltage.

ELECTRIC CIRCUIT IN A ROOM

Electricity is supplied to us at a voltage of 220 volt through a cable which has three wires, namely the live wire, the neutral wire and the earth wire. From the distribution board, electricity is distributed to various parts of the house such as rooms, kitchen, toilet, staircase, etc. All electrical appliances are connected in parallel. Fig. 8.14 shows an electric circuit of a room having two bulbs and a fan. Each appliance has a separate switch connected with its live wire. In Fig. 8.14, earth wire has not been shown.

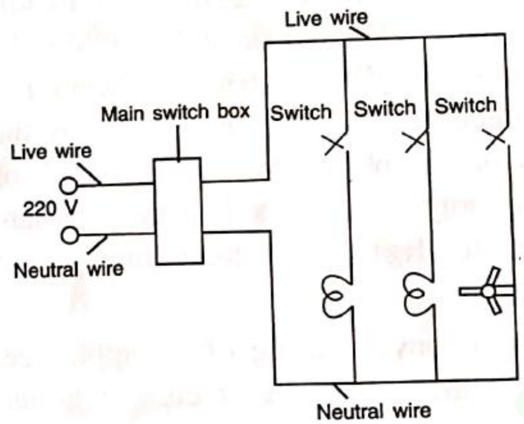


Fig. 8.14 Electrical circuit in a room

EARTHING OF THE APPLIANCES

The metallic outer body (case) of each appliance such as refrigerator, oven, geyser etc., is connected to the earth wire. The reason is that sometimes due to breaking of insulation of wires, live wires come in contact with the body of the appliance, and we get a fatal shock when the appliance is touched. If the appliance is earthed, the current will pass to the earth and we remain protected from the electric shock.

Do You Know ?

1. Short circuit occurs when a naked live wire and a neutral wire come in contact or the live wire and the earth wire come in contact. Its major cause is the poor insulation on wires.

2. Overloading of an electric circuit, is a condition when it draws more current than it is designed for.

3. Earthing is done in a house near the kWh meter.

POWER RATING OF APPLIANCES

Generally an electric appliance such as electric bulb, geyser, heater etc. is rated with power and voltage. *For example*, an electric bulb is rated as 100 W – 220 V. It means that if the bulb is lighted on a 220 V supply, it consumes 100 W electrical power (*i.e.* 100 J of electrical energy is consumed by the bulb in 1 s or in other words, 100 J of electrical energy is converted in the filament of bulb into light and heat energy in 1 second).

From the power rating of an appliance, we can find the safe limit of current which can flow through that appliance.

From relation P = VI.

Safe limit of current for an appliance

$$I = \frac{\text{Power of appliance}}{\text{Voltage at which it works}}$$

For example, for a bulb rated 100 W, 220 V, the safe limit of current when it is lighted at 220 V is

$$I = \frac{P}{V} = \frac{100\text{ W}}{220\text{ V}} = 0{\cdot}45\text{ A}$$

The table below gives the power rating of some common appliances.

Power rating of some common appliances

Appliance	Power (in watt)	Voltage (in volt)
Car (filament) bulb	20	12
Electric bulb	15-200	220
Fluorescent tube	40	220
Electric fan	60-100	220
Television set	120	220
Refrigerator	150	220
Electric iron	700	220
Electric mixer	750	220
Room heater	1000	220
Geyser	1500	220
Electric kettle	2000	220
Electric oven	3000	220

In our country a.c. is supplied at voltage equal to 220 V.

HOUSEHOLD CONSUMPTION OF ELECTRICAL ENERGY

Every home using electricity has an electric meter which measures the amount of electrical energy consumed in that home over a given period of time. The electric meter is fixed at the mains board or just outside our house. The electrical energy is sold in units of kilowatt hour (kWh). It is the unit in which the consumer pays the cost of electricity.

The electrical energy consumed by an appliance in a certain time can be calculated in kWh by the following relation :

Energy (in kWh)

$$= \text{Power (in kW)} \times \text{time (in h)}$$

$$= \frac{\text{Power (in watt)} \times \text{time (in hour)}}{1000}$$

$$= \frac{\text{V(volt)} \times \text{I (ampere)} \times \text{t (hour)}}{1000}$$

Thus the total energy consumed by an electrical appliance in kWh can be calculated by multiplying its power rating in kW with the time duration in hour (h) for which it was in use. The cost of electricity will then be the product of energy consumed in kWh with the rate in rupees per kWh.

Example : If an electric oven of power 3 kW works for two hour per day, the electrical energy consumed by the oven per day will be 3 kW × 2 h = 6 kWh, while the total electrical energy consumed in a month of 30 days will be 3 kW × (2 × 30 h) = 180 kWh. The cost of electricity at a rate of ₹ 6·25 per kWh will then be 180 kWh × ₹ 6·25 = ₹ 1125.

ACTIVITY 2

To find consumption of electrical energy.

List the electrical appliances such as bulbs, fans, air conditioners, heaters, ovens, refrigerators, washing machines etc. which are used in your house in a day. Write the power rated on these appliances and the time duration of their use.

Name of appliances	Number	Power in watt	Time in hour	Electrical energy kWh
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Then use the following relation to find the energy consumed by each appliance.

Electrical energy in kWh

$$= \frac{\text{Number} \times \text{power} \times \text{time}}{1000}$$

Record it in the above table.

Find the total sum which will give the total electrical energy consumed in your house each day.

HAZARDS OF ELECTRICITY

Apart from the uses of electricity, there are a number of its hazards too which are given below :

1. When you use a number of electrical gadgets connected in a circuit at the same time, a heavy current flows through the connecting wires. In other words, the house circuit gets overloaded. There will be overheating of the electric wires which may cause short circuiting and even electric fire.
2. Sometimes, due to poor insulation of wires, the live wire touches the neutral wire. This causes short circuiting and the flow of current becomes excess. This excess flow of current damages the electrical appliances such as T.V., refrigerator, tubelights, bulbs etc. Even the wires catch fire and there can be a mishap in form of electric fire.
3. If a person comes in contact with a live wire, he gets an electric shock. If it is a huge shock, it can cause an untimely death.

PRECAUTIONS TO BE TAKEN WHILE USING ELECTRICITY

1. We should not touch switches with wet hands.
2. The connecting wires to the plugs, sockets and switches should be tightly joined.
3. We should ensure that all the appliances are properly earthed.
4. We should not try to repair an appliance while it is in use.
5. We should ensure that the MCB or fuse and switch are connected to the live wire.
6. The wiring used must have proper insulation.
7. The ordinary copper wire should not be used as a fuse wire because the melting point of copper is 1080°C, so it will not melt even if the current exceeds its safe limit.
8. To switch off the gadgets like T.V., geyser, press, air conditioner etc. take out the plug from the socket instead of using the remote.

SOLVED EXAMPLES

1. From a battery of potential difference 12·0 volt, current 2·0 ampere flows through a wire for 30 minute. Find :
   (i) the electrical energy supplied by the battery, and
   (ii) the power spent.

Solution : *Given :* Potential difference V = 12·0 volt

Current I = 2·0 ampere,

time t = 30 min. = 30 × 60 = 1800 s

(i) Energy supplied W = VIt

$= 12{\cdot}0 \times 2{\cdot}0 \times 1800 = 43200$ J

(ii) Power P = VI

$= 12{\cdot}0 \times 2{\cdot}0 = 24{\cdot}0$ W

2. An electric heater is rated 1·5 kW, 220 V.
   (a) Find the safe current which can flow through it.
   (b) Can fuse of current rating 5 A be used with it ?
   (c) What must be the current rating of the fuse ?

Solution :

(a) *Given :* P = 1·5 kW =1500 W, V = 220 volt

From relation P = VI

$$\text{Safe current } I = \frac{P}{V} = \frac{1500\text{ W}}{220\text{ V}} = 6{\cdot}8 \text{ A}$$

(b) No, the fuse of current rating 5 A can not be used.

(c) The current rating of the fuse must be 7 A.

3. An electric geyser of power 2500 watt is used for 1 h 30 min. Find the electrical energy consumed in kWh.

Solution : *Given*, P = 2500 W,

t = 1 h 30 min = 1·5 h

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

Electrical energy consumed W = P × t

= 2500 W × 1·5 h = 3750 Wh

$$= \frac{3750}{1000} \text{ kWh} = 3{\cdot}75 \text{ kWh}$$

4. An electric bulb of 100 watt, an electric press of 750 watt and a television of 100 watt are used for 3 hour a day. Calculate the energy consumed per day.

Solution : *Given*, Total power P

= (100 + 750 +100)

= 950 watt

Time t = 3 h

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

Energy consumed W = 950 watt × 3 h

= 2850 Wh

$= \frac{2850}{1000}$ kWh

= 2·85 kWh

5. An electrical appliance of power 1·5 kW is used for 4 hour each day. Find :

(a) The electrical energy consumed in kWh, each day.

(b) The electrical energy consumed in 60 days.

(c) The cost of electrical energy consumed in 60 days at the rate of ₹ 6·25 per kWh.

Solution :

Given : Power = 1·5 kW and time = 4 h

(a) Electrical energy consumed each day

= Power × time

= 1·5 kW × 4 h

= 6 kWh

(b) Electrical energy consumed in 60 days

= 60 × 6 kWh

= 360 kWh

(c) Cost of electrical energy consumed in 60 days

= 360 × ₹ 6·25

= **₹ 2,250**

RECAPITULATION

- In our houses, we use electricity from mains which is an alternating current (a.c) of frequency 50 Hz at a potential difference of 220 volt.
- The electrical energy supplied by a source of potential difference V in flowing a current of I ampere in a circuit for time t second is given as

$$W = VIt \text{ joule}$$

and electrical power P = Energy W/time t = VI watt

Thus 1 watt = 1 volt × 1 ampere or 1 W = 1 V × 1 A

- Commercial unit of electrical energy is kilowatt hour (symbol kWh) where

$$1 \text{ kWh} = 3{\cdot}6 \times 10^6 \text{ joule}$$

- At the power generating station, electricity is generated at 11 kV. It is supplied from there at 132 kV to the different substations where its voltage is decreased in steps 132 kV to 33 kV, 33 kV to 11 kV and then from 11 kV to 220 V.
- The electric supply comes to a house first to a meter fixed on a board. The meter measures the consumption of electricity in kWh unit for which we pay to the electricity board.
- The electric fuse is a device which is used to limit the current in an electric circuit. It is a short and thin wire made of an alloy of lead and tin to have a low melting point. It safeguards the circuit and the appliances connected in the circuit from being damaged due to voltage fluctuations or short circuiting.
- The fuse wire is always connected with the live wire.

- In household circuits, all the electrical appliances are connected in parallel. Each appliance has an independent path for current and works at the same voltage. Each appliance has a separate switch connected with its live wire.
- The cable used for wiring has three wires with insulation of different colours. The red or brown wire is live wire, the black or blue wire is neutral wire and the green or yellow wire is the earth wire.
- The live wire carries current from mains to the appliance. It is at 220 V. The neutral wire is for the return of current from appliance to the mains. It is at 0 V. The earth wire is to connect the metallic case of the appliances to the earth. It is at 0 V.
- The metallic outer body of each appliance is connected to the earth wire.
- Each appliance must have its switch and fuse connected in the live wire.
- Each appliance is rated with its power and voltage. This rating indicates that the appliance when used at that voltage, the energy consumed by it in 1 second will be the power rated on it. From this rating, we can find the safe limit of current that can pass through the appliance ($I = P/V$).
- A fuse of high current rating is thicker than a fuse of low current rating.
- A switch should never be touched with wet hands.
- Electrical energy consumed in kWh by an appliance = (Power in watt/1000) × time in hour.

  kWh is also called unit (*i.e.*, 1 kWh = 1 unit)
- Cost of electricity = energy in kWh × rate of electricity per kWh.

TEST YOURSELF

A. Objective Questions :

1. Write **true** or **false** for each statement :
   (a) A fuse wire has a high melting point.
   (b) Flow of protons constitutes electric current.
   (c) A fuse wire is made of silver.
   (d) S.I. unit and commercial unit of electrical energy are same. F
   (e) Overloading of electric current in circuits can lead to short circuiting.
   (f) Our body can pass electricity through it. T
   (g) The metallic cases of all appliances are insulators of electricity. F
   (h) The earth wire protects us from an electric shock.
   (i) A switch should not be touched with wet hands.
   (j) All electrical appliances in a household circuit work at the same voltage.
   (k) In a cable, the green wire is the live wire.
   (l) A fuse is connected to the live wire.
   (m) A switch is connected to the neutral wire.

   Ans: True— (e), (f), (h), (i), (j), (l)
   False—(a), (b), (c), (d), (g), (k), (m)

2. Fill in the blanks :
   (a) The unit in which we pay the cost of electricity is ....
   (b) The electrical energy consumed in a house is measured by ....
   (c) In a household electrical circuit, the appliances are connected in .... with the mains.
   (d) A switch is connected to the .... wire.
   (e) The red colour insulated wire in a cable is the .... wire.

3.6 × 10

(f) One kilowatt hour is equal to.................. joule.

(g) A fuse wire should have low melting point ....

Ans: (a) kWh, (b) kWh meter (c) parallel (d) live (e) live (f) $3{\cdot}6 \times 10^6$ (g) melting point

3. Match the following :

Column A	**Column B**
(a) Electric power	(i) volt
(b) kWh	(ii) joule
(c) Electric current	(iii) volt × ampere
(d) Electrical energy	(iv) watt
(e) watt	(v) ampere
(f) Potential difference	(vi) electrical energy

Ans: (a)–(iv), (b)–(vi), (c)–(v), (d)–(ii), (e)–(iii), (f)–(i)

4. Select the correct alternative :

(a) All wires used in electric circuits should be covered with :
- (i) colouring material
- (ii) conducting material
- (iii) an insulating material
- (iv) none of the above.

(b) Electrical work done per unit time is :
- (i) electrical energy
- (ii) electric current
- (iii) electric voltage
- (iv) electrical power.

(c) One kilowatt is equal to :
- (i) 100 watt (ii) 1000 watt
- (iii) 10 watt (iv) none of these.

(d) Fuse wire is an alloy of :
- (i) tin-lead (ii) copper-lead
- (iii) tin-copper (iv) lead-silver.

(e) A fuse wire should have :
- (i) a low melting point
- (ii) high melting point
- (iii) very high melting point
- (iv) none of the above.

(f) When switch of an electric appliance is put off, it disconnects :
- (i) the live wire
- (ii) the neutral wire
- (iii) the earth wire
- (iv) the live and the neutral wires.

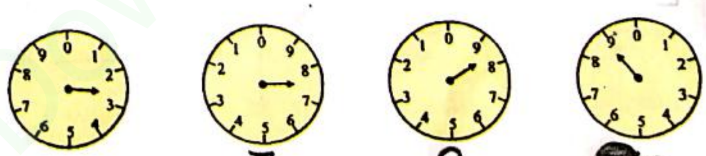
(g) The purpose of an electric meter in a house is :
- (i) to give the cost of electricity directly
- (ii) to give the consumption of elecrical energy
- (iii) to safeguard the circuit from short circuiting
- (iv) to put on or off the mains.

(h) If out of the two lighted bulbs in a room, one bulb suddenly fuses, then :
- (i) other bulb will glow more
- (ii) other bulb will glow less
- (iii) other bulb will also fuse
- (iv) other bulb will remain lighted unaffected.

Ans: (a)–(iii), (b)–(iv), (c)–(ii), (d)–(i), (e)–(i), (f)–(i), (g)–(ii), (h)–(iv)

B. Short/Long Answer Questions :

1. From where does the electricity come to our home ?
2. What is an electric meter ? Where is it fixed in our house ?
3. State the purpose of kWh meter.
4. For which unit do we pay our electricity bill ?
5. How can you check just by seeing the meter whether the electricity is in use or not ?
6. The diagram below in Fig. 8.15 shows the reading on the dials of a meter. State what is its reading.



2 7 8 9

Fig. 8.15

7. One day the meter reading is found to be 7643 units while next day, it was 7657 units. What is the consumption of electricity in a day ?

8. A source of potential difference V volt sends current I ampere in a circuit for time t second. Write expressions for (a) electrical energy supplied by the source, and (b) electrical power spent by the source.

9. Name the unit in which you pay the cost of your electricity bill. How is it related to joule ?

10. If an appliance of power P watt is used for time t hour, how much electrical energy is consumed in kWh ?

11. What is an electric fuse ? State its purpose in the household electrical circuit.

12. State one property of the material of a fuse wire.

13. Name the material of a fuse wire.

14. Can we use copper wire as a fuse wire ? Give reason.

15. How does a fuse protect the electric wiring (or an appliance) from being damaged ?

16. Which fuse wire is thick : 5 A or 15 A ?

17. Write the full form of M.C.B.

18. How is M.C.B. superior to the fuse wire ?

19. With which wire : live or neutral is the fuse wire connected ?

20. What do you mean by short circuiting of a circuit ?

21. Fig. 8.16 shows two ways of connecting the three bulbs A, B and C to a battery. Name the two arrangements. Which of them do you prefer to use in a household circuit ? Give a reason to support your answer.

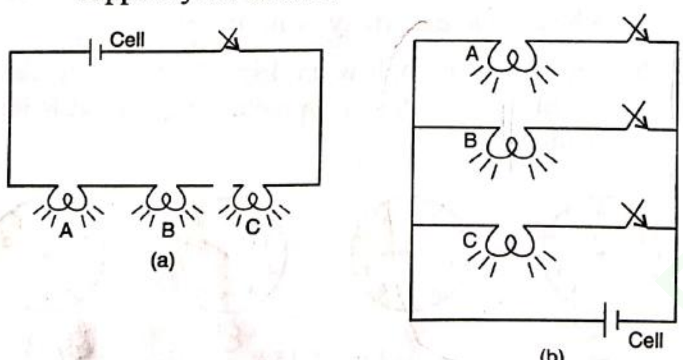


Fig. 8.16

22. How are the electrical appliances connected in a house circuit : in series or in parallel ? Give reason.

23. In the household electric circuit, if one bulb is fused in a room, the other bulbs keep glowing. Explain the reason.

24. State the voltage at which electricity is supplied to our houses.

25. Draw a labelled diagram with the necessary switches to connect a bulb, a fan and a plug socket in a room with the mains. In what arrangement will you connect them to the mains ?

25. State the colour coding of the three wires in a cable used for wiring in a household electrical circuit.

26. Why is the metal covering of an electrical appliance earthed?

C. Numericals

1. An electrical appliance is rated as 60 W – 150 V.
   (a) What do you understand by this statement?
   (b) How much current will flow through the appliance when in use ? **Ans:** 0·4 A

2. An electric iron of power 1·5 kW is used for 30 minute. to press the clothes Calculate the electrical energy consumed in (a) kilowatt hour (b) joule. **Ans:** (a) 0·75 kWh, (b) 2·7 × 10^6 J

3. Assuming the electric consumption per day to be 12 kWh and the rate of electricity to be ₹ 6·25 per unit, find how much money is to be paid in a month of 30 days ? **Ans:** ₹ 2250

4. In a premise 5 bulbs each of 100 W, 2 fans each of 60 W, 2 A.Cs each of 1·5 kW are used for 5 h per day. Find :
   (a) total power consumed per day,
   (b) total power consumed in 30 days,
   (c) total electrical energy consumed in 30 days,
   (d) the cost of electricity at the rate of ₹ 6·25 per unit.

Ans: (a) 3620 W, (b) 108·6 kW, (c) 543 kWh (d) ₹ 3393·75

360
6.25
1800
192000
3888000
2053800

12 12. 2

(B) STATIC ELECTRICITY

STATIC ELECTRICITY

The electricity which we use in our daily life for various purposes such as to glow a bulb, run a fan etc. is due to the motion of charges (or electrons). It is called current electricity. Now we shall consider the electricity at rest or the static electricity.

The word electricity came from a Greek word *elektron* which means amber (a kind of resin). About 2500 years ago, a Greek philosopher Thales found that when amber was rubbed with wool, it acquired the property of attracting small pieces of paper or cork. Later on, Dr Gilbert found that besides amber, there are many other substances such as glass, plastic, nylon, hard rubber, sealing wax, ebonite etc., which also show the same attractive property. The substance which acquires the attractive property is said to be electrified or charged.

When an object made of a substance like glass, plastic, ebonite, amber, nylon, hard rubber etc., is rubbed with wool, fur or silk, it acquires an electric charge due to friction. The object is said to be charged and it acquires the property to attract small pieces of paper, leaves or cork. This can be demonstrated by the following activities.

ACTIVITY 3

Take a plastic (or rubber) comb. Bring it near the small bits of paper lying on a table. You will observe that the comb does not attract the paper bits.

Now rub the comb on your dry hair. Again bring it close to the paper bits. You will observe that the comb now attracts the paper bits (Fig. 8.17). Thus, the plastic (or rubber) comb acquires the attractive property on rubbing it with dry hair due to friction.

Fig. 8.17 Plastic comb rubbed with dry hair attracts small bits of paper

ACTIVITY 4

Place some small bits of paper on a table. Take a plastic pen (or a plastic ruler) and bring it close to the paper bits. You will notice that the pen (or ruler) does not attract them.

Now rub the same pen (or ruler) with wool and again bring it close to the paper bits. You will observe that the pen (or ruler) now attracts the bits of paper (Fig. 8.18).

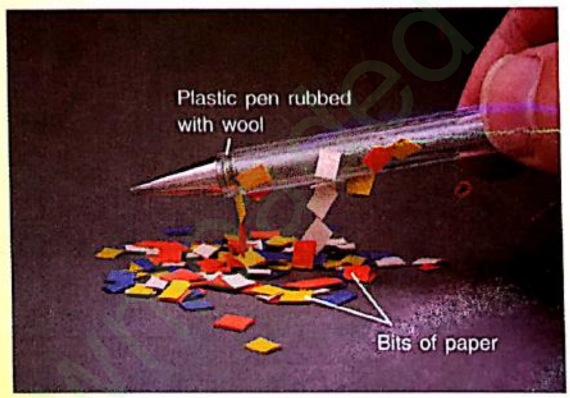


Fig. 8.18 A charged plastic pen attracts paper bits

Thus, the pen (or ruler) acquires the attractive property on rubbing it with wool due to friction.

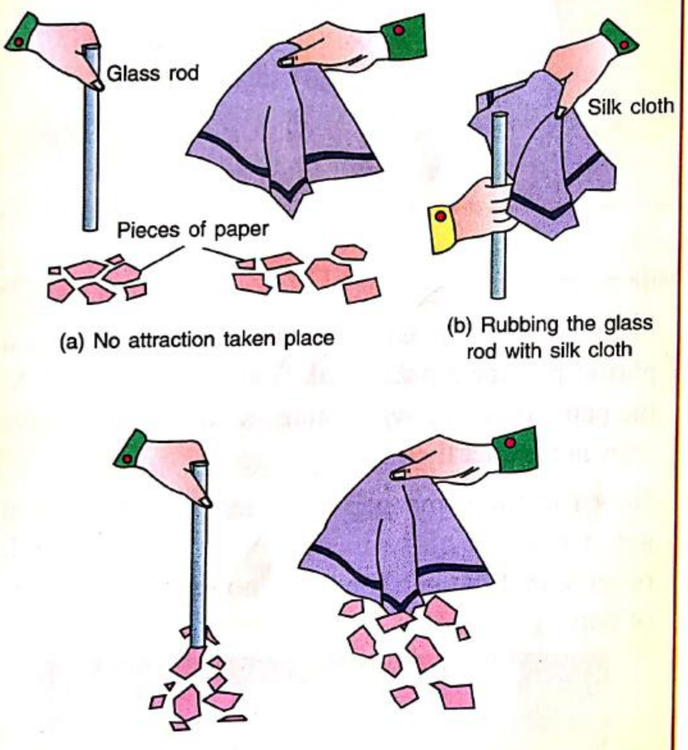
$I = \frac{60}{150} = \frac{2}{5} = 0.4A$ 3 in 1 hr

$P = 1.5$ 3 ×

ACTIVITY 5

Take a glass rod and a piece of silk cloth. Hold them close to small pieces of paper. None of them will attract the pieces of paper [Fig. 8.19(a)].

Now rub the glass rod with the silk cloth [Fig. 8.19(b)]. Bring one by one, the glass rod and the cloth slightly above the bits of paper. You will observe that both glass rod and silk cloth attract the pieces of paper [Fi.g 8.19 (c)]



(a) No attraction taken place

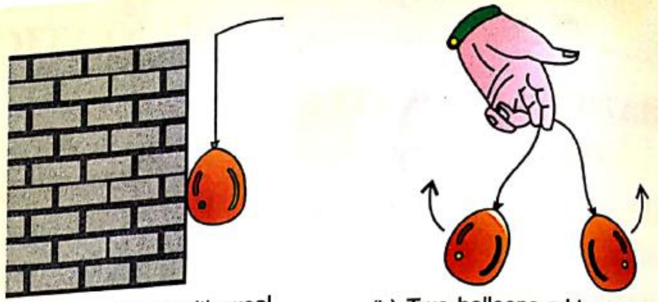
(b) Rubbing the glass rod with silk cloth

(c) Glass rod and silk cloth attract pieces of paper

Fig. 8.19 Glass rod and silk cloth get charged on rubbing

ACTIVITY 6

Take a rubber balloon. Inflate it. Bring the balloon in contact with the wall and withdraw your hand gradually. You will find that the balloon falls down (*i.e.*, it does not stick to the wall).



(a) Balloon rubbed with wool sticks to the wall

(b) Two balloons rubbed with the same wool repel each other

Fig. 8.20 Balloon gets charged on rubbing with wool

(1) Now rub the balloon with wool and again bring it in contact with the wall and withdraw your hand gradually. You will find that the balloon now sticks to the wall [Fig. 8.20(a)]. This shows that the balloon on rubbing with wool gets charged due to friction and therefore it sticks to the wall.

(2) Now take two such balloons and rub both of them with wool. Bring the balloons close to each other. Both will move away from each other *i.e.* both will repel each other [Fig. 8.20)b)].

The above activities show that an object can be charged by rubbing. If a glass rod is rubbed with silk, it will attract small bits of paper. Similarly, if an ebonite rod is rubbed with fur, it will also attract small bits of paper.

However, a charged object not only attracts small bits of paper, but it can also attract or repel other charged objects. It is found that two charged objects having like charges repel each other, while two charged objects having unlike charges always attract each other.

Do You Know ?

(1) The body which possesses electric charge is called a charged body.

(2) The body which does not possess any electric charge is called an uncharged or neutral body.

(3) A charged body attracts an uncharged body.

(4) Only insulators and isolated conductors can be charged by rubbing.

(5) Charging of two bodies on rubbing them together is also called static electricity produced by friction.

KINDS OF ELECTRIC CHARGES (LIKE CHARGES REPEL AND UNLIKE CHARGES ATTRACT)

There are two kinds of electric charges. We call them positive and negative charges. The existence of these electric charges can be demonstrated by the following experiment.

Experiment : (i) Take a glass rod A. Rub it with silk to make it charged. Suspend the charged rod A with a thread. Then take another glass rod B. Rub it also with silk and bring it near one end of the suspended rod A as shown in Fig. 8.21. You will observe that the suspended glass rod A gets repelled (*i.e.*, it moves away).

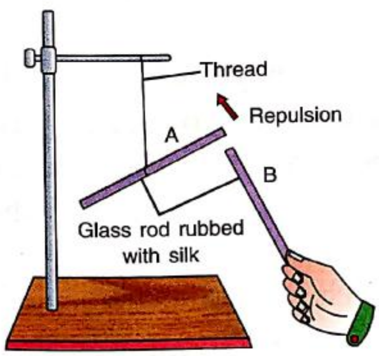


Fig. 8.21 Two charged glass rods repel each other

(ii) Take an ebonite rod A and rub it with fur to make it charged. Suspend the charged rod A with a thread. Now take another ebonite rod B. Rub it also with fur and bring it near one end of the suspended rod A as shown in Fig. 8.22. You will observe that the suspended ebonite rod A gets repelled.

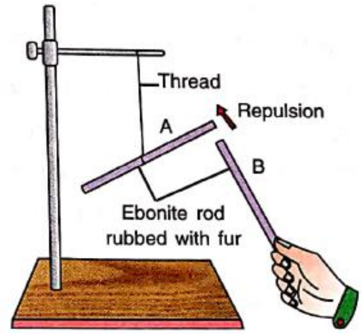


Fig. 8.22 Two charged ebonite rods repel each other

(iii) Now suspend the glass rod A rubbed with silk by means of a thread and bring the ebonite rod B rubbed with fur near one end of the rod A as shown in Fig. 8.23. You will observe that the suspended charged glass rod A gets attracted towards the charged ebonite rod B.

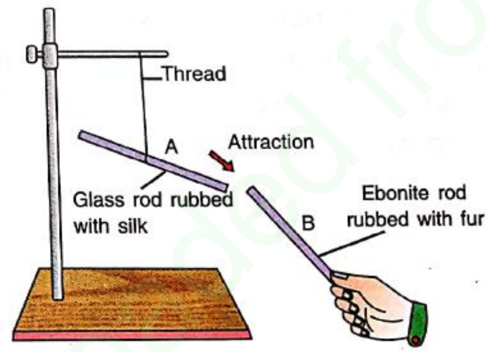


Fig. 8.23 A charged glass rod and a charged ebonite rod attract each other

In all the above steps, if the rods have not been rubbed with silk or fur, we would have found that there is no repulsion or attraction between the rods. Thus, the attraction or repulsion between the rods arises only when they are charged. In step (i) both the glass rods have been rubbed with silk, *i.e.*, they must have similar kind of charges. It is seen that these rods when brought near each other, repel each other. Hence, it is concluded that like charges repel each other. Similar is the case in step (ii). Now in step (iii), it is seen that the glass rod rubbed with silk attracts the ebonite rod rubbed with fur when brought near each other. Therefore, it is concluded that the charge on the glass rod rubbed with silk must be opposite to the charge on the ebonite rod rubbed with fur.

This experiment suggests that like charges repel (Fig. 8.21 and Fig. 8.22) while unlike charges attract (Fig. 8.23) each other.

Thus, from this experiment we can conclude that

(i) There are two kinds of charges.

(ii) Like charges repel and unlike charges attract each other.

When other substances are charged by rubbing and are tested in a similar manner, it is found that they fall into the following two categories :

1. Substances which have the charge similar as that developed on a glass rod when it is rubbed with silk. These substances are said to have positive charge or they are said to be positively charged.
2. Substances which have the charge similar as that developed on an ebonite rod when it is rubbed with fur, are said to have negative charge or they are said to be negatively charged.

Thus, there are two kinds of charges : a positive charge and a negative charge.

CONSERVATION OF CHARGE

Before rubbing the two objects, each object is uncharged, so the net charge is zero.

Now when two objects are rubbed together, both are charged equally, but the charges on them are of the opposite kinds. Thus, the total charge of the objects before and after rubbing remains same. This is called conservation of charges.

Example : When a glass rod is rubbed with silk, the glass rod is charged positively and the silk is charged negatively by the same amount.

Similarly, when an ebonite rod is rubbed with fur, the ebonite rod is charged negatively and the fur is charged positively by the same amount.

Explanation of charging on rubbing

Each body has atoms. An atom is electrically neutral. It has protons (positively charged) and neutrons (uncharged) inside its nucleus at the centre, around which the electrons (negatively charged) revolve in different orbits. The number of electrons in an atom is equal to the number of protons. However, some of these electrons can easily leave their atoms. These are called free electrons.

The two objects which are rubbed together are initially neutral (or uncharged). When they are rubbed together, the free electrons are transferred from one object to the other. The object which gains free electrons, becomes negatively charged, while the object which loses free electrons, becomes positively charged.

Examples : (1) When a glass rod is rubbed with silk, the free electrons from the