GENERAL SCIENCE 8

Based on Single National Curriculum 2022

Punjab Curriculum and Textbook Board, Lahore

بِسۡمِ اللّٰہِ الرَّحۡمٰنِ الرَّحِیۡمِ

(In the Name of Allah, the Most Compassionate, the Most Merciful.)

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8

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ONE NATION, ONE CURRICULUM

PUNJAB CURRICULUM AND TEXTBOOK BOARD, LAHORE

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Preface

This book has been designed to maintain the pace of gradual development of scientific concepts as determined by Single National Curriculum 2022 for General Science VI to VIII.

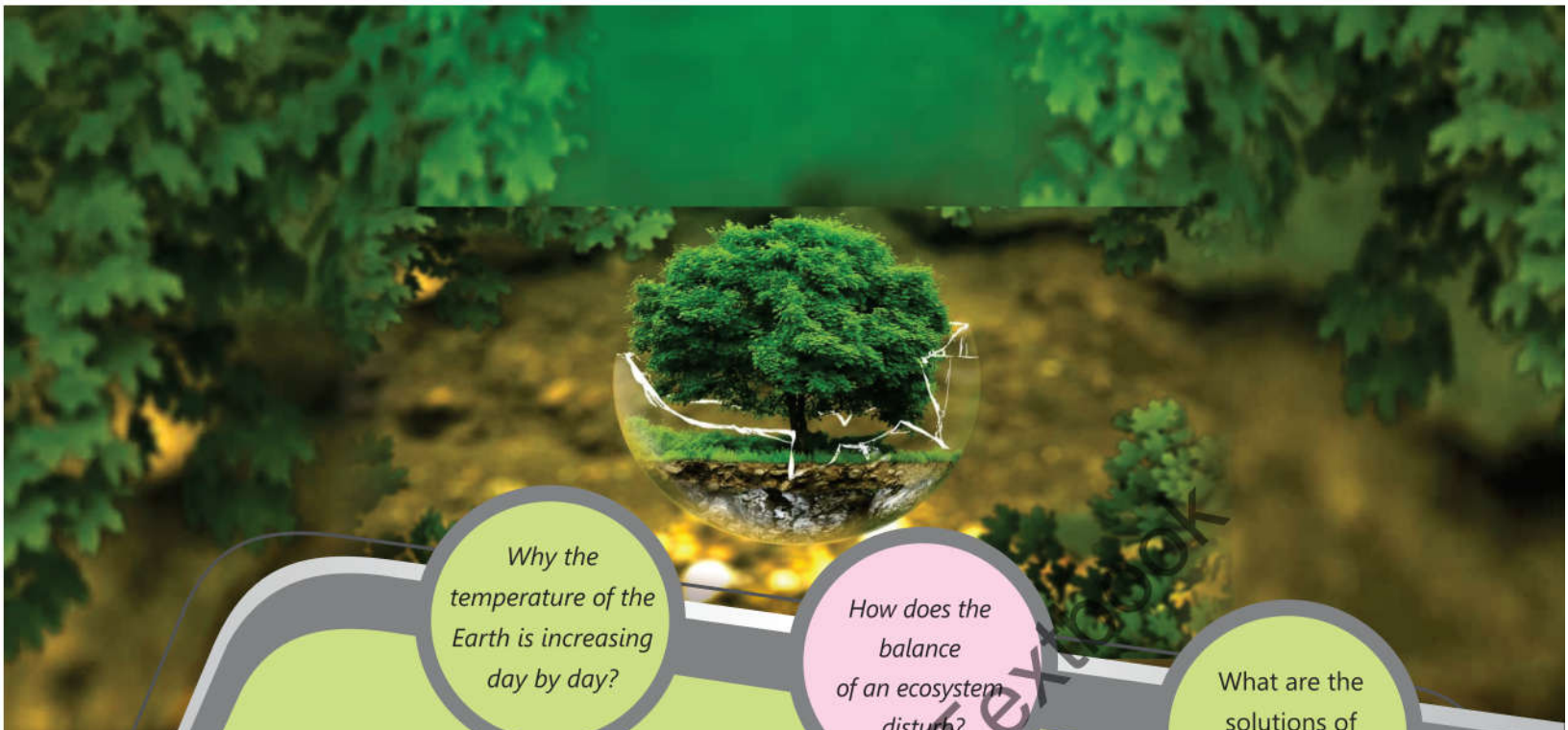
Before printing, it was thoroughly reviewed by a committee of well-known experts to seek its valuable recommendations which have been duly incorporated in the book. The review committee found it aligned with the Single National Curriculum 2022 and recommended it for onward submission for approval from the Board of Government of the Punjab Curriculum and Textbook Board. The key characteristics of the book are as under:

- The subject matter is fully equipped with specific illustrations for strengthening the concept.
- Facts and principles are explained succinctly and clearly.
- For developing an inquiry based approach and skills of practical work in the students, science activities have been included in each chapter of the book.
- Tags of interesting information, mini-exercises, the brain teasers and additional information under the captions of "Do You Know?" have been inserted at proper places to steer students through the concepts.

We wish that this book proves to be an ideal choice for the students looking for a supplement to promote their potentials in the fields of Biology, Chemistry, Physics, Geography and Space Science. As there is always a room for improvement, we cordially invite the valuable suggestions for improvement of the text of this book.

(Authors)

Contents



Why the temperature of the Earth is increasing day by day?

How does the balance of an ecosystem disturb?

What are the solutions of environmental problems?

01 Ecology

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Describe the role of living things in cycling oxygen and carbon through an ecosystem, citing the processes of respiration, photosynthesis and combustion.
- Relate how oxygen and carbon cycles are complementary processes that bring balance and symmetry to life on the Earth.
- Describe global warming and explain how threats to the carbon-oxygen balance such as overpopulation, reliance on fossil fuels, and deforestation are contributing to global warming and climate change.
- Describe how energy flows from producers to consumers and how only part of the energy flows from one level of the pyramid to the next.
- Draw a food web diagram to illustrate the food relationships between organisms.
- Describe and illustrate through examples key ecological relationships between organisms, including competition, predation and symbiosis.
- Predict how changes in an ecosystem (e.g., changes in the water supply, the introduction of a new population, hunting, migration) can affect available resources, and thus the balance among populations.
- Hypothesize what would happen in the ecosystem if the population of one of the participants in different ecological relationships is affected.
- Explain the ways in which human behavior (e.g., Planting forests, reducing air and water pollution, protecting endangered species) can have positive effects on the local environment.

The environment in our surrounding has both living and non-living things. Living things of an environment are termed as its **biotic component**, whereas, non-living things of the environment are termed as its **abiotic component**. Biotic and abiotic components of an environment are interrelated. The study of relationships between the biotic and abiotic components of an environment is called **ecology**. The system of interaction and interdependence between biotic and abiotic components of the environment is called **ecosystem**.

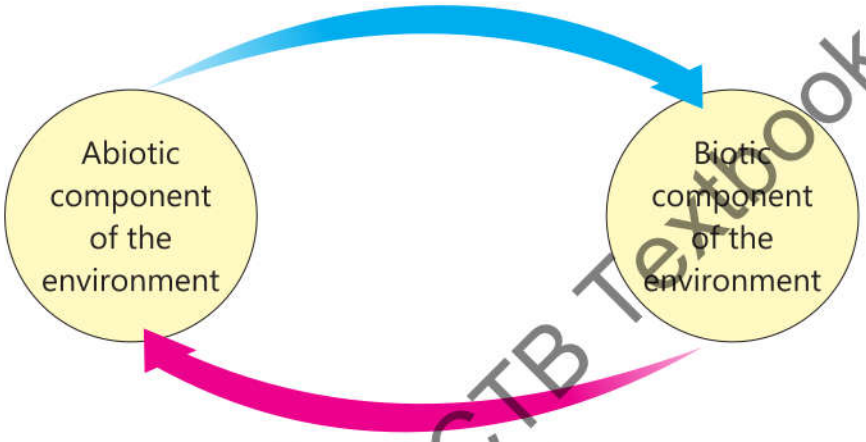


Figure 1.1 Natural cycles

In an ecosystem, abiotic matters like carbon dioxide and water, etc., are used by plants which trap the sunlight energy and convert them into food. Transport of energy to different organisms of biotic component as food chain is one of the most important functions of an ecosystem. On decay of dead bodies of the organisms, abiotic matters fixed in biotic component are released back into abiotic component. In this way, an ecosystem facilitates the transport of different materials in cyclic way and maintains the natural balance (Figure 1.1).

1.1 CARBON AND OXYGEN CYCLE

Carbon and oxygen are two elements that are essential to life. They are naturally present in the atmosphere in the form of carbon dioxide and oxygen gases. They constantly circulate between the environment and living organisms in a cyclic way. When plants prepare food in photosynthesis, they take in carbon from the atmosphere in the form of carbon dioxide (Figure 1.2). In this process, they also release oxygen gas to the atmosphere.

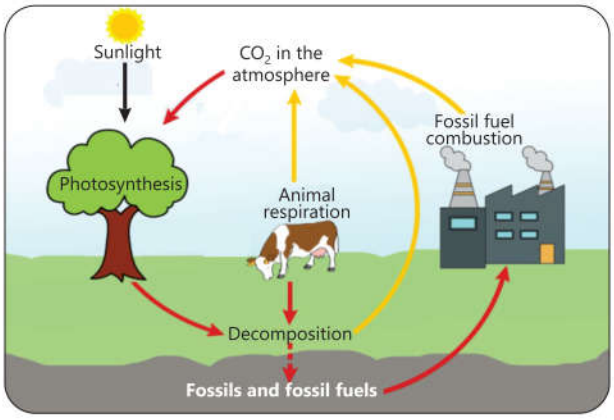


Figure 1.2 Carbon cycle

All animals and plants respire to get energy. During respiration they take in oxygen from the atmosphere and release carbon dioxide to atmosphere (Figure 1.3).

Similarly, during decomposition and combustion of biomass (matter of dead bodies), the oxygen gas present in atmosphere is used and the carbon of biomass is released into the atmosphere in the form of carbon dioxide.

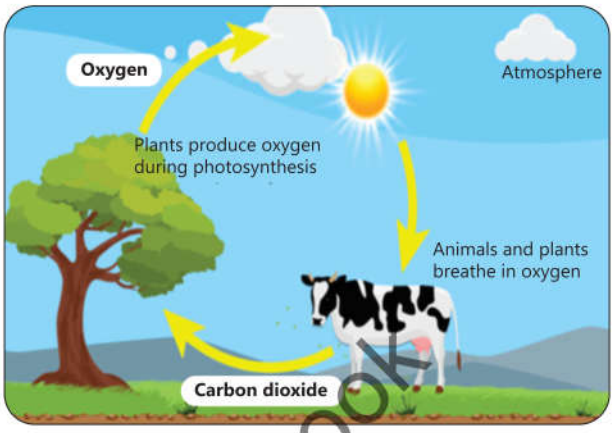


Figure 1.3 Oxygen cycle

Brain Teaser

What are fossils and fossil fuels? How are they important?

1.2 ENERGY FLOW IN THE ECOSYSTEM

We know that organisms need energy for their life activities. They get energy from food. In an ecosystem, plants produce food during **photosynthesis** and are thus termed as **producers**. During photosynthesis, plants trap energy from sunlight and store it as chemical energy in food. Animals consume the food prepared by plants and are thus termed as consumers. Animals that eat plants directly are called **primary consumers** or **herbivores**. Animals that eat other animals are called **secondary consumers** and **tertiary consumers** or **carnivores**. Human and some animals eat both plants as well as meat of animals and are thus called **omnivores**. During this process of eating and being eaten, sunlight energy stored in plants food as chemical energy is transferred from producers to different levels of consumers (Figure 1.4).

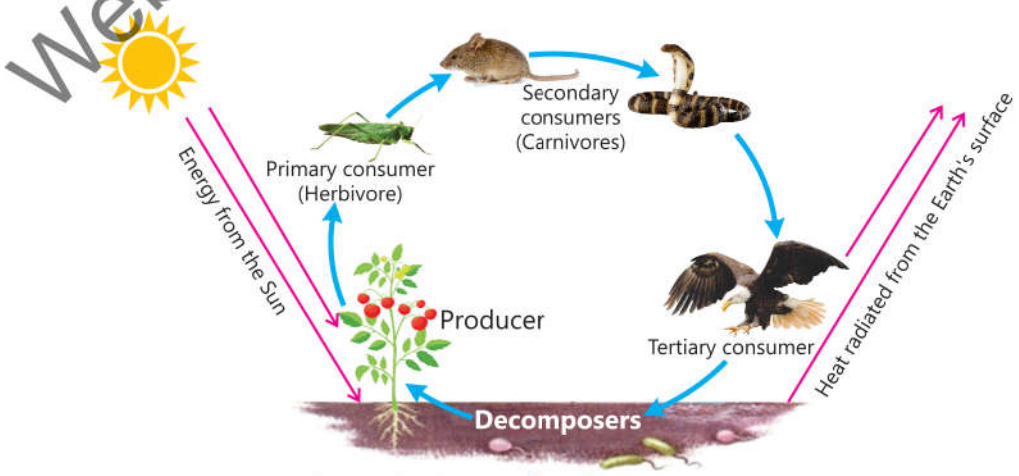


Figure 1.4 Energy flow in an ecosystem

1.2.1 Food Chain and Food Web

Production of food and the feeding relationship among organisms at different levels form a chain called **food chain**. A food chain starts at the producers level and is followed by herbivores level (primary consumers). Then, it continues to the carnivores, (secondary consumers and tertiary consumers) (Figure 1.5). At the end, the dead bodies of the organisms are consumed by **decomposers**.

In reality, food chains are not simple because animals eat a variety of organisms. A fox, for example, does not feed only on rabbits but also takes rats and squirrels in its diet. Similarly owl and hawk may also take different organisms as their food.

These relationships or interactions between different organisms can be expressed more accurately as a food web shown in Figure 1.6 where all animals feed in more than one food chain, these food chains are joined together to make a **food web**.

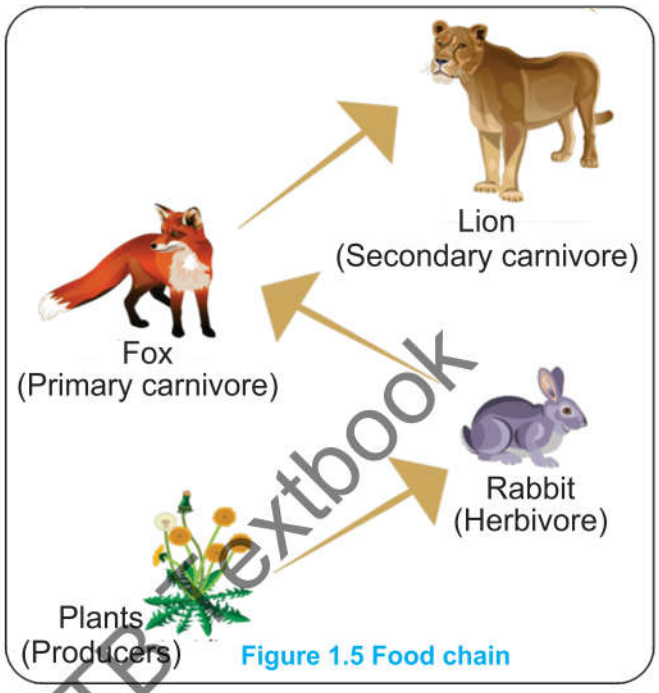


Figure 1.5 Food chain

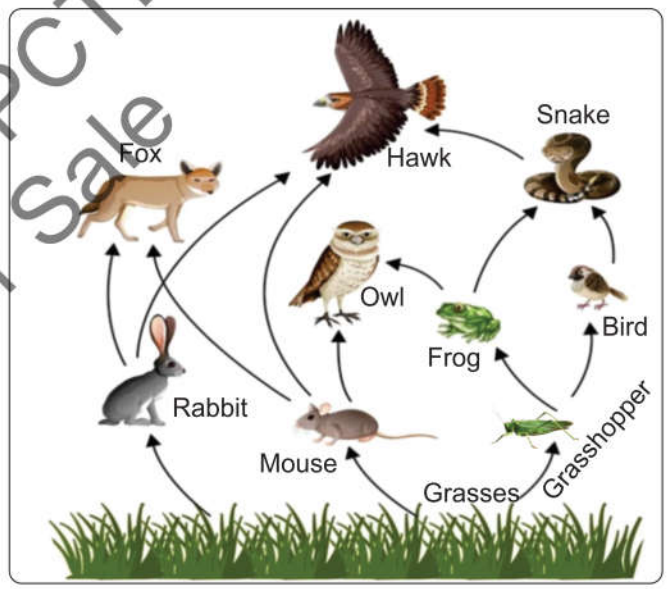


Figure 1.6 Food Web

> **Brain Teaser**
>
> What would happen if decomposers are vanished from the face of the Earth?

1.2.2 Ecological Pyramid

The different feeding levels of organisms in an ecosystem are called trophic levels e.g., producers, herbivores, primary carnivores etc. Biologists express the trophic relationships by the diagrams that take the shape of pyramids. These diagram are thus called ecological (or biological) pyramids (Figure 1.7). At the base of the pyramid are producers or green plants. The upper levels are occupied by primary, secondary and tertiary consumers in ascending order. Usually primary consumers are herbivores and the rest are carnivores (or omnivores).

The ecological pyramids are usually based on number and weight of organisms at each trophic level. Both the number and weight of organisms decrease from base to the top of pyramid. How can we explain the decrease in number or weight? It has been estimated that in an ecological pyramid, the herbivores are generally one tenth of the weight of the producers and the carnivores are one tenth of the weight of the herbivores. For example plants weighing 100,000 kg would be enough to feed small herbivore animals weighing 10,000 kg. Similarly, 10,000 kg of herbivores would support primary carnivore weighing 1000 kg. These carnivores would be enough to feed 100 kg weight of secondary carnivore.

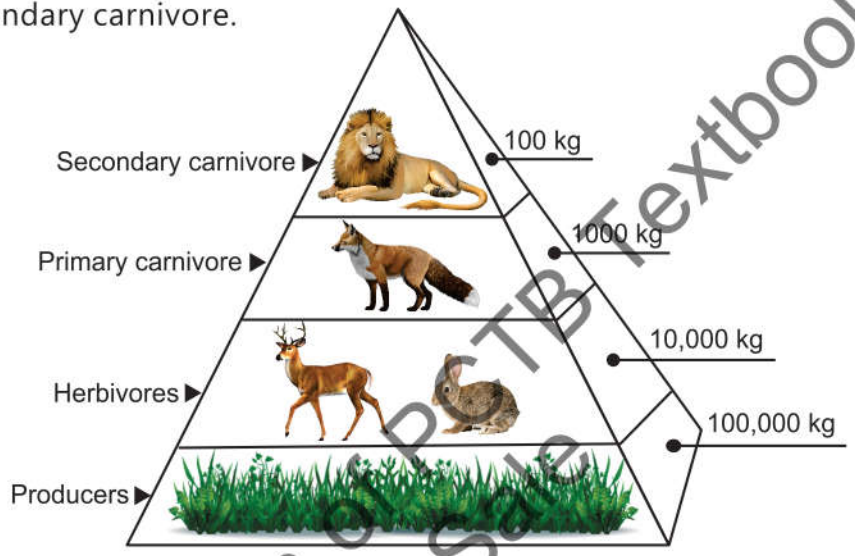


Figure 1.7 Ecological Pyramid

1.2.3 Ecological Interdependence

Organisms in ecological communities interact with one another in three major ways which are as follows:

Predation

Consumers that actively hunt other organisms are called **predators.** The organism upon which a predator feeds is called **prey**. A frog that eats an insect is a predator. The insect is the prey. The frog itself is prey to other organisms such as snakes and storks. The predators in turn are prey to larger carnivores. The size of predator and prey populations are closely linked. A large prey population supports more predators. If a prey population grows or shrinks, the number of predators may also change as well.

Figure 1.8 Predation

Competition

Competition occurs when two or more individuals or populations attempt to use the same resource of environment e.g., food, water, shelter, or sunlight. We know that every environment has limited amount of resources. When one or more individuals or population use the same resources, they become less available to others. Competition can occur among individuals within a population, the intraspecific competition, or between different species, the interspecific competition.

Figure 1.9 Competition

Symbiosis

A relationship where two species live together closely is called **symbiosis**. The type of symbiosis in which one species gets benefit while the other species is neither benefited nor harmed is called **commensalism**. For example, lichens and small plants grow on the trunks of big trees. They get nutrients from tree while the tree gets no harm or benefit. A symbiotic relationship in which both species get benefit is called **mutualism**. An example is the relationship between flowers and the insects that pollinate them. The flower provides food to the insects in the form of nectar. In return, the insects help in the cross pollination of flower.

Figure 1.10 Commensalism

Figure 1.11 Mutualism

1.2.4 Ecological Imbalance

Introduction of new species in an ecosystem, overhunting, migration, etc., are the factors which are disturbing the natural balance of ecosystem. This is called ecological imbalance.

Introduction of a new species

The entering of a foreign species into any area can imbalance the natural ecosystem. For example in the Philippines, some species such as toad and golden snail were introduced. The population of these species went uncontrollable because of lack of natural enemies.

Figure 1.12 Introduction of new species

Overhunting

It is defined as the relentless chase for wild or game animals to kill or catch them for economic or personal gains or food. Excessive hunting can cause extinction of many species. Overhunting of one animal species causes an abundance of the other, hence leading to an imbalance in the natural ecosystem and the food chain.

Figure 1.13 Overhunting

Shortage of water supply

Due to overpopulation and our constant need for factory-made products, the use of water from water bodies has been increased. This results in loss of freshwater in water bodies, i.e., rivers, canals, lakes, etc. Pollution in water bodies is not only limited to the factory waste. More domestic use of water, due to overpopulation, also contributes to the pollution and loss of freshwater in water bodies. Climate changes also affect the water supply in our environment through flood or droughts.

Figure 1.14 Factories discharging wastes in the water bodies

Migration

Migration is the movement of organisms from one place to another. This movement changes the population of a place. The migration usually takes place for search of food, water and shelter e.g birds migrate for the search of food.

Figure 1.15 Migration

1.3 ENVIRONMENTAL PROBLEMS

1.3.1 Global Warming

Some gases present in the atmosphere, e.g., carbon dioxide (CO_2), methane (CH_4), oxides of nitrogen (NO_2), water vapours, etc., trap a part of the heat reflected by the Earth causing increase in the atmospheric temperature (Figure 1.16). These gases are called **greenhouse gases** and the phenomenon is called **greenhouse effect**. Due to human activities like burning of fuel, etc., the amount of greenhouse gases is increased in the atmosphere. This speeds up the greenhouse effect. The increasing rate of greenhouse effect is increasing the average temperature of the Earth. As a result, the Earth is getting warmer. This is called **global warming**. Due to global warming, the ice in the polar regions and at the mountains melts at a greater rate. This leads to rise in the level of sea water which creates floods in low lying coastal areas. The climate of many regions of the world is also changing due to global warming. The global warming is thus a threat to the life on the Earth (Figure 1.17).

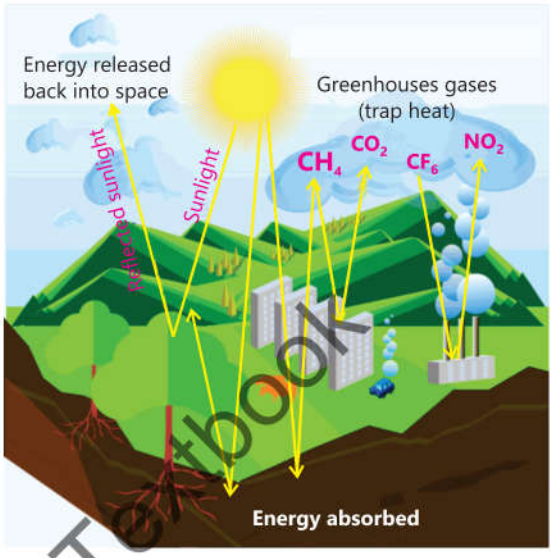


Figure 1.16 Greenhouse effect

Do You know?

Ozone layer in the upper atmosphere of the Earth stops the ultraviolet rays coming from the Sun to the Earth.

Figure 1.17 Effects of global warming

1.3.2 Factors affecting Global Warming

Burning of fossil fuels

Figure 1.18 Burning of fossil fuel

When fossil fuels are burnt to run vehicles and industries, they emit many greenhouse gases like carbon oxide which cause global warming. The burning of fossil fuels also releases poisonous substances in the air. The poisonous and harmful substances which make the air unfavorable for life are called **air pollutants**. One of the air pollutants is carbon monoxide. It affects the human organ systems badly and causes headache, brain damage and respiratory problems. Sulphur dioxide and oxides of nitrogen dissolve in rain water and cause acid rain. Exposure to sulphur dioxide can cause breathing difficulties, pneumonia, lung cancer, etc.

Deforestation

Figure 1.19 Deforestation

Destruction of forests as a result of human activities is called **deforestation**. Deforestation has many adverse effects on the environment. It changes weather and climate. Roots of trees hold the soil. Cutting of trees leads to soil erosion and fertile part of the soil is lost through this process. When forests are cut, rate of evaporation is reduced which results in less rain. Deforestation decreases the carbon dioxide consumption by plants increasing its amount in the environment. This leads to the increased greenhouse effect and global warming.

Do You know?

Changa Manga is a man-made forest in Pakistan. It is found in District Kasur in the Punjab.

Overpopulation

When the population of an organism (e.g., humans) becomes larger than the capacity of environment, it is called overpopulation. More people demand for more oil, coal, gas, and other energy sources . When more and more fossil fuels are used, more greenhouse gases and other pollutants are released into the environment. In this way, overpopulation results in more global warming.

Mini Exercise

Explain the effects of global warming on the life on the Earth.

1.4 SOLUTIONS OF ENVIRONMENTAL PROBLEMS

The Earth is the only planet in our Solar System where life exists. Pollutants are harmful to the life on the Earth. We should keep the Earth's environment clean and healthy. Here are some of the solutions of environmental problems.

1.4.1 Reducing pollution

We can take many steps to reduce pollution. Domestic trash and other solid wastes should not be dumped on open places. Instead of personal cars, public transport should be used for travel. Sulphur and lead free fuel should be used in vehicles. Factories and industries should be shifted away from the populated areas. Acidic industrial exhaust gases must be neutralized before releasing into the air. Engines of the vehicles should be tuned properly. Chlorofluorocarbons (CFCs) free products should be used. 4R strategies of Refuse-Reduce-Reuse-Recycle for the conservation of resources should be adopted. Trees should be grown along the road sides.

1.4.2 Plantation

There are many benefits of plants. Planting more trees can reduce the level of air pollution as plants absorb pollutants. It also maintains the temperature of an area at a lower level than an area that does not have trees. They are also the habitat for birds and many other animals. Trees are also a source of fruits and flowers. Each and everyone of us have to plant trees and enhance the quality of life.

Figure 1.20 Reducing Pollution

Figure 1.21 Replantation

1.4.3 Protection of endangered species

Human activities cause rapid and widespread environmental changes that affect living things. Many species of animals and plants are at risk of extinction. Such species are called **endangered species**. One of the major causes of species becoming endangered is habitat loss. Humans cut down trees in forests for harvesting. They clear forests or drain wetlands to use the land for agriculture, mining, and settlement. Similarly, pollution, global warming, excessive hunting are also the causes of species becoming endangered. Some of the endangered species of Pakistan are snow leopard, indus river dolpin, markhor, etc.

Snow leopard

Indus river dolphin

Markhor

Figure 1.22 Endangered species of Pakistan

Governments develop plans to protect the endangered species. Such plans include reducing deforestation, setting aside nature reserves, reducing pollution, and protecting natural habitats. The hunting and trade of endangered species is also banned. Moreover, governments make plans to take endangered species into "protective custody" outside their natural habitats. For example, animals may be kept in zoos.

Activity 1.1

Trace, colour and write below how the activities of the children are keeping environment clean and healthy.

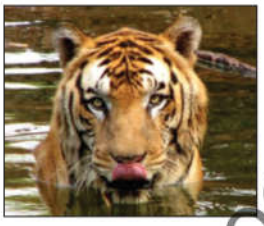
a.

b.

Activity 1.2

Use internet or any other source to find three more pictures of endangered species and paste them in the given boxes.

c.


KEY POINTS

- Carbon and oxygen cycles are the processes in which these minerals circulate between the organisms and the environment.
- Organisms need energy for their life activities.
- The different feeding levels of organism in an ecosystem are called trophic levels.
- The ecological pyramids are usually based on number and weight of organisms at each trophic level.
- The feeding relationship among organisms at different trophic levels form a chain called the food chain.
- Consumers that actively hunt other organisms are called predators.
- Competition occurs when two or more individuals or populations attempt to use the same resource of environment e.g., food, water, shelter, or sunlight.
- A relationship where two species live together closely is called symbiosis.
- Introduction of new species, over hunting, change in water supply and migration are some of the factors which can cause ecological imbalance.
- The increasing rate of greenhouse effect and ozone depletion is increasing the average temperature of the Earth. As a result, the Earth globe is getting warmer. This is called global warming.

KEY POINTS

- The poisonous and harmful substances which make the air unfavorable for life are called air pollutants.
- Burning of fossil fuels, deforestation and overpopulation are factors which are increasing global warming.
- Many environmental problems can be solved by reducing pollution, replantation and protecting endangered species.

QUESTIONS

1. Encircle the correct option.

(i) The phenomenon which does not lead to global warming:
(a) greenhouse effect (b) ozone depletion
(c) deforestation (d) photosynthesis

(ii) The feeding level of an organism in an ecosystem is called _____.
(a) tropic level (b) secession level
(c) food chain (d) food Web

(iii) The graphical representation of trophic relationship of organisms in an ecosystem is called _____.
(a) food chain (b) trophic level
(c) ecological pyramid (d) predation

(iv) All the food chains are joined together to form _____.
(a) ecological pyramid (b) food web
(c) tropical level (d) none of these

(v) The energy of the Sun is trapped as chemical energy by _____.
(a) producers (b) primary consumers
(c) secondary consumers (d) tertiary consumers

(vi) Consumers that actively hunt other organisms are called _____.
(a) prey (b) predator
(c) symbiont (d) competitor

(vii) A relationship where two species live together closely is called _____.
(a) predation (b) symbiosis
(c) competition (d) none of these

(viii) We can solve environmental problems by:
(a) reducing pollution (b) plantation
(c) protection of endangered species (d) all of these

(ix) Ecological imbalance is caused by:

(a) migration (b) overhunting

(c) over population (d) all of these

2. Write short answers.

(i) What are ecological pyramids?

(ii) What is predation?

(iii) Differentiate between:

(a) oxygen and carbon cycle (b) food chain and food web

(iv) Write any one of the solution of environmental problems.

(v) Name some of the factors which can cause ecological imbalance.

3. Constructed response questions

(i) How carbon and oxygen cycles are helpful for the environment?

(ii) Is the Sun the main source of energy for life on the Earth? Explain.

(iii) What would be the effect of overhunting?

4. Investigate

(i) What would happen if we will not work to reduce global warming?

(ii) Why do the producers occupy the base of the pyramid?

(iii) Hypothesize what would happen in the ecosystem if the population of one of the species is affected.

Project

Grow a plant in an earthen pot.

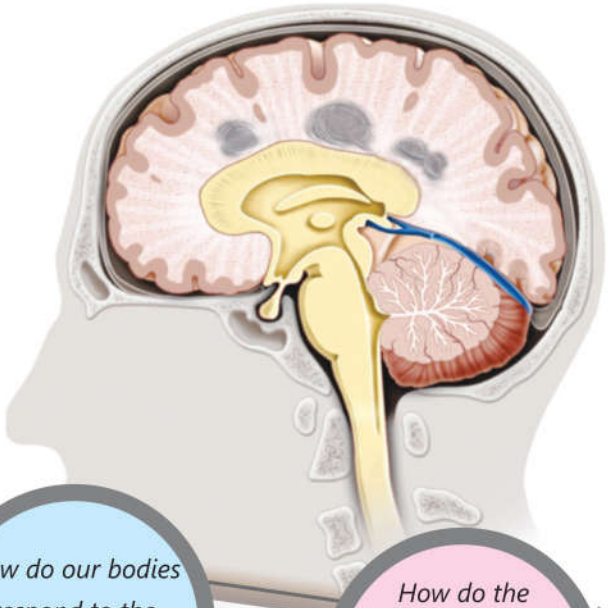
Materials

Earthen pot, soil, cattle manure, seasonal plant seeds

Procedure

1. Take an earthen pot.
2. Fill it with soil.
3. Mix small quantity of cattle manure in the soil.
4. Sow a few seasonal plant seeds into the soil in the earthen pot.
5. Sprinkle water on the soil.
6. Place the pot where it can get access to sunlight.
7. After 2 weeks, observe the small seedling grown in the earthen pot.

Write how this project will be helpful in reducing the pollution.



How do our bodies respond to the changes in environment?

How do the messages travel from one part of body to the other?

Why do you pick your hand quickly when it touches a hot object?

02 Human Nervous System

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Identify the organs, functions and processes of the Human Nervous System.
- Sketch and label a diagram of the Human Nervous System.
- Explain how the brain works as the control station of the human body.
- Identify the major parts of the brain.
- Describe the structure of the cerebrum, its division into two hemispheres (left and right) and the role of each hemisphere in the control of the body.
- Map the various steps in the transmission of messages through the body and to the brain via a reflex arch.
- Describe the type and function of neurons in transmitting message through the body.
- Match various body function with the relevant part of the brain that controls or regulates them (For instance, associating breathing with the brain stem).
- Explain and represent how messages flow through the body from and to the brain, and how the brain collaborates with the sensory organs to regulate this process.
- Map the various steps in the transmission of messages through the body and to the brain.
- Predict what would happen if a nerve connection broke.

In previous classes, we have learnt about various organs and their functions in human body. In this chapter we will study the functions of human brain, spinal cord and nerves which constitute **nervous system**.

2.1 NERVOUS SYSTEM

Whenever a person gets injury on his foot while walking, he feels pain and his hand immediately reaches the injured site. Who asked the hand to reach the site? In fact, there is an organ system in our body which carries messages form one part of the body to another and coordinates body functions. This system is called nervous system. Human nervous system consists of central nervous system (CNS) and peripheral nervous system (PNS) (Figure 2.1). The central nervous system is composed of brain and spinal cord. Peripheral nervous system consists of a network of nerves which connect the central nervous system to all parts of the body.

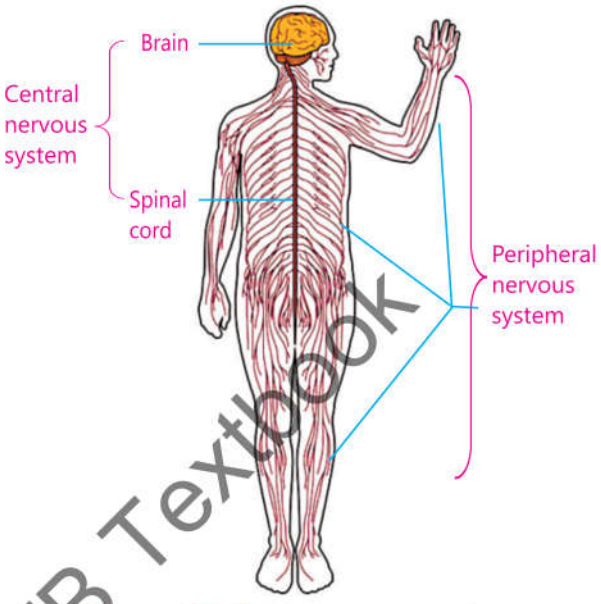


Figure 2.1 Human nervous system

Neuron or Nerve Cell

Neuron or nerve cell is the basic structural and functional unit of the nervous system. All parts of the nervous system, i.e., brain, spinal cord and nerves are made up of neurons. Neurons transmit messages in the form of electrochemical waves called **nerve impulses**.

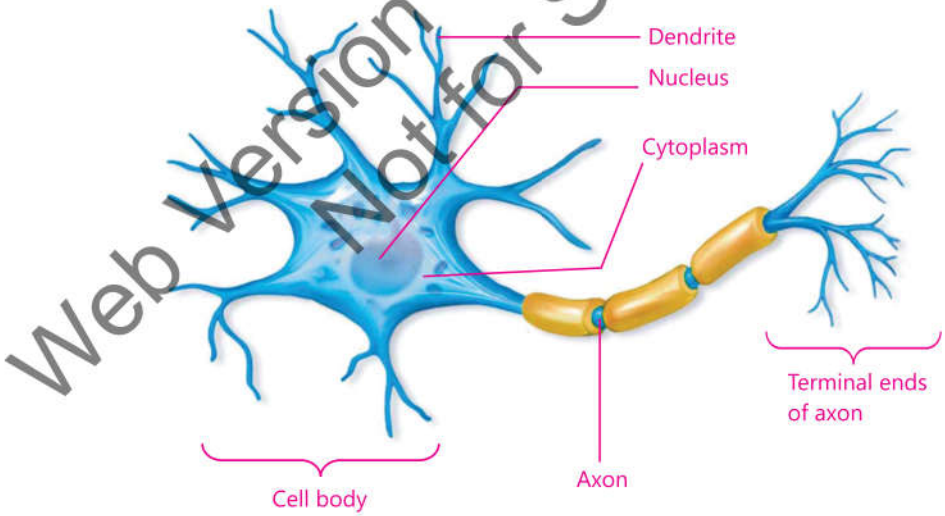


Figure 2.2 Structure of Neuron

The part of a neuron which contains nucleus and most of the cytoplasm is called **cell body.** The fine projections of the cell body which receive messages are called **dendrites**. A long projection of the cell body which conducts messages away from the cell body is called **axon** (Figure 2.2). Terminal ends of the axon transmit the messages to the next cells.

Nerve

A nerve is cable-like bundle of axons enclosed in a common sheath. Nerve transmits messages from one part of body to another.

Types of neurons

On the basis of their functions, neurons are of three types, i.e. sensory neurons, motor neurons and interneurons. **Sensory neurons** carry nerve impulses from sense organs (ears, eyes, skin, tongue, nose etc.) to the central nervous system. **Motor neurons** carry nerve impulses from central nervous system to **effectors** (muscles and glands), i.e., the parts which respond. **Inter-neurons** are present in central nervous system (brain and spinal cord). They form a link between sensory and motor neurons (Figure 2.3).

Interesting information

Impulses may travel as fast as 150 metre per second or as slow as 0.2 metre per second.

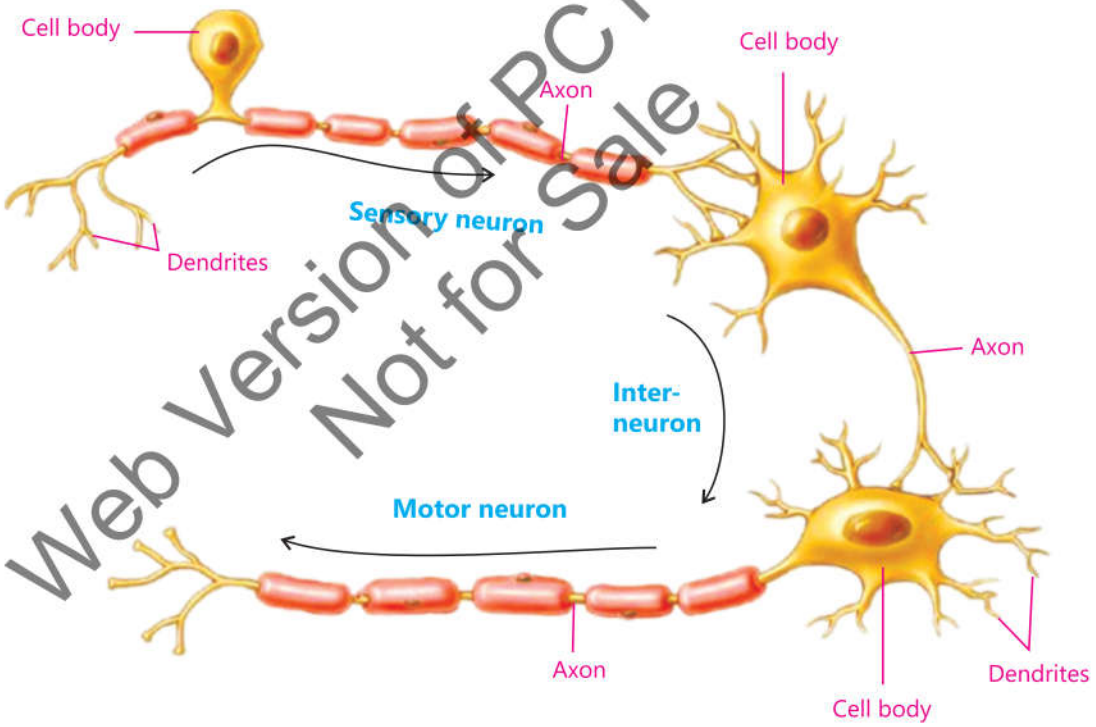


Figure 2.3 Sensory neuron, Inter-neuron and Motor neuron

Mini Exercise

Draw the structure of a neuron or nerve cell and label its different parts.

2.1.1 Central Nervous System(CNS)

Central nervous system acts as a control centre of the whole nervous system. It comprises brain and spinal cord.

Brain

Human brain (Figure 2.4) is enclosed in a bony skull called cranium, and consists of billions of inter-neurons. It is divided into the following parts:

1. Forebrain

Forebrain is the largest part of the brain. It consists of three main parts, i.e., cerebrum, thalamus and hypothalamus. **Cerebrum** is the topmost and the largest part of the brain. It is divided into right and left cerebral hemispheres. Each hemisphere controls the opposite side of the body. In general, the left hemisphere controls speech, comprehension, arithmetic, and writing. The right hemisphere controls creativity, spatial ability, artistic, and musical skills. Inside cerebrum there is a small structure called **thalamus**. It controls many sensory functions. **Hypothalamus** lies at the base of thalamus. It controls body temperature, hunger and thirst.

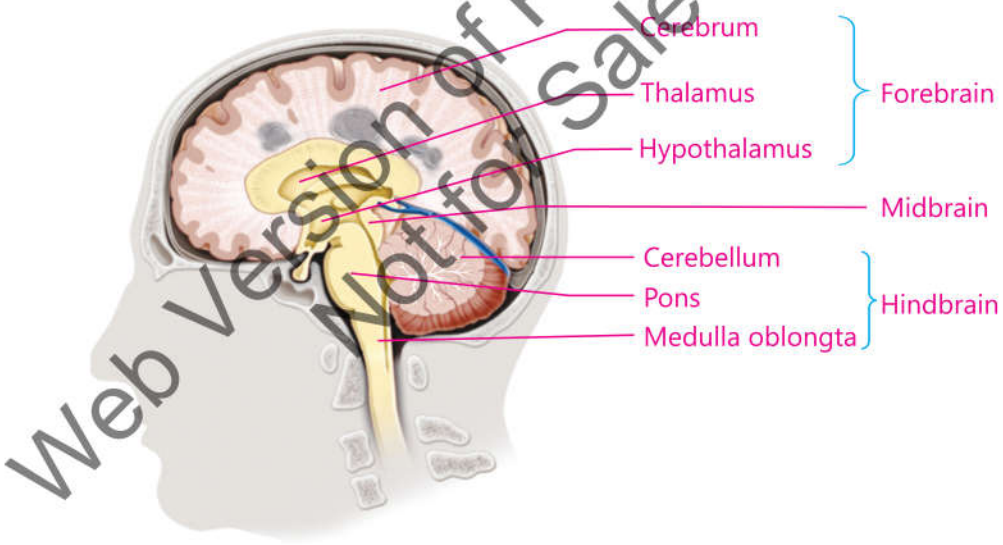


Figure 2.4 Section of skull showing different parts of human brain

2. Midbrain

Midbrain is a small part of the brain which is present below the cerebrum. It receives information from sense organs which is then passed to the appropriate part of the forebrain.

3. Hindbrain

Hindbrain consists of three parts, i.e., cerebellum, pons and medulla oblongata.

Cerebellum lies under the back part of the cerebrum. It acts as a controller for maintaining the body balance and making precise and accurate movements. **Pons** is an oval structure present beneath midbrain. It controls many functions like sleep, swallowing, equilibrium and taste, etc. **Medulla oblongata** forms the posterior part of the brain where it is connected with the spinal cord. Medulla oblongata controls heartbeat, breathing and digestion, etc. Medulla oblongata keeps on working when rest of the brain goes to sleep.

Do you know?

Brain of an adult weighs about 1.5 kg and consists of about one hundred billion neurons.

Spinal cord

Spinal cord is an extension of medulla oblongata (Figure 2.5). It runs backwards inside the backbone up to its lower end. It is also made up of inter-neurons.

Spinal cord creates a link between brain and different body parts. It also controls some reflex actions (immediate and involuntary actions) and some other involuntary actions.

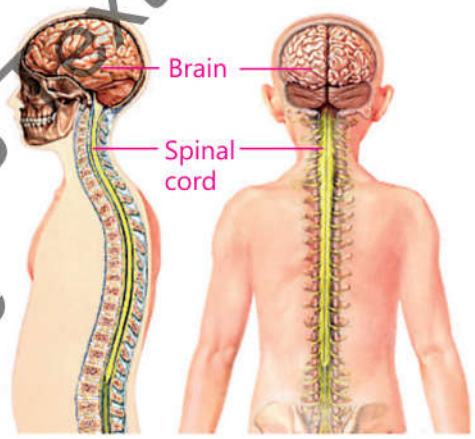


Figure 2.5 Spinal cord

2.1.2 Peripheral Nervous System

Peripheral nervous system (PNS) consists of a network of nerves which spread in the body to connect all the body parts to the central nervous system (brain and spinal cord) (Figure 2.1). The nerves which arise from brain are called **cranial nerves**. The nerves which arise from spinal cord are called **spinal nerves**. There are 12 pairs of cranial nerves and 31 pairs of spinal nerves in human body.

2.1.3 Working Model of the Nervous System

Nervous system coordinates all body functions. It also detects the changes in environment and produces response to the changes. Figure 2.6 shows the working of the nervous system as described below:

- Any change in the environment (external or internal) that can be detected by a receptor to initiate a nerve impulse is called **stimulus** (Plural: stimuli). Heat, cold, pressure, sound waves, etc. are the examples of stimuli. The special organs, tissues or

- The sensory neurons carry the messages regarding stimuli in the form of nerve impulses from receptors to central nervous system.
- The central nervous system processes the messages and transmits the nerve impulses to motor neurons.
- The motor neurons carry the nerve impulses to the parts of the body which produce responses. Such parts are called effectors. Muscles and glands in the body act as effectors.

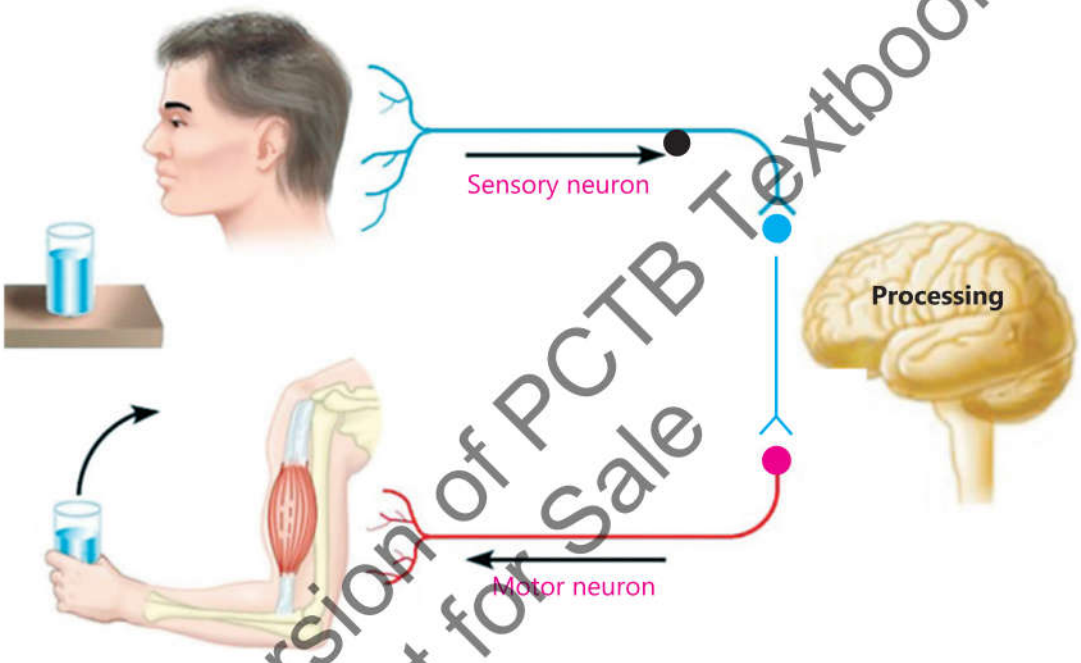


Figure 2.6 Function of nervous system

Activity 2.1

Make a flow diagram showing the pathway of a nerve impulse when you pat at the shoulder of your friend.

2.1.4 Actions Controlled by the Nervous System

Voluntary actions

The body actions which are performed under conscious control, i.e., which are done after thinking over them are called voluntary actions. For example; speaking, eating, reading, walking, running, clapping, etc., are voluntary actions.

Involuntary actions

The body actions which are performed without involvement of thinking process are called involuntary actions. Involuntary actions are not performed under conscious control.

Heartbeat, breathing, blinking of eyes, movement of small intestine, etc., are the examples of involuntary actions.

2.2 REFLEX ACTION

An immediate and involuntary response to a stimulus is called **reflex action**. Quick pulling of hand just after touching the hot object is a common example of reflex action.

In this example of reflex action shown in Figure 2.7, temperature of hot object is a stimulus which is received by the cells (thermoreceptors) of the skin. A nerve impulse is created in the sensory neuron present in skin. The nerve impulse is carried by the sensory neuron to the spinal cord. The inter-neuron of the spinal cord transmits the impulse to the motor neuron. The motor neuron carries the impulse to the arm muscles (effectors). The arm muscles contract and the hand is pulled back. The pathway of nerve impulses which complete a reflex action is called **reflex arc**. It consists of receptor, a sensory neuron, an inter-neuron, a motor neuron and effector.

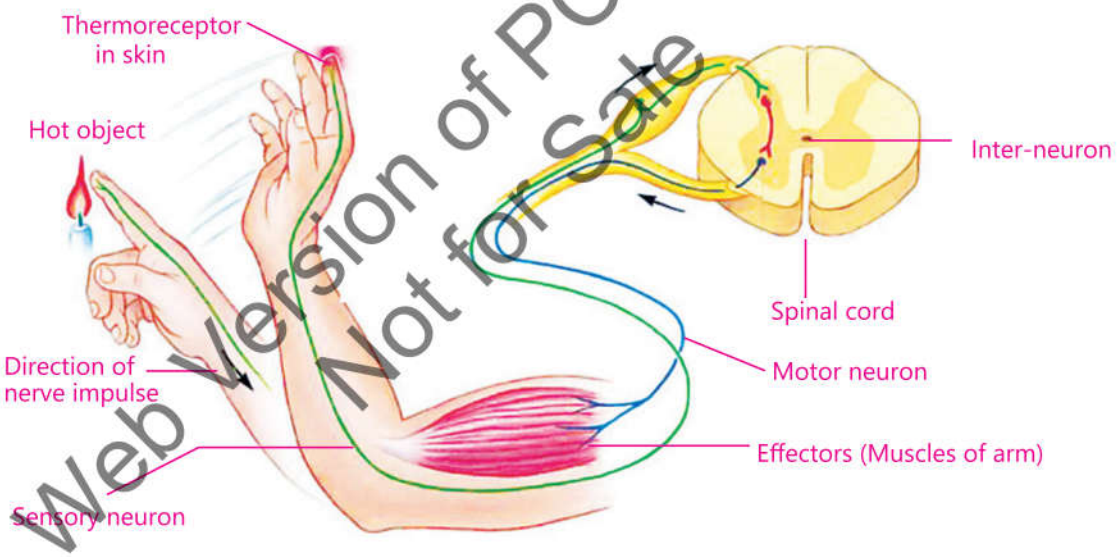


Figure 2.7 Reflex arc representing reflex action. Touching a hot object (flame in this example) results in immediate withdrawal of hand through contraction of muscles of arm.

KEY POINTS

- Nervous system carries messages from one part of the body to another and coordinates body's functions.
- Central nervous system consists of brain and spinal cord.
- Peripheral nervous system consists of a network of nerves which connects the central nervous system to all the body parts.
- Sensory neurons carry messages from sense organs to central nervous system.
- Motor neurons carry messages from central nervous system to muscles and glands.
- Inter-neurons are present in brain and spinal cord. They form a link between sensory neurons and motor neurons.
- The actions which are performed under conscious control are called voluntary actions.
- The actions which are performed without involvement of thinking process are called involuntary actions.
- An immediate and involuntary response to a stimulus is called reflex action.

QUESTIONS

1. Encircle the correct option.

(i) The neurons which decide about the action for a certain stimulus:

(a) sensory neuron (b) motor neuron
(c) inter-neuron (d) all of above

(ii) The parts of a neuron which receive messages are:

(a) cell bodies (b) dendrites
(c) axons (d) nuclei

(iii) Heartbeat is controlled by:

(a) cerebrum (b) cerebellum
(c) medulla oblongata (d) hypothalamus

(iv) Many axons present side by side and enclosed in a common sheath form:

(a) nerve cell (b) nerve
(c) dendrite (d) spinal cord

(v) Sensory neurons carry messages towards:

(a) muscles (b) glands

(c) sense organs (d) brain and spinal cord

(vi) Which part of brain is involved in precise and accurate body movements?

(a) Cerebellum (b) Cerebrum

(c) Thalamus (d) Midbrain

(vii) When you have a toothache, you feel pain because:

(a) there is a cavity in your tooth

(b) tiny bits of food are left between your teeth

(c) bacteria digest the food left between your teeth and produce an acid

(d) the cavity reaches the nerves and the nerves send a message to the brain

2. Write short answers.

(i) Write the functions of midbrain, hypothalamus and spinal cord..

(ii) Differentiate between:

(a) Receptors and effectors

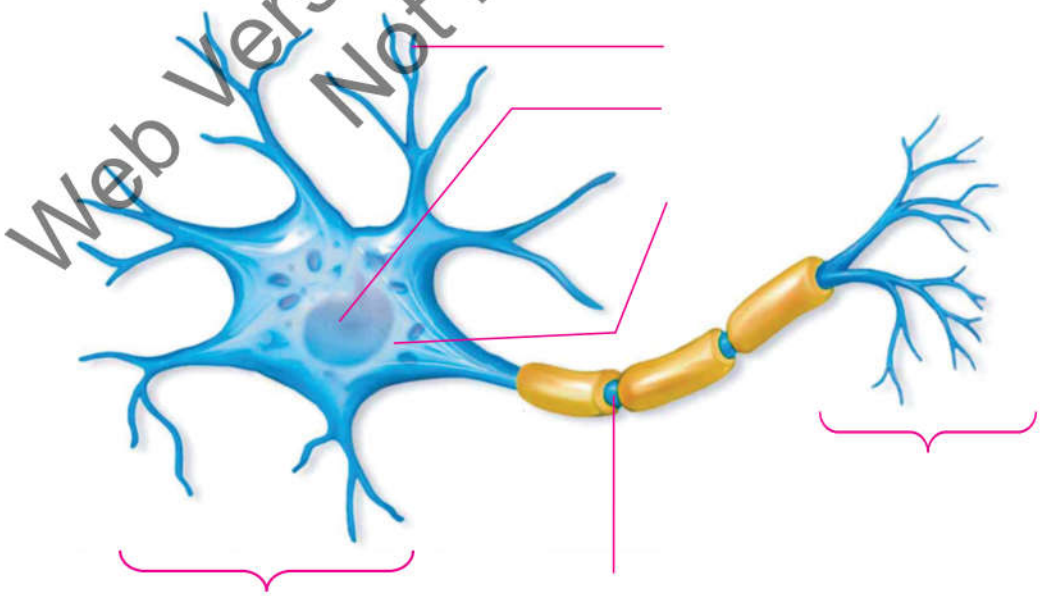
(b) Neuron and nerve

(c) Sensory neuron and motor neuron

(d) Cerebrum and cerebellum

(iii) Write a note on the central nervous system.

(iv) Identify and label the following diagram.



3. Constructed response questions

(i) The table below shows the list of your daily activities. Write the name of that part of brain (forebrain, midbrain or hindbrain) which is controlling this activity.

No.	Activity	Part of brain controlling activity
1.	Sleeping	
2.	Brushing your teeth	
3.	Taking the breakfast	
4.	Balancing your body	
5.	Taking deep breath	

(ii) Predict what would happen if a nerve connection broke.

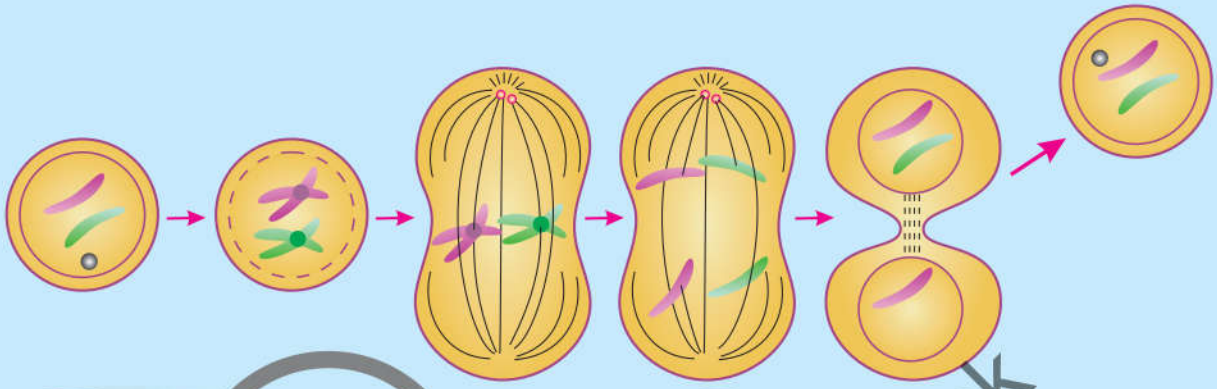
4. Investigate

(i) Why a motor cyclist is advised to wear the helmet?

(ii) A person met an accident in a car. When he was brought to the hospital he did not know even his name. What could have happened to him? Relate your answer with reference to your nervous system.

Project

Teacher should make a group of four students and ask one of the student to read aloud a paragraph for one to two minutes. Ask other students to listen carefully. As the student stops reading, ask all the others three students to write in a given space what they have listened. After writing the paragraph ask all the students to compare their written paragraph with the actual paragraph in a book. The greater they found resemblance between the actual and written paragraph the stronger memory they have.



How are animals and plants adapted to their environment?

Why do we look like our parents?

Where do new cells come from?

03 Variations, Heredity and Cell Division

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Describe variation and adaptation in living organisms.
- Explain and illustrate the differences between variation and adaptation.
- Identify sources of variation from environmental and genetic factors.
- Explain how different adaptations affects the chances of survival of different species of organism.
- Recognize Genetics as the study of heredity and understand and define heredity as the transfer of genetic information that specifies structure, characteristics, and functions, from parents to offspring.
- Differentiate between the concept of genes and chromosomes and relate them to how genetic characteristics are inherited.
- Describe the composition and structure of DNA.
- Design a model of DNA to demonstrate its structure, functions, and various components.
- Describe cell division and its types - mitosis and meiosis and relate them to the passage of genetic information through reproduction.
- Explain the process of mitosis and meiosis and identify their key phases.

It is a common observation that living things grow in size. It is also observed that offspring resemble their parents. We have learnt that all the living things are made up of cells. Hence, more and more cells are needed for growth and development of living things. The new cells arise by the divisions of pre-existing cells. In this chapter, we will discuss the process of cell division. We will also study why do offspring resemble their parents and why they have differences. Heredity and basis of heredity will also be discussed in this chapter.

3.1 HEREDITY

During reproduction, living things pass on their characteristics to their offspring. This is the reason that babies look like their parents. Plants grown from seeds resemble their parent plants. The transmission of characteristics from parents to offspring is called **heredity.** The characteristics such as the colour of eyes, skin colour, hair colour, free or attached earlobes, height, intelligence, etc., are the examples of the characteristics that are transmitted from parents to the offsprings and are called **hereditary** characteristics.

Life in all organisms; every character of their structure, function, metabolism and behaviour is programmed and controlled by a set of instructions. These instructions are in the form of biological codes called **genes**. You have received your genes from your parents, and they have received their genes from their parents. Thus you and your siblings share many genes of your parents and even of your grandparents. Inherited characters are determined by genes. These are transmitted from generation to generation through genes. Heredity is the way genes transmit characteristics from parents to offspring. The word "genetics" is derived from "genes". **Genetics** is the science of heredity. Gene is the basic unit of biological information. Genetics deals with transfer of biological information in the form of genes from parents to offspring; i.e., from generation to generation

Activity 3.1 - Comparing hereditary characteristics

Closely observe your own body features as well as those of your parents, grandparents (both maternal and paternal), brothers and sisters. Record your observations in the table given below:

Characteristics	Yourself	Father	Mother	Sister	Brother	Grandparents (Paternal)		Grandparents (Maternal)	
Hair (straight or curly)									
Eye colour (blue, brown, black)									
Complexion (fair, wheatish, dark)									
Height (tall, medium, short)									

Activity 3.1

- What characteristics are common between you and your brothers and sisters?
- Which of these characteristics are also present in your parents or grandparents?
- What conclusions do you draw from the previous observations?
- What characteristics are transferred from parents to offspring, are called?
- Which of your body characteristics are different from your brothers and sisters?
- What the characteristics, which are different in members of a family or in members of a species, are called?

We know that children possess many features similar to those of their parents but they also differ from their parents in certain respects. Similarly, brothers and sisters also show differences in many characteristics. Any difference in the characteristics of the members of a species is called **variation.** Variations help organisms to adapt (live successfully) their environment, have greater chances of survival and continue their race.

3.2 DIFFERENCE BETWEEN ADAPTATION AND VARIATION

3.2.1 Variation

As you already know that the differences shown by the individuals of one kind of organisms (one species) are called variations. There are two types of variations on the basis of their causes. The variations which arise due to changes in genes are called **genetic variations** e.g., skin colour, blood type, eye colour, tongue rolling etc. Such variations are passed from parents to offspring. The primary source of genetic variations is mutation. **Mutation** is a change in the genetic material (gene). The variations which are caused by environmental influence are called **environmental variations** e.g., language, scar on skin etc. Such variations are not transferred to offsprings. Some genetic variations also have a lot of environmental influence e.g., weight and height.

3.2.2 Adaptation

Adaptation is the physical or behavioral characteristic of an organism that helps an organism to survive better in the environment. Living things are adapted to the habitat they live in. This is because they have special features that help them to survive. For example, animals that live in cold places have adaptations to keep them warm. Plants that live in dry areas have adaptations to help them conserve water.

Figure 3.1 (a) Camel

Figure 3.1 (b) Cactus plants

The body of camels shows excellent adaptation for living in the desert. They have long eyelashes to keep sand out of their eyes and wide feet to distribute their weight evenly on the sand. Their hump can store fats and which are used for long time. Plants also show adaptations. The best example is cactus plant to survive in the desert. Its stem can store water. The leaves are modified in spines and have thick cuticle on the surface to reduce water loss. It has shallow roots that spread close to the surface to quickly absorbs rainwater.

3.3 BASIS OF HEREDITY

The basic physical and functional unit of heredity is called gene. **Genes** act as instructions to make molecules called proteins. Genes occur in pairs. Every hereditary character in an organism (e.g.,height, eye colour, attachment of earlobe, skin colour, hair type etc.) is controlled by a pair of genes. One member of a gene pair comes from male parent (father) while the other comes from female parent (mother). Where are genes found physically? Genes are the sections of DNA (Deoxyribonucleic Acid) molecule and are located on chromosomes. As different sections of DNA (genes) are a set of information for the development of different characters in an organism, DNA is called **hereditary material.** DNA and proteins are the components of chromosomes. **Chromosomes** are thread-like structures found in the nucleus of a cell. They appear as distinct structures only during cell division. A typical chromosome consists of two arms called **chromatids**

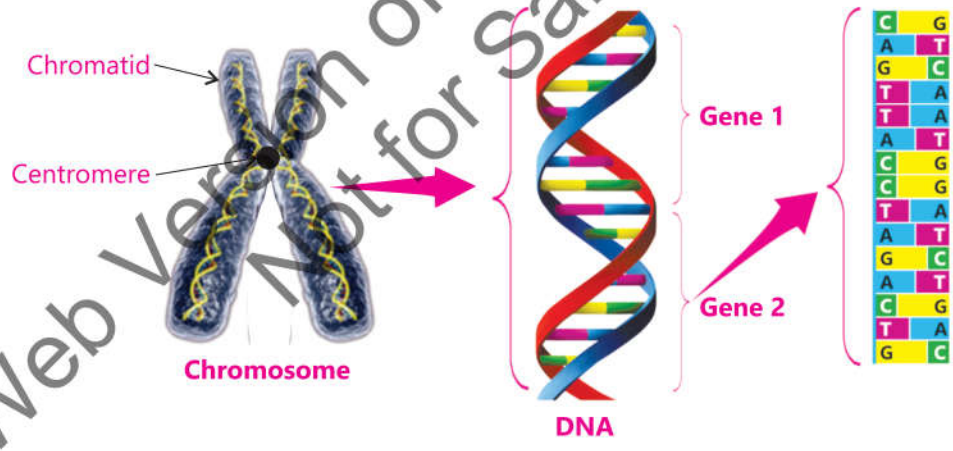


Figure 3.2 Relationship between Chromosome, DNA and Gene

which are attached to the same part called **centromere**. The relationship between the chromosomes, DNA and genes is shown in Figure 3.2. The number of chromosomes is specific and constant for every kind (species) of organism.

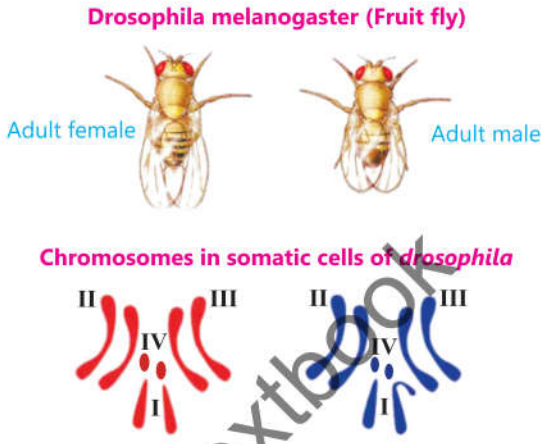
In general body cells (somatic cells), the chromosomes occur in pairs but the gametes (sperms or eggs) or spores which are formed by meiosis contain one member of each chromosome pair. For example; in man, every somatic cell has 46 chromosomes in the form of 23 pairs but every sperm or egg cell has 23 chromosomes.

Mini Exercise

Observe the Figure and answer the questions:

1. What is the number of chromosomes in a somatic cell of *Drosophila*?

2. What will be the number of chromosomes in the gametes of *Drosophila*?



3.4 WATSON AND CRICK MODEL OF DNA

Each DNA molecule is made of thousands of small units called **nucleotides**. There are four types of nucleotides in DNA. These are **Adenine (A) nucleotide, Thymine (T) nucleotide, Cytosine (C) nucleotide** and **Guanine (G) nucleotide**.

According to Watson and Crick's model, DNA consists of two strands of nucleotides. The two strands are held together by hydrogen bonds between nitrogenous bases of nucleotides of opposite strands (Figure 3.3). The nitrogenous base Adenine of one strand makes bonds with Thymine of the opposite strand. Similarly, Guanine of one strand makes bonds with Cytosine of the opposite strand.

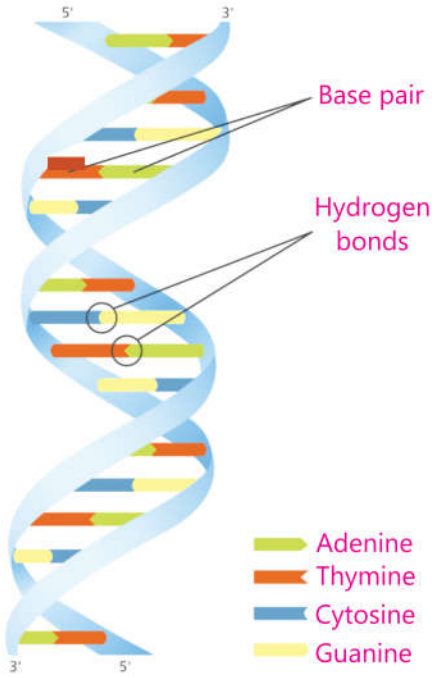


Figure 3.3 DNA

3.5 TRANSMISSION OF CHARACTERS

When an organism forms gametes (sperms or eggs) by meiosis, the number of chromosomes is reduced to half in the gametes, i.e., **haploid (n)** sperms or eggs are produced. It means, the hereditary material (DNA) is also reduced to half in the gametes. When male and female organisms mate, the haploid (n) sperm cell from male and haploid (n) egg cell from female fuse with each other to form a **diploid (2n)** cell called **zygote**. In this way the complete hereditary material (DNA) is restored in the zygote, i.e., the physical

and functional units of all the characters (gene pairs) are transferred in the zygote. The zygote after passing through various changes develops into a full organism with specific characteristics from both parents. Thus, zygote is the first cell from which the life of an organism starts.

3.6 CELL DIVISION

Cell division is a process by which a cell divides into two daughter cells. The cell which divides is called **parent cell**. The cells which are produced as a result of cell division are called **daughter cells**. Before the start of cell division, the parent cell passes through a phase called **interphase**. Before a cell divides, each of its chromosomes is made of a single chromatid. During interphase, the chromosomes duplicate. It means that each chromosome makes a new chromatid. As a result, each chromosomes consists of two chromatids. The process of cell division involves two phases, i.e., nuclear division and cytokinesis. **Nuclear division** is the division of nucleus which is followed by cytokinesis. **Cytokinesis** is the division of cytoplasm. Cell division is of two types which are called mitosis and meiosis.

Mitosis

Mitosis is a process by which the parent cell divides into two daughter cells with same number of chromosomes as in the parent cell. The number of chromosomes is doubled during interphase. During mitosis when the nucleus of parent cell divides both chromatids of each chromosome separate. In this way, two sets of chromosomes are formed; each with single chromatid. The two sets of chromosomes are distributed equally in the two daughter nuclei (Figure 3.4). After nuclear division a shallow groove arises in the middle of the cytoplasm which deepens further and divides the cell into two daughter cells, each having a nucleus.

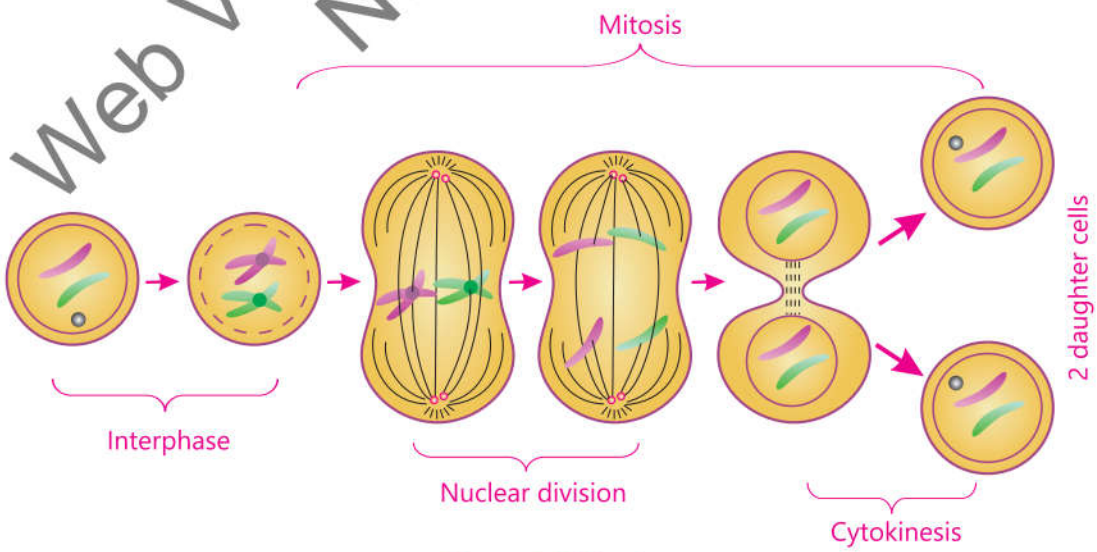


Figure 3.4 Mitosis

Meiosis

Meiosis is a process by which the cell divides twice to form four daughter cells in such a way that the number of chromosomes in each daughter cell is reduced to half as, compared to the parent cell (Figure 3.5).

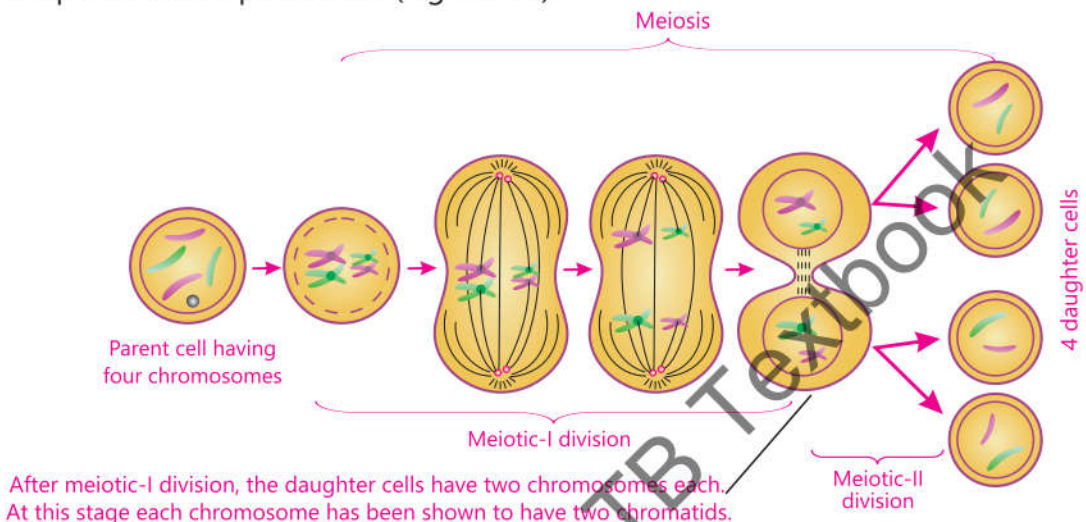


Figure 3.5 Meiosis

The process of meiosis consists of two divisions, meiotic-I division and meiotic-II division. During meiotic-I division, the number of chromosomes is reduced to half as compared to the parent cell. Meiotic-II division is similar to mitosis because the half number of chromosomes is retained in the four daughter cells.

Differences between Mitosis and Meiosis

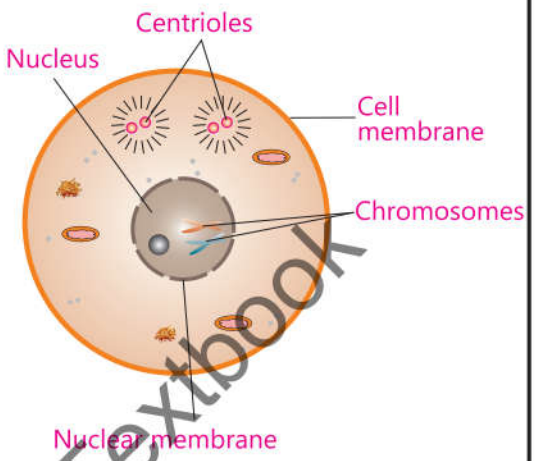
Sr. No.	Mitosis	Meiosis
1.	During mitosis, two daughter cells are formed from the parent cell.	During meiosis, four daughter cells are formed from the parent cell.
2.	The number of chromosomes in the daughter cells remain the same as in the parent cell.	The number of chromosomes in the daughter cells is reduced to half as compared to that in the parent cell.
3.	Mitosis occurs in somatic cells.	Meiosis occurs to produce gametes (sperms and eggs) in animals or spores in plants.

For your information

- Characters of living things are controlled by the genes on the chromosomes. Mitosis is a great blessing of nature. If there were no mitosis, the number of chromosomes could not have been maintained constant.
- Similarly, meiosis has also a significant importance in controlling the hereditary characters generation after generation.

You need to know...

- Nucleus is part of the cell which controls all activities of the whole cell.
- Chromosomes are found in the nucleus of the cell. They consist of proteins and DNA.
- DNA stands for Deoxyribonucleic Acid.
- DNA is the material that contains complete set of instructions for developing a new cell or an organism. That is why DNA is called hereditary material.
- For one kind (species) of organism the number of chromosomes in the cells remain the same. However, when gametes are formed (sperms or eggs in animals) or spores (in plants), the number of chromosomes is reduced to half in the gametes or spores.



KEY POINTS

- The transmission of characteristics from parents to offspring is called heredity.
- Genetics is the science of heredity. It is the study of structure and behaviour of genes.
- The basic physical and functional unit of heredity is called gene.
- Genes act as instructions to make molecules called proteins. Genes are located on chromosomes.
- Variation means an individual that possesses characteristics different from the others of the same kind.
- The characteristics of an organism that help it to survive in a given environment are called adaptations.
- Each DNA molecule is made of thousands of small units called nucleotides.
- The number of chromosomes is constant for every kind (species) of organisms.
- When a sperm and an egg fuse to form zygote, the characters (genes) are transferred in the zygote. Zygote after passing through various changes develops specific characters in the new baby.
- The process by which a parent cell divides into two daughter cells is called cell division.
- Mitosis is a process in which a parent cell divides into two daughter cells with same number of chromosomes as in the parent cell.
- Meiosis is a process in which a cell divides twice to form four daughter cells in such a way that the number of chromosomes in daughter cells is reduced to half as compared to that in the parent cell.

QUESTIONS

1. Encircle the correct option.

(i) Which of these is NOT a genetic variation?

(a) Mark of a cut on skin (b) Eye colour
(c) Attached earlobes (d) Blood group

(ii) You are different from your brother and sisters. This is called:

(a) variation (b) adaptation
(c) hereditary (d) mitosis

(iii) In humans, the eye colour is developed due to the effects of:

(a) diet (b) environment
(c) genes (d) both 'a' and 'b'

(iv) The section of DNA which has information for making a specific protein is called:

(a) DNA strand (b) nucleotide
(c) chromosome (d) gene

(v) Chromosomes are made of:

(a) DNA only (b) proteins only
(c) DNA, proteins and fats (d) DNA and proteins

(vi) The characters which are passed from parents to offspring:

(a) hereditary characters (b) non-inheritable characters
(c) environmental characters (d) none of these

(vii) An event that occurs during interphase:

(a) division of nucleus (b) division of cytoplasm
(c) duplication of chromosomes (d) formation of cell wall

(viii) Reduction of chromosomes takes place during:

(a) mitosis (b) meiotic-I
(c) meiotic-II (d) both mitosis and meiotic-II

(ix) In humans, a sperm has 23 chromosomes. Egg cell has:

(a) 23 chromosomes (b) 46 chromosomes
(c) no chromosomes (d) 69 chromosomes

(x) Zygote is formed by the fusion of:

(a) two sperm cells (b) two egg cells
(c) two somatic cells (d) sperm cell and egg cell

2. Write short answers.

(i) What is the primary source of genetic variation?

(ii) Plants are adapted to their environment. Give examples.

(iii) What is difference between variations and adaptations?

(iv) What is a gene?

(v) Define heredity and describe its importance in transferring of characteristics from parents to offspring.

(vi) Differentiate between mitosis and meiosis.

(vii) What is the structure of DNA?

3. Constructed response questions

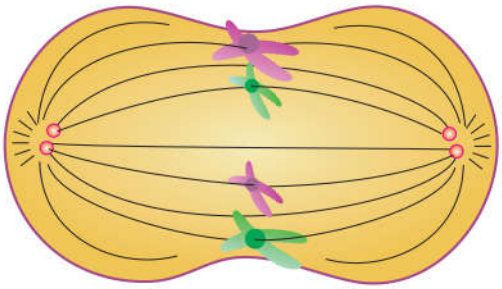
(i) Gametes are haploid cells. What do you think would happen if the gametes forming a zygote are diploid?

(ii) An injury on a person's body needs more and more cells for the repair of his body. What type of cell division do you think will provide more and more cells for his body repair?

(iii) Which of the following Figures represent a phase of mitosis and the other a phase of meiosis?

(a)

(b)



4. Investigate

(i) How are fish adapted to their environment?

(ii) When you get a cut on your hand how it gets healed?

Project

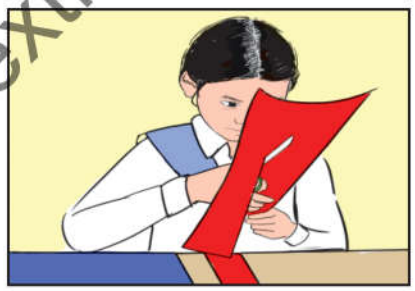
Make a model of DNA

Materials

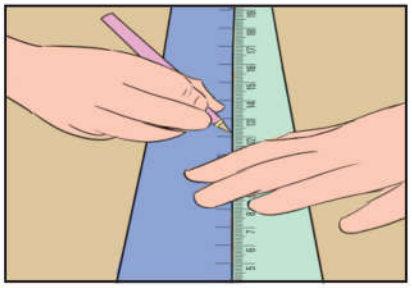
1. Coloured papers (blue and red)
2. Scissors
3. A pencil
4. A box of toothpicks (not the coloured ones)
5. Markers
6. A ruler
7. Scotch tape

Procedure

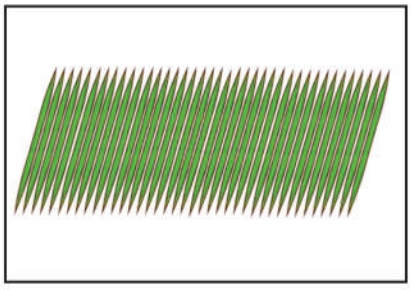
1. Take two papers of different colours. Cut both of the papers in long strips as shown in the Figure. The size of each strip should be of 2 feet long and 1 inch broad.



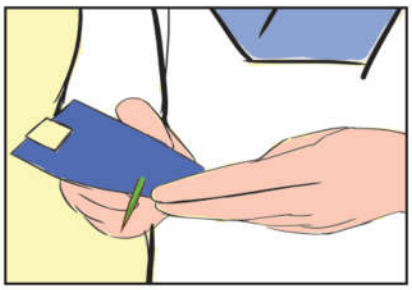
2. Mark each inch of strip with pencil. This would be the step of ladder . Write A , T, C and G with different colour markers on each step..



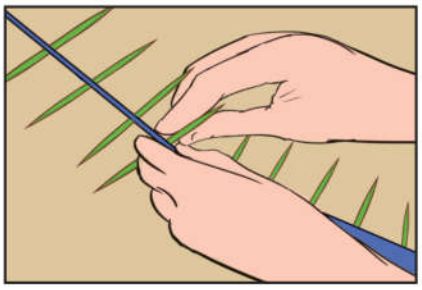
3. Take 10 toothpicks and colour them with different colours.



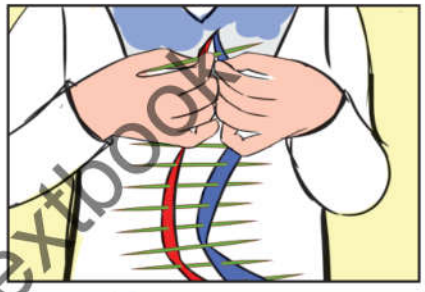
4. Hold both strips of paper and stick them together with scotch tape from the top.



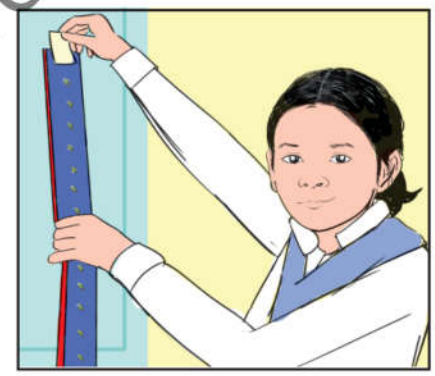
5. Prick the toothpick through the middle of strips at every inch.



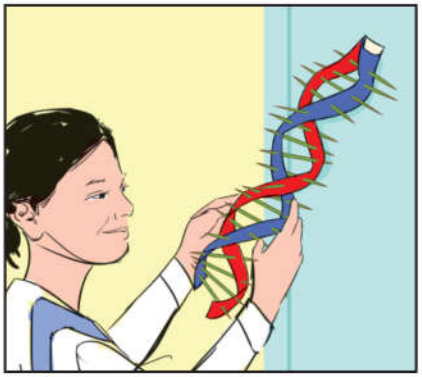
6. Gently spread the two strips apart until your model looks like a ladder.



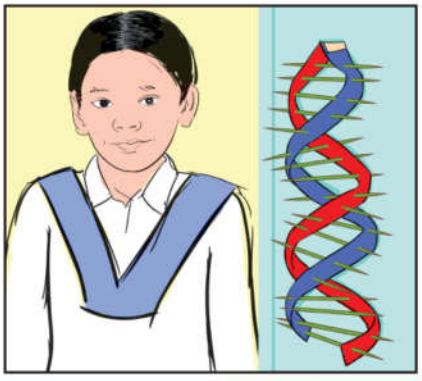
7. Hang your model of DNA on the door or soft board of your school.

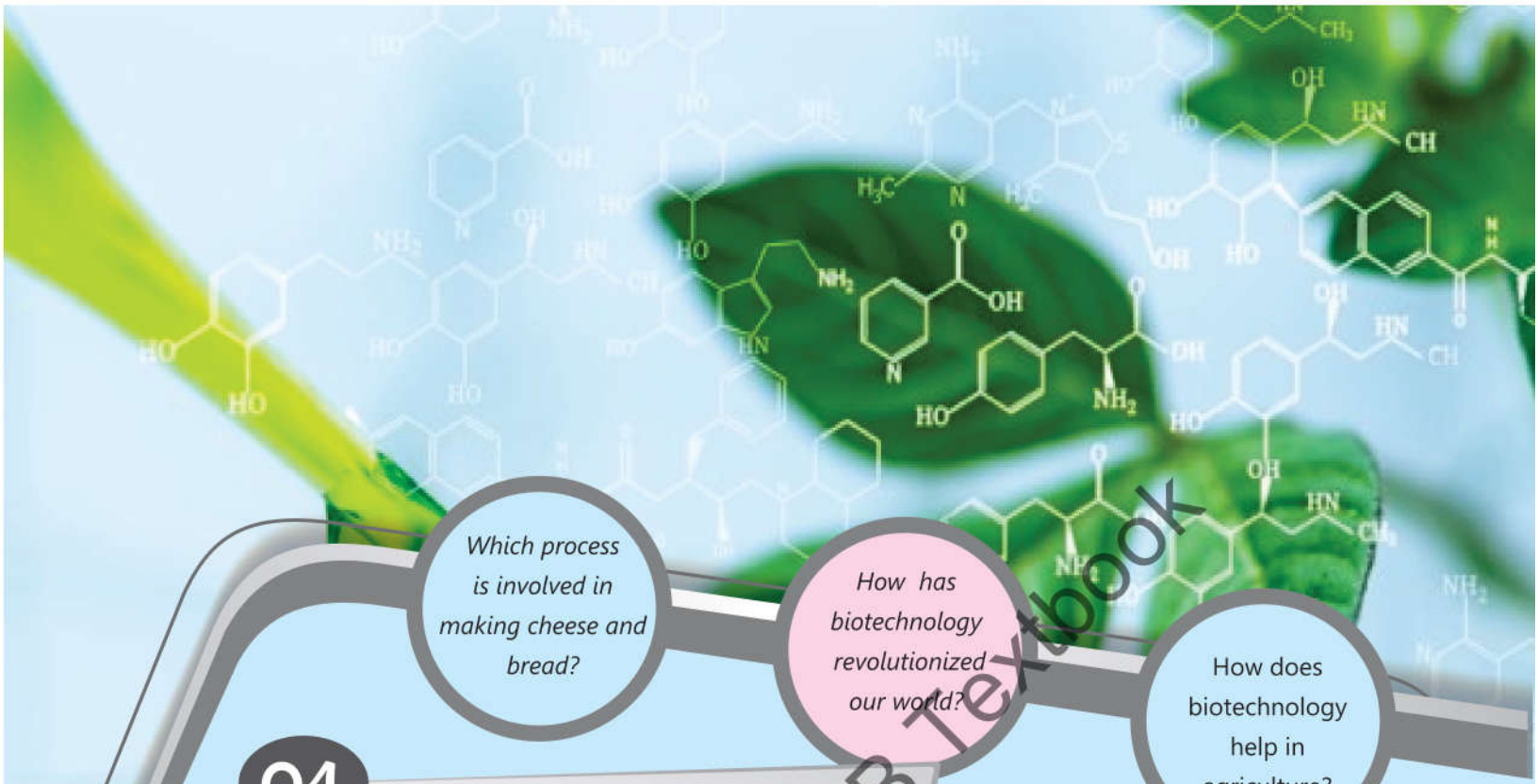


8. Twist the two strips around to make it double helix.



9. Your DNA model is ready.





04 Biotechnology

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Define biotechnology as the use of living cells and organisms in products and processes that can improve the quality of life.
- Illustrate how biotechnology is a disciplined/field that has the potential to transform how we live.
- Discuss the applications of biotechnology in the Pakistani context and their effects on the people and the environment of Pakistan over time e.g., bread-making, making of yogurt and cheese, vaccines for immunization, insulin production, dyes, etc.
- Relate the use of biotechnology in food sciences in producing foods with higher nutritional value and improved taste and quality (how fermentation has been improved by genetically modified organisms or the introduction of certain genes to raise iron content in rice, can be taken as examples).

Application of knowledge in the areas like engineering and medicines, etc., is called technology. Biotechnology is the use of living cells and organisms in products and processes that can improve the quality of life. Microorganisms are used in making bread, yogurt, cheese, vinegar and several medicines. Fermentation, tissue culture and genetic engineering, etc., are the processes and techniques in which microorganisms are used for making many industrial products and in the research work. In this chapter, some principles and techniques used in biotechnology will be introduced. General applications of biotechnology in the fields of agriculture, environment, health, food production and preservation, etc., will also be discussed.

4.1 GENETIC ENGINEERING

Genes act as instructions to make specific substances (proteins) which are used for specific structural and physiological purposes in the body. Genetic engineering is an advanced technique in biotechnology in which scientists select and isolate the useful gene from one organism (donor organism) and insert it into another organism (usually bacterium). The organism that contains a foreign gene in its cells is called **transgenic organism**. The inserted gene produces the desired product (protein) in transgenic organism.

4.1.1 Importance of Bacteria in Genetic Engineering

The scientist use bacterial cell because it is very simple and easy to grow. It does not have an organized nucleus. The chromosome, consisting of DNA, floats in the cytoplasm. Additional circular pieces of DNA called **plasmids** are also present in the cytoplasm (Figure 4.1). Plasmids can be easily isolated from a bacterial cell and a gene can be attached with it. Plasmid can carry the attached foreign gene into the bacterium. In this way, plasmid acts as a carrier of a foreign gene. Another reason for using bacteria in genetic engineering is their fast rate of reproduction.

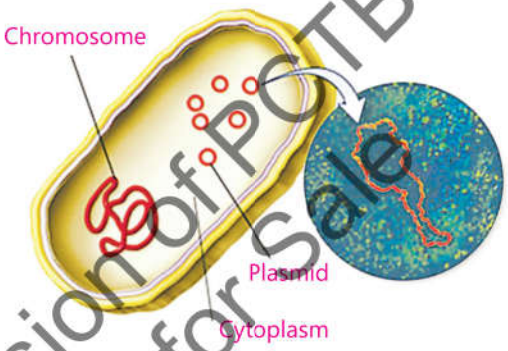


Figure 4.1 Bacterial cell

4.1.2 Introduction of Gene into Bacterium

The first step of genetic engineering for inserting a gene into a bacterial cell is the identification and isolation of the gene of desired protein from the donor organism (see Figure 4.2). An enzyme is used to cut the gene from the donor organism. The isolated gene is then attached with plasmid DNA taken from a bacterium. The same enzyme (used for cutting the donor gene) is used to cut the plasmid DNA at a specific site so that the gene can be attached at the cut end of the plasmid. The attached gene of desired protein and the plasmid DNA are collectively called **recombinant DNA**. The recombinant DNA is inserted back into the same type of bacterium from which the plasmid was isolated. The bacterium which takes in the recombinant DNA is called genetically modified bacterium (GM bacterium) or **transgenic bacterium** (Figure 4.2).

Do you know?

A bacterial cell divides to form two daughter cells within 20 minutes.

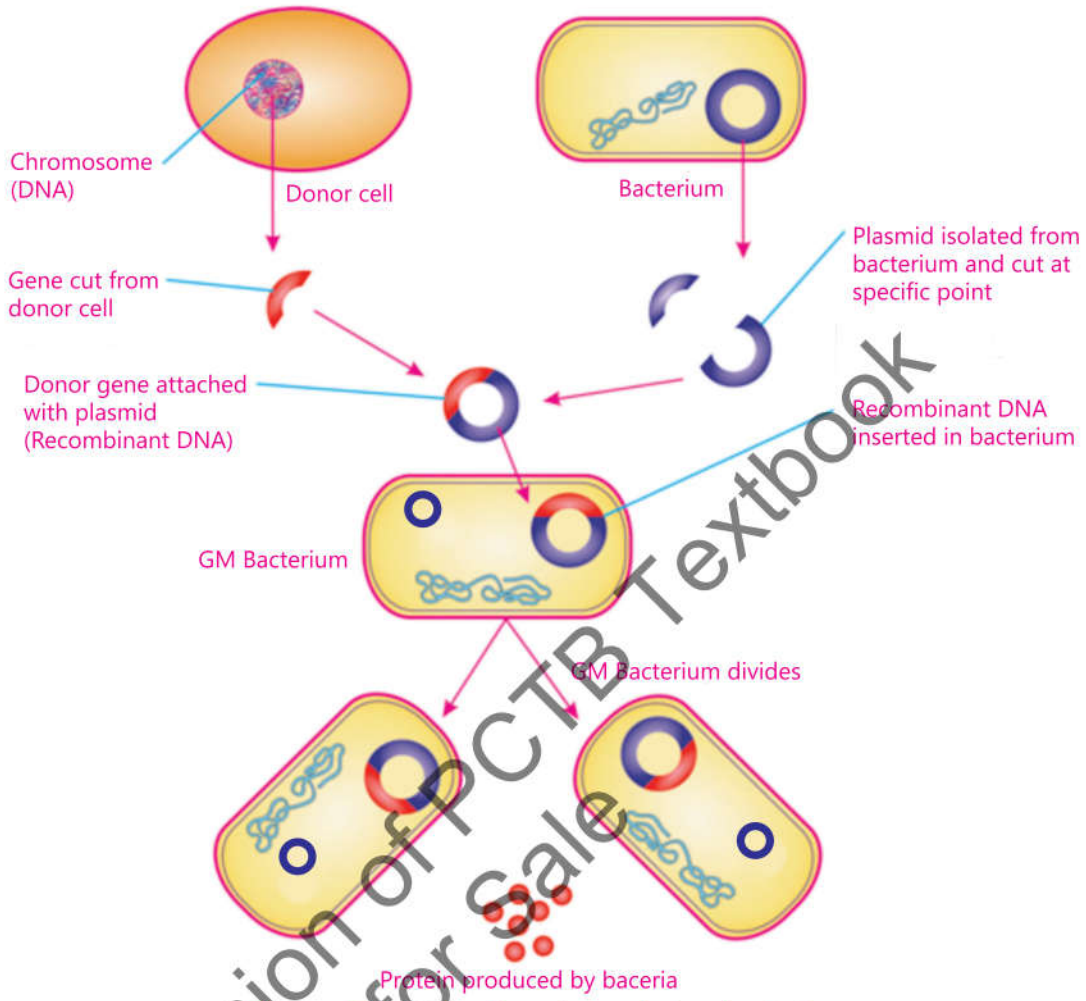


Figure 4.2 Introduction of gene into a bacterium

GM bacterium starts dividing and produces a bacterial colony. Every bacterium of the colony contains a copy of the gene of desired protein. When bacterial colony grows, it starts making proteins under the instructions of inserted gene.

In genetic engineering, genes of various useful proteins, e.g., insulin, enzymes for the synthesis of various medicines, vaccines, etc., are inserted in bacteria and desired proteins are obtained.

4.2 FERMENTATION

It is a catabolic process in which partial degradation of sugar occurs without the help of oxygen. Lactic acid fermentation by certain fungi and bacteria is used in the dairy industry to make cheese and yogurt. In bread making, the flour used contains starch, protein and an enzyme amylase. Yeast is added in the flour. The flour is mixed with water to form dough. The carbon dioxide produced causes the dough to rise and because of this cavities appear.

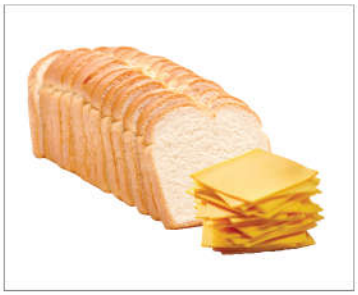


Figure 4.3 Bread and Cheese

4.3 BIOTECHNOLOGY PRODUCTS

Genetic engineers change the genetic material of organisms by the removal, addition or modification of genes. The organism whose genes are modified is called **Genetically Modified Organism** (GMO). It is the modern method to change the characters of organisms. For example, this process is used in crops to develop resistance in plants against disease-causing microorganisms. Similarly, the edible plants are genetically modified to improve the nutritional quality of plants. Moreover, GMOs are used to prepare useful products such as insulin and vaccines etc.

Insulin

Insulin is an animal protein, which is produced by pancreas. It controls the glucose level in blood. If pancreas does not produce the required amount of insulin, the level of glucose in blood rises. This condition is known as diabetes mellitus in human. Diabetic patients need regular injections of insulin to control glucose level in the blood. In past, insulin was extracted from the pancreas of animals. Nowadays, genetic engineers produce insulin by inserting its gene in bacteria.

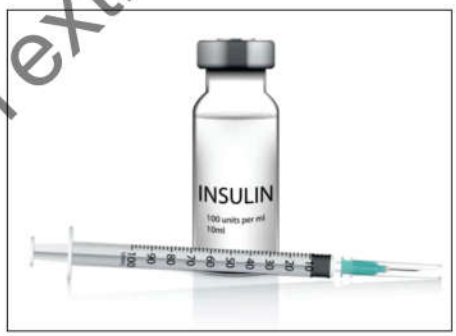


Figure 4.4: Insulin

Vaccines

Vaccine is a material which contains weakened or killed pathogens (disease causing germs) and is used to produce immunity (resistance) against a disease. When a vaccine is injected into the human body, the blood cells in the body take the weak or dead pathogens as real ones and prepare antibodies against them. These antibodies remain in blood. When any real pathogen enters the body, the already present antibodies kill it immediately and the body becomes protected from disease.

Nowadays, biotechnologists use bacteria to prepare vaccines. They identify some proteins of pathogens that do not cause disease but can stimulate blood cells to make antibodies. The gene of such protein is isolated from pathogen and is inserted into bacterium. The GM bacteria make colonies and prepare the pathogen proteins. These proteins act as vaccine. When these proteins are injected in human body, the blood cells produce antibodies. These antibodies can kill the kind of the pathogen from which the gene was taken. In this way the human becomes safe from that kind of pathogens. Vaccines for COVID-19, hepatitis-B, typhoid, measles, etc., have been developed using biotechnological technique. Vaccines for malaria and HIV are being developed. Other

Figure 4.5: Vaccine

important life saving biotechnology products include blood clotting factors, growth hormones, etc.

4.4 APPLICATIONS OF BIOTECHNOLOGY

Four major areas in which biotechnology is applied include agriculture, food production and preservation, health and environment.

4.4.1 Agriculture

Biotechnology has played a revolutionary role in improving our agriculture and production of high yields of crops (Figure 4.6). Herbicides (weed killing chemicals) and pesticides (insect killing chemicals) are used to eliminate the crop enemies (weeds and insects). Such chemicals also cause damage to the crop plants. Using biotechnology, scientists insert weed resistance and pest resistance genes into the plants. Such genetically modified plants prepare proteins which are harmful for weeds and pest /insects.

Figure 4.6 High yield crop

Cultivation of such genetically modified crops improves the yields of the crops and makes them safe for human use. The major crops that have been modified are maize (corn), wheat, rice, canola, potato, soybean, cotton, etc. Drought and excessive salts in the soil also have harmful effects on crop productivity. Biotechnologists are working to find genes that can enable crops to tolerate such extreme conditions. Scientists in some universities have introduced a gene to raise iron content in rice and wheat. This may help to overcome iron deficiency in food. In Pakistan many biotech crops such as wheat, rice and potato have been developed.

You need to know!

- In poor countries of South Asia, where rice is the main food of the rural population, deficiency of vitamin A is the common problem which may lead to early blindness and weak immune system especially in children. Scientists have successfully transferred genes of vitamin A from other species into rice, creating a variety of rice rich in vitamin A. Genetically modified golden rice is produced by genetic engineering.

Genetically modified golden rice

- Most of the high yield crops or fruit trees are susceptible to diseases. Introduction of disease resistance genes into such crops or fruit trees enables them to resist diseases.
- Insects called aphids damage the wheat crop. This problem can be solved by producing aphid resistant varieties using genetic engineering techniques.

4.4.2 Food Production and Preservation

Use of better quality genes in the animals is producing high yields of milk and meat (Figure 4.7).

You need to know.

Vitamin B12, widely used as in additive food and in some medicines, is produced in high-yielding cultures of bacteria.

Milk producing animal

Meat producing animals

Goat meat

Figure 4.7 Genetically modified animals and animal product

Production of better quality fruits and vegetables and increasing their shelf lives are also due to using biotechnological techniques (Figure 4.8).

Better quality fruit

Vegetables

Figure 4.8 : Genetically modified fruits and vegetables

4.4.3 Health

Biotechnology techniques are also used for curing diseases and improving health. The diseases for which previously no adequate treatment was available can now be treated using biotechnology techniques. Identification of root causes of diseases, production of medicines for fighting against diseases, curing and correction of genetic defects, etc., are the major roles of this technology in developing better health. Various biotechnology products which are used in Pakistan to save lives include:

Insulin:	useful for diabetics
Vaccines:	used against many infectious diseases
Growth hormone:	useful for stimulating growth
Beta-Endorphin:	a pain killer drug
Interferon:	anti-viral proteins

4.4.4 Environment

Environmental problems, like pollution, degradation of land and sewage water, etc., are also resolved using biotechnology. Microorganisms, e.g., genetically modified bacteria are used to treat sewage and refuse. They may also be used to clear spilled oil. Microbes which are used as bio-pesticides, bio-fertilizers, biosensors, etc., are being developed using biotechnology techniques.

Science, Technology, Society and Environment

Biotechnologists have identified a gene in weed plant which enables the plant to show tolerance to salts, drought, heat and cold. In a research project; when this gene was inserted into tomato and tobacco cells, they withstood the said adverse conditions far better than ordinary cells. If these preliminary results prove successful in larger trials, then this gene can help in producing crops which can better withstand the unfavourable conditions.

Various research institutes in Pakistan conduct genetic engineering on humans, livestock and crop plants e.g., National Institute for Biotechnology and Genetic Engineering (NIBGE), Faisalabad; National Centre of Excellence in Molecular Biology (CEMB), University of the Punjab, Lahore; Centre for Advanced Studies (CAS), University of Agriculture, Faisalabad; Nuclear Institute for Agriculture & Biology (NIAB), Faisalabad; and Pakistan Council of Scientific and Industrial Research (PCSIR), Islamabad.

KEY POINTS

- The technology in which living things are used in different ways to help and benefit human beings is called biotechnology.
- The special parts of DNA having information for making specific proteins are called genes. Genes are located on chromosomes.
- Genetic engineering is a biotechnological technique by which a particular gene is cut and transferred from one type of organism to another organism such as bacterium.
- The attached gene of desired protein and the plasmid DNA are collectively called recombinant DNA.
- The bacterium which takes in the recombinant DNA is called genetically modified bacterium (GM bacterium).
- Bacteria which are genetically modified with human insulin gene produce human insulin which control the glucose level in blood.
- Nowadays, vaccines produced by genetic engineering are used against the diseases like Hepatitis B (a human disease), foot and mouth disease (a viral disease in cattle, goat and sheep, etc.) and many other diseases.
- Biotechnology has played a revolutionary role in improving our agriculture and livestock. Production of high yield of crops, milk and meat are the results of using biotechnology.
- Biotechnology is also used for resolving environmental problems, like pollution, degradation of land and sewage water, etc.

QUESTIONS

1. Encircle the correct option.

(i) The additional circular pieces of DNA present in a bacterial cell are called:

(a) RNA (b) nucleotides
(c) chromatids (d) plasmids

(ii) What may be the objective of genetic modifications of plants?

(a) Production of disease resistant plants
(b) Improvement in nutritional quality of plants
(c) Production of herbicide resistant plants
(d) All of these

(iii) Plasmid and attached foreign gene with it are collectively called:

(a) recombinant cell (b) recombinant DNA
(c) recombinant plasmid (d) recombinant chromosome

(iv) The organisms whose cells and plasmids are usually used in genetic engineering are:

(a) bacteria (b) fungi
(c) algae (d) viruses

(v) Sections of DNA serving as codes for developing characters in an organism are called:

(a) genes (b) nucleotides
(c) plasmids (d) proteins

(vi) Which of the following is not a biotechnology product?

(a) Insulin (b) Quinine
(c) Beta-endorphin (d) Interferon

(vii) How do genetic engineers get insulin for diabetic patients?

(a) Isolate from human pancreas
(b) Isolate from pancreas of other animals
(c) Insulin gene inserted in human pancreas
(d) Insulin gene inserted in bacteria

(viii) Why do genetic engineers use bacteria in genetic engineering?

(a) The chromosome of bacteria is made of DNA and proteins
(b) Their nucleus is very big and easy to handle
(c) They have many chromosomes
(d) Bacteria divide very fast and make colonies

(ix) A gene is inserted into a bacterium by:

(a) tissue culture (b) fermentation

(c) biodegradation (d) genetic engineering

2. Write short answers.

(i) What is biotechnology?

(ii) Name at least two life saving products of biotechnology.

(iii) Write the application of biotechnology in

(a) agriculture (b) health (c) food production

3. Constructed response questions

(i) How can biotechnology be helpful in agriculture?

(ii) Find out which biotechnological products you are using in your daily life.

4. Investigate

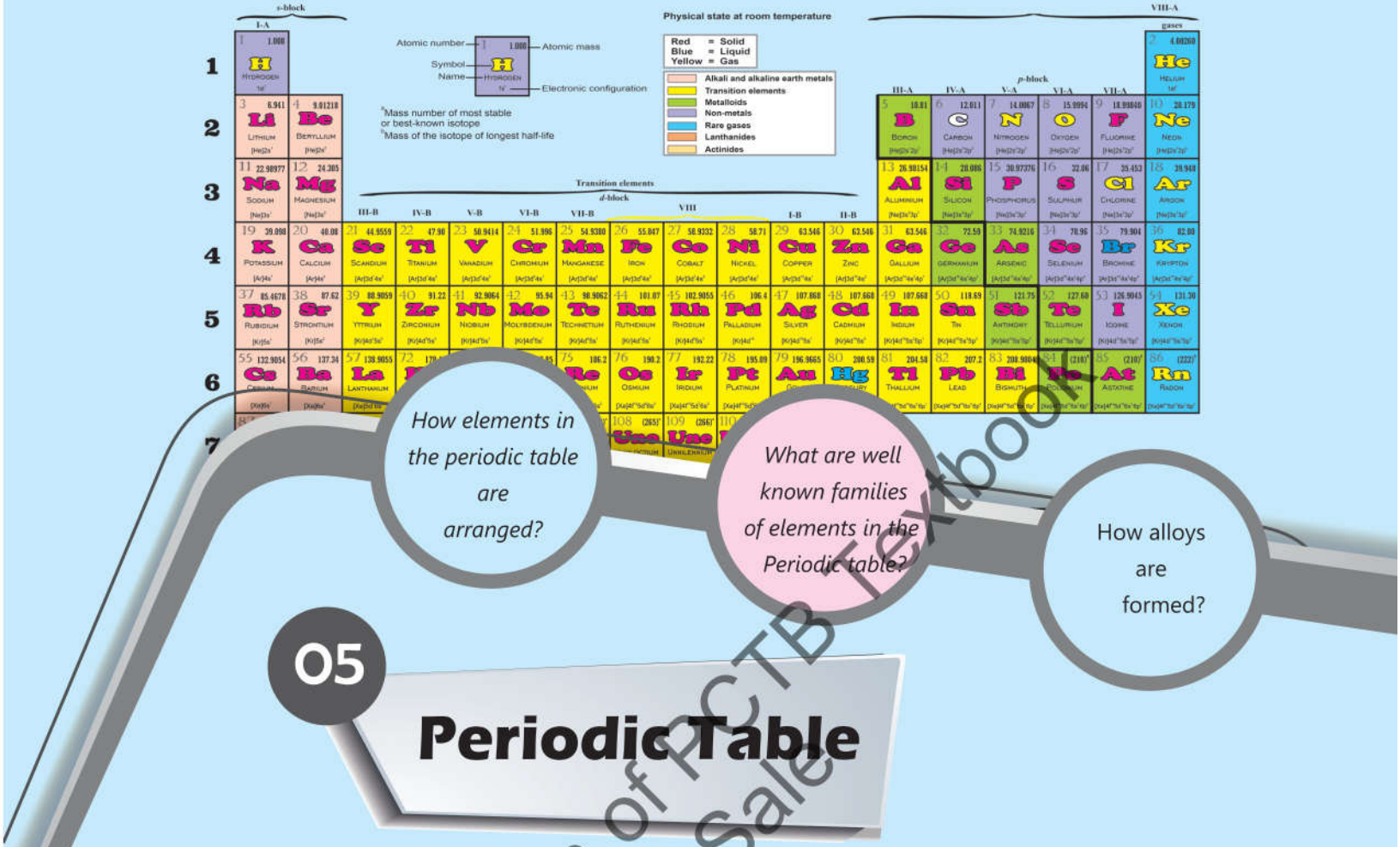
(i) Find out in the history where pandemic was controlled by vaccines.

(ii) Investigate how the biotechnology has brought revolution in the field of health.

Project

Conduct a research in the supervision of your teacher to explore the outcomes of scientists in the field of biotechnology.

	Name of the scientist	Contribution
Used biotechnology in the field of food production.		
Used biotechnology in the field of medicine.		
Used biotechnology in the field of agriculture.		



05

Periodic Table

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Recognize Periodic Table as a way of classifying the elements in groups and periods.
- Identify the names and location of the first 18 elements only.
- Identify properties of metals and non-metals.
- Relate the properties to the uses of metals.

We have already learnt that every thing in this world is made of matter and is called a material thing. All the material things do not have same type of matter present in them. Rather they may contain different types of matter called **Element**, the basic constitutent of matter. An element is a substance, which cannot be split into two or more substances by ordinary chemical changes. The basic particle of an element is called an **atom**. All the atoms of an element are similar but these are different from the atoms of other elements. There are near about 118 elements, 92 of which are naturally occurring. Scientists have arranged the elements in a table called Periodic Table of elements (Figure 5.1).

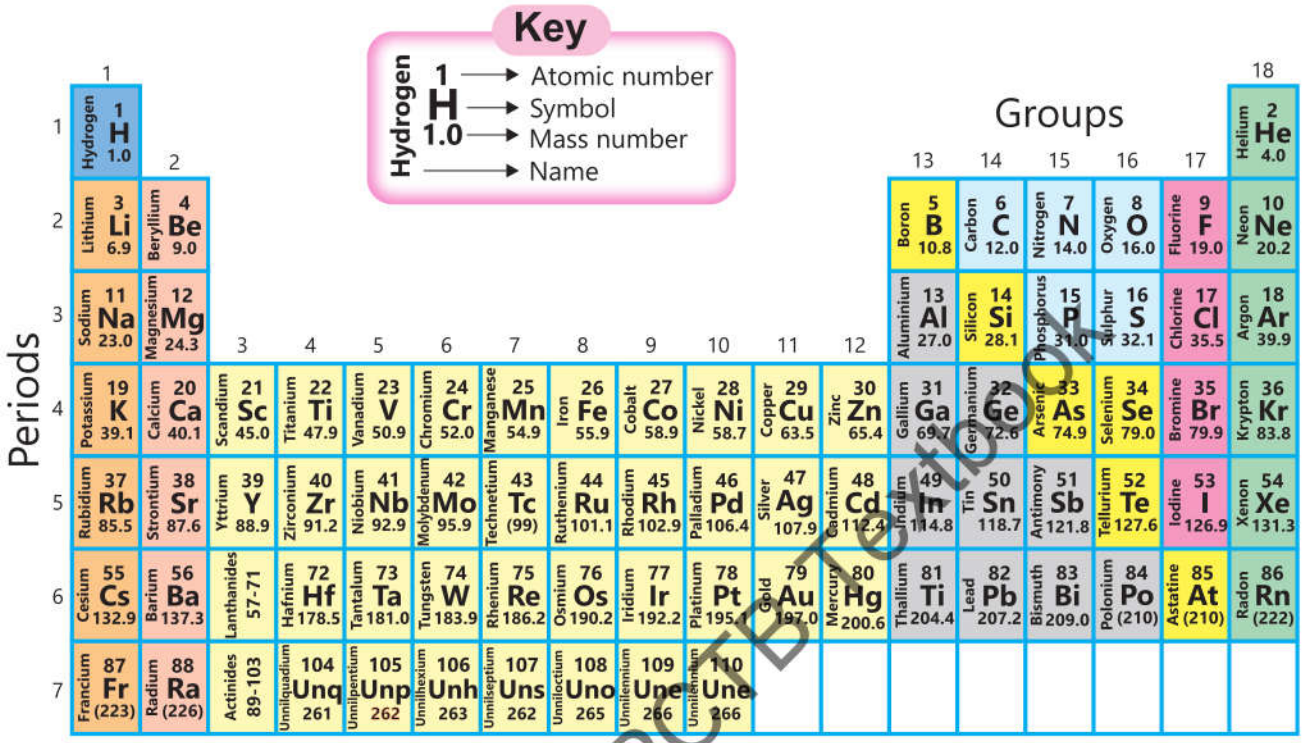


Figure 5.1 The Periodic Table of Elements

Reminder

- Proton, electron, neutron, etc., are the fundamental particles of an atom.
- The number of protons present in an atom of an element is called **atomic number (Z)** of that element.
- In an atom, the number of protons is equal to the number of electrons.
- The number of protons plus the number of neutrons present in an atom of an element is called **mass number (A)** of that element.

5.1 PERIODIC TABLE OF ELEMENTS

Elements in the Periodic Table are arranged in an ascending order of their atomic numbers. When arranged in such a way, the elements form horizontal rows which are called **Periods** and the vertical columns which are named as **Groups**. In the periods, elements are arranged from left to right in a continuous manner. There are seven periods in the Periodic Table. First period is called short period. It consists of two elements, hydrogen (H) and helium (He). Second and third periods are called normal periods, each having 8 elements in it. Eight elements of second period are lithium (Li), beryllium (Be), boron (B), carbon (C), nitrogen (N), oxygen (O), fluorine (F) and neon (Ne). Eight elements of third period are sodium (Na), magnesium (Mg), aluminium (Al), silicon (Si), phosphorus (P), sulphur (S), chlorine (Cl) and argon (Ar). Fourth and fifth periods are called long periods, each having 18 elements in it.

Sixth and seventh periods are very long periods, each containing 32 elements shown in the Periodic Table. Elements in a period have different properties. Period number of an element is equal to number of shells it has.

Table 5.1 Different Periods of the Periodic Table

Period No.	Name of the Period	Number of Elements	Range of Atomic Numbers
1st	Short Period	2	1 to 2
2nd	Normal Period	8	3 to 10
3rd	Normal Period	8	11 to 18
4th	Long Period	18	19 to 36
5th	Long Period	18	37 to 54
6th	Very Long Period	32	55 to 86
7th	Very Long Period	[32]*	87 to 118*

** Since new elements are expected to be discovered, it is an incomplete period.*

Activity 5.1

Look at the Periodic Table and write names and symbols of the elements given in its fourth and fifth periods.

Period	Names and Symbols of Elements
4th	
5th	

There are eighteen groups in the Periodic Table. Groups are numbered on the basis of number of electrons present in the outermost shell or valence shell of their atoms. For example, each element of group 1 contains one electron in the outermost shell or valence shell of its atoms. Each element of group 2 contains two electrons in the outermost shell or valence shell of their atoms. Elements in a group have similar properties as they have same number of valance electrons.

Groups 1 and 2 and 13 to 17 contain normal elements. Groups 3 to 12 contain transition elements. The elements of group 18 are called noble gases. Their valance shells are completely filled. Table 5.2 given below shows distribution of different families of elements in groups 1 to 18.

Table 5.2 Different Groups of the Periodic Table

Group No.	Number electrons in the valence shell	Family name of elements Present in the group
1	1	Alkali metals
2	2	Alkaline earth metals
3 to 12		Transition metals
13	3	Boron family
14	4	Carbon family
15	5	Nitrogen family
16	6	Oxygen family
17	7	Halogen family
18	8	Noble gases

5.2 FIRST 18 ELEMENTS OF THE PERIODIC TABLE

Names, symbols, atomic number and mass number of the fisrt eighteen elements are shown in table 5.3.

Table 5.3 First Eighteen Elements of Periodic Table

Name	Symbol	Atomic Number	Mass Number
Hydrogen	H	1	1
Helium	He	2	4
Lithium	Li	3	7
Beryllium	Be	4	9
Boron	B	5	11
Carbon	C	6	12
Nitrogen	N	7	14
Oxygen	O	8	16
Fluorine	F	9	19
Neon	Ne	10	20
Sodium	Na	11	23
Magnesium	Mg	12	24
Aluminium	Al	13	27
Silicon	Si	14	28
Phosphorus	P	15	31
Sulphur	S	16	32
Chlorine	Cl	17	35
Argon	Ar	18	40

Activity 5.2

Examine

The Periodic Table of Elements is shown in Figure 5.1. Write down the period number and the group number of the following elements

Element	Period No.	Group No.
1. Phosphorus (P)		
2. Alumimum (Al)		
3. Silver (Ag)		
4. Mercury (Hg)		

5.3 METALS AND NON-METALS

Metals are those elements, which are mostly solid and hard. They reflect light from their surfaces and are good conductors of heat and electricity. Some metals are ductile, i.e., these can be pulled into wires. Some metals are malleable, i.e., these can be bent or hammered into desired shapes or sheets. Iron, gold, silver, copper, sodium, potassium, mercury, etc., are the examples of metals.

Non-metals are usually soft and bad conductors of heat and electricity. However, graphite (a form of carbon) is a good conductor of electricity. Non-metals cannot be drawn into wires or sheets because they are brittle. Non-metals except bromine exist, both in solid and gaseous states. Bromine is the only liquid non-metal. Examples are carbon, sulphur, chlorine, bromine, hydrogen, oxygen, nitrogen etc.

5.3.1 Properties and Uses of Metals

i. State

Most of the metals are found in solid state at room temperature. Mercury (Hg) is the metal which exists in liquid state and is filled in the bulbs of thermometers to measure temperature. (Figure 5.2)

Figure 5.2 Mercury filled in thermometer

ii. Hardness

Generally metals are hard solids. Due to this property, iron is used to make steel, railway tracks and ships, etc. (Figure 5.3)

Steel products

Railway track

Ship

Figure 5.3 Uses of metals due to hardness

Can you tell?

Why is silver not used in pure form?

iii. Lustre

Metals have brilliant and shiny surfaces. Due to this property aluminium is used to make reflectors of light, picture frames and mirrors, etc. Silver and gold are used to make jewellery. (Figure 5.4)

Aluminium reflector of light

Silver jewellery

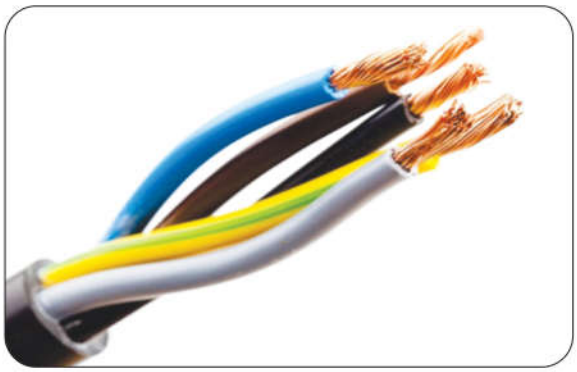
Gold jewellery

Figure 5.4 Uses of aluminium, silver and gold

iv. Conductance

Metals are good conductors of heat and electricity. Due to good conductor of heat, aluminum and copper are used to make cooking pots and pans. Due to good conductor of electricity, copper and aluminum are used to make electrical wires.

Alluminium cooking pan



Cooper electrical wires

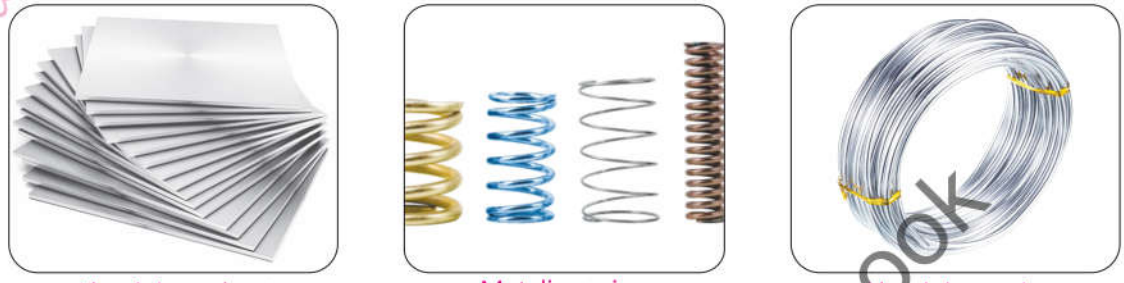
Figure 5.5 Uses of aluminium and copper

V. Malleability and ductility

Generally metals are malleable and ductile. Due to this property, metals are used to make sheets, wires, springs and other desired shapes, etc.

Do you know?

1. A metal which can be hammered into sheets is called malleable.
2. A metal which can be drawn into wires is called ductile.



Aluminium sheet | Metalic spring | Aluminium wire

Figure 5.6 Property of metals due to malleability and ductility

vi. Melting and boiling points

Metals have high melting and boiling points. Due to this property, some of these metals are used to make kitchen utensils.

Figure 5.7 Kitchen utensils

vii. Alloy formation

Molten forms of different metals are mixed to form alloys like, German silver and brass. Alloys are corrosion resistant having higher strength and better thermal property. German silver is an alloy of copper, zinc, and nickel. It is used to make jewellery and decoratory objects. Brass is an alloy of copper and zinc. It is used to make pipes, nozzles and jewellery.

Plate made of german silver | Pot made of brass

Figure 5.8 Objects made of brass and german silver

5.3.2 Properties and Uses of Non-metals

Non-metals are usually soft and bad conductors of heat and electricity.

1. Graphite is a form of carbon. It is mixed with clay to use in lead pencils.
2. Diamond is another form of carbon. It is the hardest matter on the Earth. It is used to cut glass. It is a shiny matter and is used in jewellery.
3. Phosphorous is used in match industry.
4. Hydrogen when burnt with oxygen gives a very hot flame which is used for cutting and welding metals. Hydrogen is also used for the manufacture of banaspati ghee from vegetable oils.
5. Oxygen cylinders are used in hospitals for curing patients feeling breathing problems.
6. Hydrogen and nitrogen are used for the manufacture of urea (fertilizer).

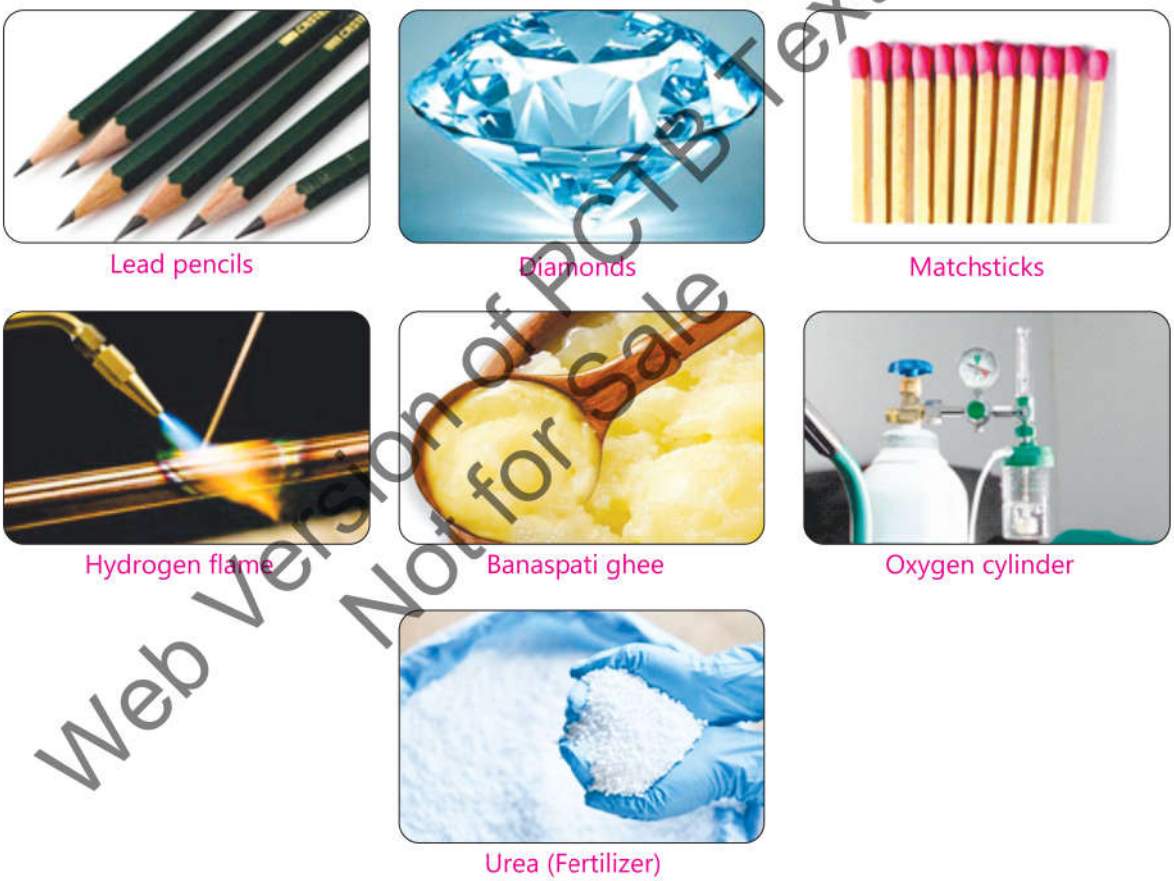


Figure 5.9 Uses on non-metals

Can you tell?

Two wires of equal length, one of copper and the other of some alloy have the same thickness, which one can be used for:

(a) Electrical transmission lines.

(b) Electric heating devices.

Give reason of your answer.

KEY POINTS

- There are about 118 elements, 92 of which are naturally occurring.
- Scientists have arranged the elements in a table called Periodic Table.
- Horizontal rows of elements in the Periodic Table are called periods.
- Vertical column in the Periodic Table are called groups.
- In the periods, elements are arranged from left to right in a continuous increasing order of their atomic numbers.
- Groups are numbered on the basis of number of electrons in the outermost shell or valence shell of their atoms.
- Metals reflect light from their surface and are good conductors of heat and electricity.
- Some metals are ductile and can be pulled into wires. Some are malleable and can form thin sheets.
- Non-metals are usually soft and poor conductors of heat and electricity. They cannot be drawn into wires or sheets because they are brittle.

QUESTIONS

1. Encircle the correct option.

(i) An element of the third period in the Periodic Table:

(a) H (b) P
(c) He (d) Li

(ii) Mg belongs to the period of the Periodic Table:

(a) 1^{st} (b) 2^{nd}
(c) 3^{rd} (d) 4^{th}

(iii) An alkali metal:

(a) F (d) Be
(c) Al (d) Na

(iv) Ne belongs to:

(a) nitrogen family (b) fluorine family
(c) noble gases (d) alkaline earth metals

(v) An element of group 17 of the Periodic Table:

(a) Cl (b) Ar
(c) S (d) Si

(vi) Atomic number of the element at fourth position in second period:

(a) 4 (b) 5

(c) 6 (d) 7

(vii) How many periods are there in the Periodic Table?

(a) Five (b) Six

(c) Seven (d) Eight

(viii) A metal:

(a) Cu (b) C

(c) Cl (d) Ne

(ix) A non-metal:

(a) H (b) Na

(c) Li (d) Be

(x) An atom containing two electrons:

(a) H (b) He

(c) Li (d) Be

2. Write short answers.

(i) What is meant by a period in the Periodic Table?

(ii) What is meant by a group in the Periodic Table?

(iii) Define element.

(iv) What do you mean by an atomic number?

(v) How many electrons are there in the valence shell of H?

3. Constructed response questions

(i) Oxygen is a non-metallic element.

(a) What is the atomic number of oxygen?

(b) In which group of the Periodic Table, oxygen is located?

(c) In which period of the Periodic Table, oxygen is located?

(d) How many electrons are required by oxygen atom to complete its valence shell?

(e) State any two uses of oxygen in daily life.

(ii) Sodium is a metallic element.

(a) What is the symbol of sodium?

(b) What is the atomic number of sodium?

(c) In which period of the Periodic Table, sodium is located?

(d) What is the group number of sodium in the Periodic Table?

(e) Name the family of metals to which sodium belongs?

(iii) Name the members of the following families in the Periodic Table?

(a) Alkali metals
(b) Alkaline earth metals
(c) Halogens
(d) Noble gases
(e) Name the element having same period number and group number.

(iv) Relate the following properties of metals with their uses in daily life.
(a) Conductance of heat
(b) Conductance of electricity
(c) Malleability and ductility
(d) Hardness
(e) Lustre

4. Investigate

(i) Why the chemical properties of the elements present in a group are similar?

(ii) Why is mercury used in the thermometer to measure the body temperature?

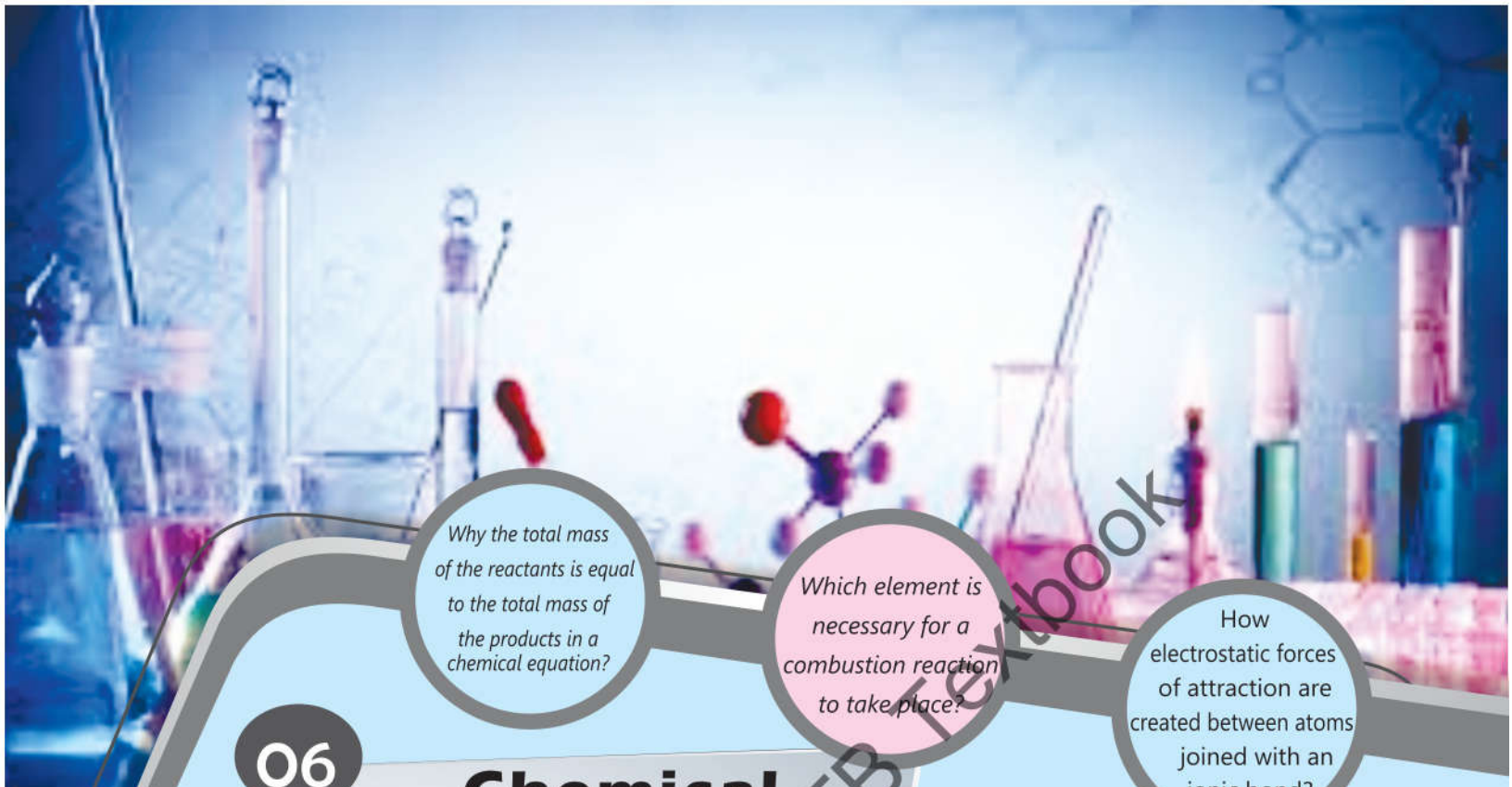
(iii) Magnesium and Calcium are kept in the same group of the Periodic Table. Explain why?

Project

Manage and conduct a discussion with your teacher and classmates on the following:

(i) Trends of atomic number and atomic size of the elements when we move from left to right in different periods of the Periodic Table.

(ii) Trends of number of valence shell electrons and atomic size of the elements when we move from top to bottom in different groups of the Periodic Table.



Why the total mass of the reactants is equal to the total mass of the products in a chemical equation?

Which element is necessary for a combustion reaction to take place?

How electrostatic forces of attraction are created between atoms joined with an ionic bond?

06 Chemical Reactions

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Identify chemical reactions and give examples.
- Define the Law of Conservation of Mass and demonstrate the law with an experiment.
- Write and balance chemical equations.
- Distinguish between different types of reactions (combination, displacement, double displacement, combustion).
- Distinguish between endothermic and exothermic reactions.
- Recognize the importance of exothermic and endothermic reactions in daily life.
- Design a car that is powered solely by a chemical reaction and can travel. (STEAM)
- Discuss formation of ionic bonds as a result of electrostatic forces between atoms (e.g., NaCl).
- Discuss types and formation of covalent bond as a result of mutual sharing of electrons between atoms (e. g., H_2, O_2, N_2).
- Name certain ionic and covalent compounds.
- Draw cross and dot structures showing formation of ionic compounds and covalent compounds.

We have already learnt that elements and compounds are the examples of pure matter. The substances such as hydrogen (H_2), oxygen (O_2) etc., are elements. Water (H_2O), carbon dioxide (CO_2), etc., are the compounds. It is our daily observation that water can be changed into ice. It can also be changed into steam. During both these changes, chemical composition of water (H_2O) and its chemical properties are not changed. It means that liquid water, ice and steam are the three physically different forms of the same substance,

i.e., water. On the other hand, when we pass electricity through acidified water (H_2O), it changes into hydrogen (H_2) and oxygen (O_2) which are entirely different substances with different chemical compositions and chemical properties. Such a change in a substance during which entirely new substances with different chemical compositions and properties are formed is called a chemical change. A chemical change is always brought about by a chemical reaction. In this chapter, we will learn further about chemical reactions.

6.1 CHEMICAL REACTIONS

We deal with a large number of chemical reactions in our daily life. During these reactions, atoms present in different substances rearrange themselves to form new substances. Burning of coal and natural gas (methane) in air are well known examples of chemical reactions. Chemically coal is carbon (C). It exists in solid state and is black in colour. Its burning in air is in fact a chemical reaction of carbon with oxygen of the air to form carbon dioxide (CO_2). Carbon dioxide is a colourless gas. Its chemical composition and chemical properties are entirely different from those of carbon and oxygen. The rearrangement of atoms that takes place during this chemical reaction can be represented as follows in Figure 6.1.

Figure 6.1 Rearrangement of atoms during chemical reaction of carbon with oxygen

Substances which take part in a chemical reaction are called the **reactants** and those which are formed as a result of the reaction are called the **products**. When methane burns in air, carbon dioxide and water are formed. During the rearrangement of atoms in burning of methane (natural gas), carbon atom of methane gets attached with two oxygen atoms to give carbon dioxide while hydrogen atoms attach themselves with oxygen atom to give water vapours (Figure 6.2).

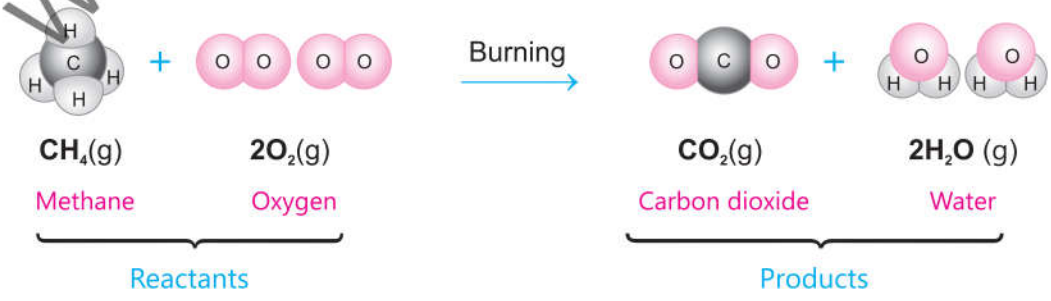


Figure 6.2 Rearrangement of atoms during chemical reaction of methane with oxygen

The rearrangement of atoms during the chemical reaction of hydrogen with oxygen to form liquid water is shown in Figure 6.3.

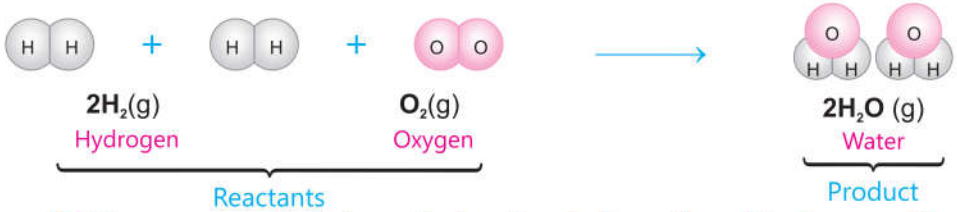


Figure 6.3 Rearrangement of atoms during chemical reaction of hydrogen with oxygen

The signs (s), (l) and (g) stands for physical states of the substances, i.e., solid, liquid and gas respectively.

6.1.1 Applications of Chemical Reactions

Burning, respiration and photosynthesis, etc., are the examples of chemical reactions which take place everywhere in our environment. Fuel (natural gas or petrol, etc.) on burning in a vehicle engine produces different gases. The gases so produced develop pressure to move the piston in the engine and to run the vehicle. Heat produced during burning of fuel in our kitchens is used to cook food. Similarly, heat produced during burning of fuel in industries is used to produce steam from water.

During photosynthesis in plants, carbon dioxide (CO_2) and water (H_2O) react to produce glucose ($C_6H_{12}O_6$). This reaction takes place in the presence of sunlight and green pigment chlorophyll in plant leaves.

$$\underset{\text{Carbon dioxide}}{6CO_{2(g)}} + \underset{\text{Water}}{6H_2O_{(\ell)}} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \underset{\text{Glucose}}{C_6H_{12}O_{6(aq)}} + \underset{\text{Oxygen}}{6O_{2(g)}}$$

As a result of respiration, the oxygen of air reacts with food (glucose) to produce, carbon dioxide and water in the cells of living organisms. The energy produced during this reaction is used to perform all the body functions in living organisms.

$$\underset{\text{Glucose}}{C_6H_{12}O_{6(aq)}} + \underset{\text{Oxygen}}{6O_{2(g)}} \longrightarrow \underset{\text{Carbon dioxide}}{6CO_{2(g)}} + \underset{\text{Water}}{6H_2O_{(g)}} + \text{Energy}$$

Conversion of milk into yogurt and formation of baking products involve the chemical changes which are brought about by microorganisms. Such chemical changes or reactions are called fermentation reactions.

Activity 6.1

Apparatus / Material required

China dish, burner, tripod stand, wire gauze, sulphur powder, iron turnings

Procedure

- Take a few iron turnings and a small amount of sulphur powder in a china dish.
- Heat the contents of china dish for a few minutes as shown in the Figure.
- Stop heating and observe the content in the china dish.
- Record your observations.

$$\underset{\text{Iron}}{Fe_{(s)}} + \underset{\text{Sulphur}}{S_{(s)}} \longrightarrow \underset{\text{Iron sulphide}}{FeS_{(s)}}$$

We will learn from activity 6.1 that iron (Fe) reacts with sulphur (S) on heating. The result of this reaction is the formation of a black mass of iron sulphide.

Activity 6.2

Apparatus / Material required

Test tube, iron nails and water

Procedure

- Take some iron nails in the test tube.
- Add a little water in the test tube in such a way that the iron nails are not fully dipped as shown in the Figure.
- Leave the nails in the test tube partially dipped in water.
- Observe the nails after two days.
- Record your observations.

We will learn from the activity 6.2 that iron (Fe) reacts with oxygen of the air to form iron oxide (Fe_2O_3).The reaction is called rusting of iron and it takes place in the presence of moisture.

$$\underset{\text{Iron}}{4Fe_{(s)}} + \underset{\text{Oxygen}}{3O_{2(g)}} \xrightarrow{\text{Moisture}} \underset{\text{Iron oxide}}{2Fe_2O_{3(s)}}$$

6.1.2 Chemical Equations

A chemical equation is the representation of a chemical reaction in terms of symbols, formulae and signs, etc. In a chemical equation the reactants and products are separated by an arrow. Symbols and formulae of reactants are written on left hand side of the arrow whereas those of products are written on right hand side of the arrow. The arrow is directed towards the products. Physical states of reactants and products are also expressed along with their formulae or symbols by (s), (ℓ), (g) and (aq) which stand for solid, liquid, gas and aqueous states respectively. For example, chemical equation representing the reaction of sulphur with oxygen to form sulphur dioxide is written as follows:

$$\underset{\text{Sulphur}}{S_{(s)}} + \underset{\text{Oxygen}}{O_{2(g)}} \longrightarrow \underset{\text{Sulphur dioxide}}{SO_{2(g)}}$$

The chemical equation written above shows that sulphur in its solid state reacts with oxygen gas. The product of the reaction, i.e., sulphur dioxide is also a gas.

Similarly, the chemical equation given as follows indicates that zinc in its solid state reacts with aqueous solution of sulphuric acid and produces aqueous solution of zinc sulphate and hydrogen gas.

$$\underset{\text{Zinc}}{Zn_{(s)}} + \underset{\text{Sulphuric acid}}{H_2SO_{4(aq)}} \longrightarrow \underset{\text{Zinc sulphate}}{ZnSO_{4(aq)}} + \underset{\text{Hydrogen}}{H_{2(g)}}$$

6.1.3 Balancing the Chemical Equations

The chemical equation in which the number of atoms of each substance on both sides of the equation, i.e., reactant side and product side are equal is called a balanced chemical equation. For example, the chemical equation shown below is a balanced chemical equation.

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(\ell)}$$

The chemical equation in which the number of atoms of each substance on both sides of the equation, i.e., reactant side and product side is not equal is called an unbalanced chemical equation. For example, the chemical equation given below is an unbalanced chemical equation.

$$H_{2(g)} + Cl_{2(g)} \longrightarrow HCl_{(g)}$$

Unbalanced equations can be balanced by different methods. The trial and error method is commonly used. According to this method, trial and error process of adjusting coefficients before symbols or formulae is continued till the number of atoms of each substance on both sides of the equation becomes equal.

The working rules for balancing a chemical equation are as follows:

(i) Write the unbalanced equation and count the number of atoms of each substance on both sides of the arrow.

(ii) Work with one substance at a time.

(iii) Multiply the symbol or formula with suitable integers (2, 3, 4, 5, etc.) on that side of the equation where the number of atoms of a particular substance is less and try to balance the atoms on both sides of the equation. Start multiplying with relatively small numbers.

(iv) Repeat the process for all the substances one by one.

(v) Balance the diatomic molecules like H_2 , N_2 , O_2 , Cl_2 , etc., at the end.

For your information

Subscript is a number written below on the right side of a chemical symbol or formula. Coefficient is a number that is placed in front of a chemical symbol or formula. We can change the coeffient but subscript cannot be changed when we balance the equation.

Some examples for balancing the equation are given below:

Example 1

Consider the following equation:

$$N_{2(g)} + H_{2(g)} \longrightarrow NH_{3(g)}$$

Step I

Count the number of atoms of each element on both sides of the arrow.

Reactants	Products	Balanced/Unbalanced
2 N atoms	1 N atom	N is unbalanced
2 H atoms	3 H atoms	H is unbalanced

Step II

Add appropriate coefficient to balance N:

$$N_{2(g)} + H_{2(g)} \longrightarrow 2NH_{3(g)}$$

Reactants	Products	Balanced/Unbalanced
2 N atoms	2 N atoms	N is balanced
2 H atoms	6 H atoms	H is unbalanced

Step III

Now try to balance H atoms.

$$N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$$

Reactants	Products	Balanced/Unbalanced
2 N atoms	2 N atoms	N is balanced
6 H atoms	6 H atoms	H is balanced

Thus the equation is balanced.

Example 2

$$CH_{4(g)} + O_{2(g)} \longrightarrow H_2O_{(g)} + CO_{2(g)}$$

Step I

Count the number of atoms of each element or compound on both sides of the arrow:

Reactants	Products	Balanced/Unbalanced
1 C atom	1 C atom	C is balanced
4 H atoms	2 H atoms	H is unbalanced
2 O atoms	3O atoms	O is unbalanced

Step II

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow 2H_2O_{(g)} + CO_{2(g)}$$

Add appropriate coefficients:

Reactants	Products	Balanced/Unbalanced
1 C atom	1 C atom	C is balanced
4 H atoms	4 H atoms	H is balanced
4 O atoms	4 O atoms	O is balanced

Thus the equation is balanced.

Example 3

$$CaCl_{2(aq)} + Na_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + NaCl_{(aq)}$$

Step I

Count the number of atoms of each element or compound on both sides of the arrow.

Reactants	Products	Balanced/Unbalanced
1 Ca atom	1 Ca atom	Ca is balanced
2 Cl atoms	1 Cl atom	Cl is unbalanced

2 Na atoms	1 Na atom	Na is unbalanced
1 C atom	1 C atom	C is balanced
3 O atoms	3 O atoms	O is balanced

Step II

Add appropriate coefficients to balance Na and Cl.

$$CaCl_{2(aq)} + Na_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + 2NaCl_{(aq)}$$

Reactants	Products	Balanced/Unbalanced
1 Ca atom	1 Ca atom	Ca is balanced
2 Cl atoms	2 Cl atoms	Cl is balanced
2 Na atoms	2 Na atoms	Na is balanced
1 C atom	1 C atom	C is balanced
3 O atoms	3 O atoms	O is balanced

Thus the equation is balanced.

Can you tell?

What is wrong with the following chemical equation?

$Mg + O \longrightarrow MgO$

Correct and balance it.

Mini Exercise

Balance the following equations.

$Fe_{(s)} + Cl_{2(g)} \longrightarrow FeCl_{3(s)}$

$Al_{(s)} + O_{2(g)} \longrightarrow Al_2O_{3(s)}$

$Na_2CO_{3(aq)} + HClO_{3(aq)} \longrightarrow NaClO_{3(aq)} + CO_{2\ (g)} + H_2O_{(\ell)}$

$CO_{2(g)} + H_2O_{(\ell)} \longrightarrow C_6H_{12}O_{6(aq)} + O_{2(g)}$

6.1.4 Law of Conservation of Mass (Matter)

Law of conservation of mass was put forward by a French Chemist Lavoisier in 1785. This law states that during a chemical reaction, mass is neither created nor destroyed but it changes from one form to another. In other words during a chemical reaction, total mass of the products is equal to the total mass of the reactants.

Activity 6.3

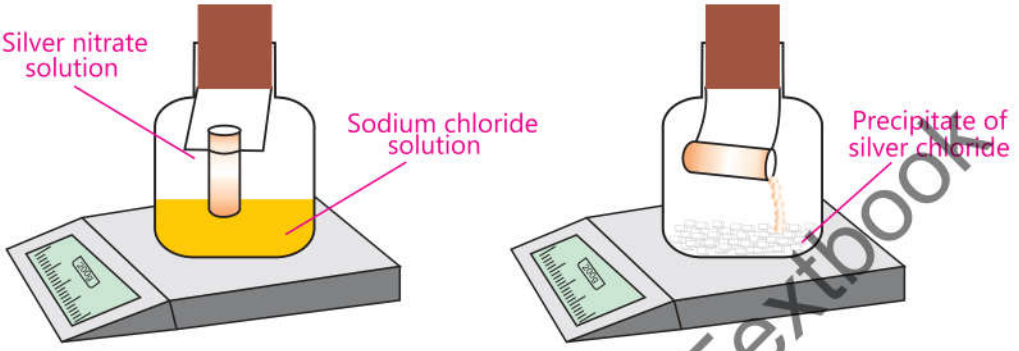
Apparatus / Material Required

Conical flask, weight balance, sodium chloride solution, silver nitrate solution and test tube.

Procedure

- Take a small amount of sodium chloride solution in a conical flask and silver nitrate solution in a small test tube.
- Place the test tube (containing silver nitrate solution) in the flask along its wall in such a way that two solutions do not mix with each other.

- Seal the flask with a cork and weigh it along with its contents.
- Shake the test tube in the flask and allow the two solutions to mix with each other.
- Observe what happens when two solutions mix with each other and record your observations.
- Weigh the flask again and note whether both the weights are equal or not.



Through the activity 6.3 we observe the formation of white precipitate of silver chloride (AgCl) as a product of the reaction between sodium chloride (NaCl) and silver nitrate ($AgNO_3$) solutions. The balanced chemical equation for the reaction is as follows:

$$AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow AgCl_{(s)} + NaNO_{3(aq)}$$

We also notice that during a chemical reaction total mass of the products is equal to the total mass of reactants. This verifies the law of conservation of mass.

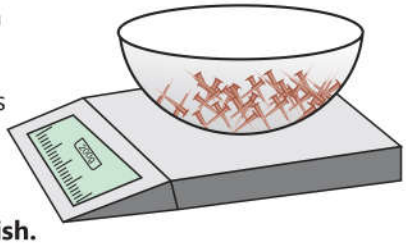
Activity 6.4 - Higher Order Thinking

Apparatus / Material Required

China dish and pieces of iron

Procedure

- Take some iron nails in the china dish.
- Weigh the china dish along with iron nails with the help of an electric balance.
- Place the china dish containing iron nails in a bathroom for five days.
- Weigh the china dish along with iron nails again after five days.
- Note whether the weight (mass) of the iron nails increases, decreases or does not change after keeping them in the bathroom.



Explain the phenomenon taking place in the china dish.

6.1.5 Types of Chemical Reactions

Thousands of chemical reactions are taking place all the time in the world. They are classified into different types, e.g., combination reactions, decomposition reactions, displacement reaction and double displacement reactions.

1. Combination reactions

The chemical combination of two or more substances to form one compound is called combination reaction. The following are the examples of combination reactions:

$2H_{2(g)}$ Hydrogen	+	$O_{2(g)}$ Oxygen	⟶	$2H_2O_{(g)}$ Water
$H_{2(g)}$ Hydrogen	+	$Cl_{2(g)}$ Chlorine	⟶	$2HCl_{(g)}$ Hydrogen chloride
$N_{2(g)}$ Nitrogen	+	$3H_{2(g)}$ Hydrogen	⟶	$2NH_{3(g)}$ Ammonia
$2Mg_{(s)}$ Magnesium	+	$O_{2(g)}$ Oxygen	⟶	$2MgO_{(s)}$ Magnesium oxide
$2Na_{(s)}$ Sodium	+	$Cl_{2(g)}$ Chlorine	⟶	$2NaCl_{(s)}$ Sodium chloride
$CaO_{(s)}$ Calcium oxide	+	$CO_{2(g)}$ Carbon dioxide	⟶	$CaCO_{3(s)}$ Calcium carbonate

2. Decomposition reactions

A chemical reaction during which a compound splits up into two or more simple substances is called a decomposition reaction. Usually heat is required to bring about decomposition of compounds. The following are some examples of decomposition reactions.

$2KClO_{3(s)}$ Potassium chlorate	Heat ⟶	$2KCl_{(s)}$ Potassium chloride	+	$3O_{2(g)}$ Oxygen		
$CaCO_{3(s)}$ Calcium carbonate	Heat ⟶	$CaO_{(s)}$ Calcium oxide	+	$CO_{2(g)}$ Carbon dioxide		
$2Pb(NO_3)_{2(s)}$ Lead nitrate	Heat ⟶	$2PbO_{(s)}$ Lead oxide	+	$4NO_{2(g)}$ Nitrogen dioxide	+	$O_{2(g)}$ Oxygen

3. Displacement reaction

Displacement reaction involves the replacement of an atom or a radical by another in a compound. The ability of an atom or radical to displace another depends upon its electro-positive or electronegative nature.

$$Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$$

In this reaction, the more electropositive element zinc displaces the less electropositive element copper from the aqueous solution of its salt $CuSO_4$. Consider another reaction:

$$2KBr_{(aq)} + Cl_{2(g)} \longrightarrow 2KCl_{(aq)} + Br_{2(\ell)}$$

In this reaction, the more electronegative element chlorine displaces less electronegative element bromine from the solution of its salt.

4. Double displacement reaction

In double displacement reaction, two reactants are decomposed to form new substances by exchanging their radicals, i.e.,

$$AB + CD \longrightarrow AD + CB$$

Some examples are given below:

(a) $BaCl_{2(aq)} + Na_2SO_{4(aq)} \longrightarrow \underset{\text{White ppt.}}{BaSO_{4(s)}} + 2NaCl_{(aq)}$

(b) $AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow \underset{\text{White ppt.}}{AgCl_{(s)}} + NaNO_{3(aq)}$

6.2 ENERGY CHANGES IN CHEMICAL REACTIONS

In order to learn about the nature of chemical change in various reactions we need to know about the change in energy of substances. The energy of a substance is a particular amount of energy due to which the structure of the substance remains stable. A substance undergoes a chemical change or chemical reaction when its energy is changed. The change in energy of a substance takes place by absorbing or releasing heat or light. On the basis of the change in energy, chemical reactions can be classified into two types, i.e., exothermic and endothermic reactions.

6.2.1 Exothermic Reactions

Exo means outside and therm means heat. Exothermic reactions are those reactions during which heat is released by the substances and surroundings become hot. Burning is a common example of exothermic reaction. Fossil fuels (coal, natural gas, etc.) burn in the air to release heat.

$$\underset{\text{Carbon}}{C_{(s)}} + \underset{\text{Oxygen}}{O_{2(g)}} \longrightarrow \underset{\text{Carbon dioxide}}{CO_{2(g)}} + \text{Heat}$$

$$\underset{\text{Methane}}{CH_{4(g)}} + \underset{\text{Oxygen}}{2O_{2(g)}} \longrightarrow \underset{\text{Carbon dioxide}}{CO_{2(g)}} + \underset{\text{Water}}{2H_2O_{(g)}} + \text{Heat}$$

$$\underset{\text{Iron}}{Fe_{(s)}} + \underset{\text{Sulphur}}{S_{(s)}} \longrightarrow \underset{\text{Iron Sulphide}}{FeS_{(s)}} + \text{Heat}$$

Fireworks are also the examples of exothermic reactions (Figure 6.4). Surroundings become hot during exothermic reactions.

Figure 6.4 Fireworks

Activity 6.5 - Exothermic Reaction

Apparatus / Material Required

Beaker, unslaked lime and water

Procedure

- Take a beaker and fill it half with water.
- Add some unslaked lime (CaO) in the beaker and stir it.
- After 20 to 30 seconds, touch the outer side of the beaker.

$$\underset{\text{Calcium oxide}}{CaO_{(s)}} + \underset{\text{Water}}{H_2O_{(\ell)}} \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_{2(aq)}} + \text{Heat}$$

1. What do you feel?
2. Why does it happen so?

6.2.2 Endothermic Reactions

Endo means inside. The reactions during which heat is absorbed by the substances from surroundings are called endothermic reactions. Thermal decomposition of calcium carbonate to produce carbon dioxide on commercial scale is an endothermic reaction.

$$\underset{\text{Calcium carbonate}}{CaCO_{(s)}} + \text{Heat} \longrightarrow \underset{\text{Calcium oxide}}{CaO_{(s)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}}$$

Activity 6.6 - Endothermic Reaction

Apparatus / Material Required

Beaker, sodium carbonate solution, calcium chloride solution, thermometer

Procedure

- Take a small beaker and fill it half with sodium carbonate solution .
- Insert a thermometer in the solution and note down the temperature.
- Mix calcium chloride solution in it.
- Note down the temperature again after mixing.

$$\underset{\text{Calcium chloride}}{CaCl_{2(aq)}} + \underset{\text{Sodium carbonate}}{Na_2CO_{3(aq)}} + \text{Heat} \longrightarrow \underset{\text{Calcium carbonate}}{CaCO_{3(s)}} + \underset{\text{Sodium chloride}}{2NaCl_{(aq)}}$$

1. What do you observe?
2. Why does it happen so?

Formation of nitric oxide from nitrogen and oxygen and hydrogen iodide from hydrogen and iodine are also the examples of endothermic reactions.

$$\underset{\text{Nitrogen}}{N_{2(g)}} + \underset{\text{Oxygen}}{2O_{2(g)}} + \text{Heat} \longrightarrow \underset{\text{Nitric oxide}}{2NO_{2(g)}}$$

$$\underset{\text{Hydrogen}}{H_{2(g)}} + \underset{\text{Iodine}}{I_{2(g)}} + \text{Heat} \longrightarrow \underset{\text{Hydrogen iodide}}{2HI_{(g)}}$$

6.2.3 Importance of Exothermic Reactions

Exothermic reactions have great importance in our daily life. They are extensively used to fulfill our needs of heat energy for various purposes. The heat released during burning of

fuel at our homes is used for cooking food and to warm our rooms. The heat released during burning of petrol or diesel in the vehicle engine increases pressure of the products (gases) to push and move the piston in the cylinder. The force of the piston turns the wheels and makes the vehicle move.

Heat produced by the burning of fuel in thermal power stations is used in generating electricity. Heat produced during digestion of food in our body keeps us warm and alive. Ignition of dynamite and gunpowder are also highly exothermic reactions and are termed as explosions. Such explosions are used for blasting in mines.

6.2.4 Importance of Endothermic Reactions

1. The cooking of an egg is generally considered a physical change since no chemical bonds are broken in the process. The unwinding of protein (denaturation) during cooking is an endothermic process.
2. Evaporation liquid water is an endothermic process. This process is used to create cooling in rooms with the help of room coolers.
3. Cold pack contains liquid water. Inside the water, there is plastic bag containing ammonium nitrate. When you break the plastic bag inside it, the water mixes with the salt and absorbs heat to undergo a chemical reaction. The temperature of the solution falls to about 35 °F for ten to fifteen minutes. This is the best example of endothermic reaction. Cold packs are used to treat injuries during sports activities.

6.3 CHEMICAL BOND

Atoms of the elements except noble gases cannot exist independently. They unite to form molecules or formula units. Chemical bond is a force that unites the atoms together to form a molecule or formula unit. The valence shells of the atoms in most of elements (except noble gases) are incomplete, as they have 1 to 7 electrons in their valence shells. Thus, to attain stability, the atoms of these elements either donate or accept electrons in their valence shells to complete them, i.e., to have the electronic configuration of the nearest noble gas.

6.3.1 Ionic Bond

This bond is formed by the complete transfer of electron or electrons from one atom to the other atom. In doing so, the atom which loses the electron(s) becomes positively charged (cation) and the atom which gains the electron(s) becomes negatively charged (anion). The electrostatic force of attraction is thus developed between a cation and an anion. Such a force of attraction which unites the cation and anion together to form a formula unit is called ionic bond.

The atoms of metals have 1 to 3 electrons in their valence shells. In order to attain stability, they lose their electrons from valence shell and form positively charged ions. The atoms of non metals have 5 to 7 electrons in there valence shells. In order to attain stability, they gain electrons in valence shell and form negatively charged ions.

The atomic number of sodium (Na) is 11. The electronic configuration of Na is 2, 8, 1. It loses an electron to attain the stable configuration of nearest noble gas (neon).

$$\underset{\substack{2,8,1\\ \text{Sodium atom}}}{Na} \longrightarrow \underset{\substack{2,8\\ \text{Sodium ion (cation)}}}{Na^+} + \underset{\substack{1\\ \text{Electron}}}{e^-}$$

The atomic number of chlorine (Cl) is 17. Its electronic configuration is 2, 8, 7. It accepts an electron from sodium atom to form negatively charged chloride ion. Thus it attains the stable configuration of the nearest noble gas (argon).

$$\underset{\substack{2,8,7\\ \text{Chlorine atom}}}{Cl} + \underset{\substack{1\\ \text{Electron}}}{e^-} \longrightarrow \underset{\substack{2,8,8\\ \text{Chloride ion (anion)}}}{Cl^-}$$

Formation of ionic bond between Na^+ and Cl^-

$$\underset{\substack{\text{Sodium ion}\\ \text{(cation)}}}{Na^+} + \underset{\substack{\text{Chloride ion}\\ \text{(anion)}}}{Cl^-} \longrightarrow \underset{\substack{\text{Sodium chloride}\\ \text{(Formula unit)}}}{NaCl}$$

Similarly:

$$\underset{\text{Magnesium atom}}{Mg} \longrightarrow \underset{\substack{\text{Magnesium ion}\\ \text{(cation)}}}{Mg^{2+}} + \underset{\text{Electrons}}{2e^-}$$

$$\underset{\text{Oxygen atom}}{O} + \underset{\text{Electrons}}{2e^-} \longrightarrow \underset{\substack{\text{Oxide ion}\\ \text{(anion)}}}{O^{2-}}$$

Formation of ionic bond between Mg^{2+} and O^{2-}

$$\underset{\substack{\text{Magnesium ion}\\ \text{(cation)}}}{Mg^{2+}} + \underset{\substack{\text{Oxide ion}\\ \text{(anion)}}}{O^{2-}} \longrightarrow \underset{\substack{\text{Magnesium oxide}\\ \text{(Formula unit)}}}{MgO}$$

Ionic bond formation in aluminium chloride is as under:

$$\underset{\text{Aluminium atom}}{Al} \longrightarrow \underset{\substack{\text{Aluminium ion}\\ \text{(cation)}}}{Al^{3+}} + \underset{\text{Electrons}}{3e^-}$$

$$\underset{\text{Chlorine atoms}}{3Cl} + \underset{\text{Electrons}}{3e^-} \longrightarrow \underset{\substack{\text{Chloride ions}\\ \text{(anions)}}}{3Cl^{1-}}$$

Formation of ionic bond between Al^{3+} and $3Cl^{1-}$

$$\underset{\substack{\text{Aluminium ion}\\ \text{(cation)}}}{Al^{3+}} + \underset{\substack{\text{Chloride ions}\\ \text{(anions)}}}{3Cl^{1-}} \longrightarrow \underset{\substack{\text{Aluminium chloride}\\ \text{(Formula unit)}}}{AlCl_3}$$

Examples of Ionic compounds

i. Sodium chloride	(NaCl)	ii. Potassium iodide	(KI)
iii. Calcuim oxide	(CaO)	iv. Zinc oxide	(ZnO)
v. Magnesium bromide	($MgBr_2$)	vi. Ferric chloride	($FeCl_3$)
vii. Calcium bromide	($CaBr_2$)	viii. Ferrous sulphide	(FeS)

6.3.2 Covalent Bond

This bond is formed between two atoms of same or different elements by mutual sharing of electron or electrons. Usually non-metal atoms have more than 4 electrons in their valence shells. They attain the nearest noble gas configuration by mutual sharing of electrons.

There are three types of covalent bonds

i. Single covalent bond
ii. Double covalent bond
iii. Triple covalent bond.

i. Single covalent bond

This bond is formed by the mutual sharing of one electron by each atom and is shown by a short line (-)

Formation of hydrogen molecule (H_2)

Hydrogen atom has one electron in its valence shell. When two atoms of hydrogen come close to each other, they share one electron each.

ii. Double covalent bond

This bond is formed by mutual sharing of two electrons by each atom. It is represented by two short lines (=).

Formation of oxygen molecule (O_2)

Oxygen atoms have six electrons in their valence shells. They need two electrons to attain the nearest noble gas electronic configuration. Each atom shares a pair of electrons to form a double bond.

iii. Triple covalent bond

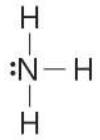
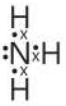
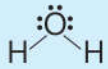
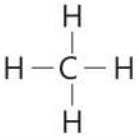
This type of bond is formed by the mutual sharing of three pairs of electrons i.e., each bonded atom shares 3 electrons. This bond is represented by three short lines (≡).

Formation of nitrogen molecule (N_2)

Nitrogen atom has five electrons in its valence shell. It needs 3 electrons to complete its valence shell. When two nitrogen atoms approach each other they share 3 pairs of electrons i.e., each bonded atom shares 3 electrons.

Examples of covalent compounds

Name	Bonding shown by line(s)	Dot and cross structure
Hydrogen bromide (HBr)	H—Br	H×Br
Hydrogen chloride (HCl)	H—Cl	H×Cl

Name	Bond shown by line	Dot and cross structure
Ammonia (NH_3)		
Water (H_2O)		
Methane (CH_4)		

Activity 6.7

The following molecules contain single, double and triple bonds. Draw the bonds.

Single covalent bond	Double covalent bond	Triple covalent bond
Hydrogen H_2	Oxygen O_2	Nitrogen N_2

Activity 6.8

Complete the Table

Formula	Metal	Non-metal	Type of bond
HCl			
NaCl			
MgO			
NH_3			
H_2O			

Science Project

Toy Car Powered by Chemical Reaction

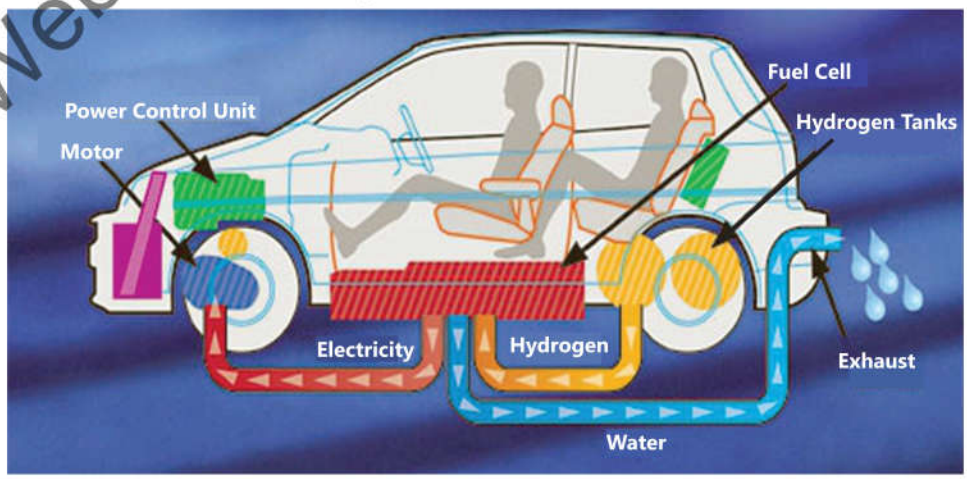
1. Assemble the low cost no cost material as shown in the Figure.
2. Pour one small cup of vinegar in the bottle.
3. Place bottle upright and add one tablespoon of baking powder into the bottle.
4. Quickly close the bottle with cap having little hole in its center.
5. Shake the bottle and place car wheels on the ground and observe.
6. What makes the car move?



Science Project

Car Powered by Hydrogen Gas

Hydrogen mixed with air is pumped into fuel cell. Inside the fuel cell, a chemical reaction extracts electrons from hydrogen. The resulting protons (H^+) move across the cell and combine with oxygen of the air to produce water. Meanwhile, the electron creates electricity which is supplied to an induction motor. This motor along with other components creates the mechanical energy needed to turn the gears of the car, which in turn, rotates the tyres.



KEY POINTS

- The process during which a substance changes into entirely new substance with different chemical composition and properties is called chemical reaction.
- During chemical reactions, atoms present in different substances are rearranged to form new substances.
- The substances which take part in a chemical reaction are called reactants and those which are formed as a result of the reaction are called products.
- The representation of a chemical reaction in terms of symbols, formulae and signs used for indicating physical states of the substances is called chemical equation.
- The use of co-efficients to balance the number of different types of atoms in a chemical equation is called the balancing of chemical equation.
- Law of conservation of mass states that during a chemical reaction, the total mass of the reactants is equal to the total mass of the products.
- Addition reactions involve the chemical combination of two or more substances to form one compound.
- A chemical reaction which involves the splitting up of one compound into two or more simple substances is called decomposition reaction.
- The chemical reactions during which heat is evolved are called exothermic reactions.
- The chemical reactions during which heat is absorbed are called endothermic reactions.
- Heat evolved during exothermic reaction is used to cook food, drive vehicles and . generate electricity
- Atoms of elements transfer or accept electron or electrons completely to form ionic bond.
- Atoms of elements share their electrons to form single, double and triple covalent bonds.

QUESTIONS

1. Encircle the correct option.

(i) Carbon burns in air to release energy along with the formation of:

a. carbon dioxide. b. carbon dioxide and water.
c. carbon dioxide and hydrogen d. carbon monoxide and hydrogen.

(ii) The products of the reaction between zinc and dilute sulphuric acid are:

a. zinc oxide and water b. zinc sulphide and water
c. zinc sulphate and hydrogen. d. zinc sulphide and hydrogen

(iii) Which of the following is an unbalanced chemical equation?

a. $CH_{4(g)} + 2O_{2(g)} \longrightarrow 2H_2O_{(g)} + CO_{2(g)}$
b. $Na_{(s)} + Cl_{2(g)} \longrightarrow NaCl_{(s)}$
c. $C_{(s)} + Cu_2O_{(s)} \longrightarrow CO_{(g)} + 2Cu_{(s)}$
d. $C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$

(iv) Heating of solid potassium chlorate produces a gas:

a. chlorine
b. carbon dioxide
c. carbon monoxide
d. oxygen

(v) Which of the following is an exothermic reaction?

a. Formation of iron sulphide by heating the mixture of iron and sulphur.
b. Formation of nitric oxide by heating the mixture of nitrogen and oxygen.
c. Formation of hydrogen iodide by heating the mixture of hydrogen and iodine.
d. Formation of calcium oxide and carbon dioxide by heating calcium carbonate.

(vi) Which of the following is a balanced chemical equation?

a. $Fe + 3Cl_2 \longrightarrow 2FeCl_3$
b. $Fe + 3Cl_2 \longrightarrow FeCl_3$
c. $2Fe + 3Cl_2 \longrightarrow 2FeCl_3$
d. $Fe + Cl_2 \longrightarrow FeCl_3$

(vii) The following equation is properly balanced when:

$x\ CO_{(g)} + y\ O_{2\ (g)} \longrightarrow z\ CO_{2\ (g)}$

a. x = 1, y = 2 and z = 3
b. x = 2, y = 1 and z = 1
c. x = 2, y = 2 and z = 2
d. x = 2, y = 1 and z = 2

(viii) How many oxygen atoms are present in one molecule of $Mg(HCO_3)_2$?

a. 2
b. 4
c. 6
d. 8

(ix) The reaction between calcium oxide and carbon dioxide to form calcium carbonate is an example of:

a. addition reaction
b. decomposition reaction
c. acid-base reaction
d. neutralization reaction

(x) Thermal decomposition of calcium carbonate produces a gas:

a. oxygen
b. carbon dioxide
c. nitrogen
d. carbon monoxide

2. Write short answers.

(i) Define a chemical reaction.
(ii) What are reactants?
(iii) What are products?
(iv) What is a chemical equation?
(v) State the law of conservation of mass.
(vi) Differentiate between
   a. Balanced chemical equation and unbalanced chemical equation
   b. Exothermic reactions and endothermic reactions

3. Complete and balance the following incomplete equations.

(i) $Mg_{(s)} + O_{2(g)} \longrightarrow$

(ii) $CH_{4(g)} + O_{2(g)} \longrightarrow$

(iii) $Fe_{(s)} + S_{(s)} \longrightarrow$

(iv) $N_{2(g)} + H_{2(g)} \longrightarrow$

(v) $Na_{(s)} + Cl_{2(g)} \longrightarrow$

4. Balance the following equations.

(i) $Ca(HCO_3)_2 + HCl \longrightarrow CaCl_2 + CO_2 + H_2O$

(ii) $NaBr + Cl_2 \longrightarrow NaCl + Br_2$

(iii) $Fe + O_2 \longrightarrow Fe_2O_3$

(iv) $NH_4OH + H_2SO_4 \longrightarrow (NH_4)_2SO_4 + H_2O$

(v) $Zn + HCl \longrightarrow ZnCl_2 + H_2$

5. Write at least two examples of the following chemical reactions.

(i) Combination reaction (ii) Decomposition reaction

(iii) Exothermic reaction (iv) Endothermic reaction

6. How do the following reactants react together? Write down complete reactions and balance the resulting equations.

(i) Iron + Hydrochloric acid

(ii) Calcium oxide + Carbon dioxide

(iii) Carbon monoxide + Oxygen

(iv) Methane + Oxygen

(v) Carbon dioxide + Water

7. Constructed response questions

(i) How combination and decomposition reactions are related to each other?

(ii) Why the mass of ash obtained when a piece of coal is burnt is less than the mass of coal?

(iii) How electricity is generated with the help of an exothermic reaction?

8. Investigate

(i) How will you notice whether a chemical reaction has taken place upon mixing the reactants?

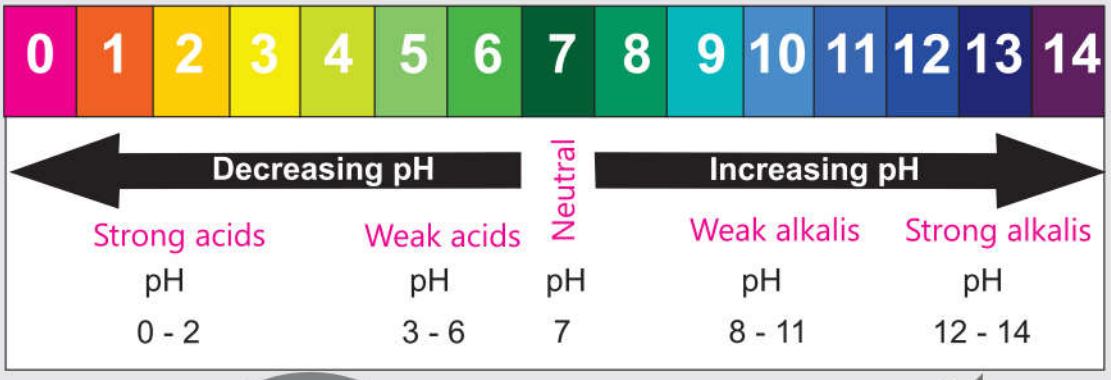
(ii) Which metal when ignited in the presence of air gives off intense light?

(iii) How does photosynthesis demonstrate the law of conservation of mass? Explain with specific examples from the reaction.

Project

(i) Seek the help of your teacher to prepare a sample of cheese from milk.

(ii) Prepare a sample of white wash and paint dog's house with it.



Where do we get HCl in our stomach from?

Why is wood ash used to wash utensils?

Which salts are present in drinking water?

07 Acids, Bases and Salts

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Classify acids, alkalis, and salts and give examples of each.
- Identify the physical properties of acids, alkalis, and salts.
- Define pH and its ranges with reference to indicators.
- Interpret the pH scale and identify acids, alkalis, and describe neutralization reaction with real life examples.
- Observe and write the uses of acids, bases, and salts in daily life.

You have already read that a large number of compounds can be made by the combination of various elements. More than three million compounds are known to the scientists. It is practically impossible for anyone to learn about each of these compounds. Therefore, all these compounds are divided into different groups to make their studies easier. In this chapter, we will learn about acids, alkalis and salts, their properties and uses, pH, its range in aqueous medium and indicators.

7.1 ACIDS

The word **acid** is derived from Latin word 'acidus' means sour. In chemistry, the term acid has been used to name a group of compounds that have sour taste. Acids are defined as the compounds which produce hydrogen ions (H^+) in their aqueous solutions. Citrus fruits (Figure 7.1) have sour taste due to presence of citric acid. Hydrochloric acid is an important mineral acid. It is found in gastric juice of the stomach. It acts as an antiseptic and is helpful in digestion of proteins.

Figure 7.1 Citrus fruits

Sources of Common Acids

Generally, acids are obtained from two different sources. Some acids occur in plants and animals and are known as **organic acids** while others are obtained from minerals and are called **mineral acids**. Some common organic acids and their sources are given in Table 7.1.

Table 7.1 Some important acids obtained from animals or plants

Name	Source	Name	Source
Formic acid	Ant's sting	Tartaric acid	Tamarind, grapes
Acetic acid	Vinegar	Lactic acid	Yoghurt
Oxalic acid	Tomatoes	Maleic acid	Apples
Citric acid	Citrus fruit	Stearic acid	Fats

Some examples of the acids which are prepared from mineral elements are given in Table 7.2.

Table 7.2 Some important mineral acids and their formulae

Mineral acid	Formula
Hydrochloric acid	HCl
Nitric acid	HNO_3
Sulphuric acid	H_2SO_4
Phosphoric acid	H_3PO_4

Properties of Acids

Let us now study the properties which are common to all acids.

(i) All acids have a sour taste.

Activity 7.1

Apparatus / Material required:

Test tube, water, dilute acetic acid

Procedure:

- Take a clean test tube and fill it half with water.
- Add a few drops of vinegar in it.
- Close the mouth of the test tube with your thumb and shake it well.
- Taste the wet thumb.

How does it taste and why?

Warning

Don't taste the acids, bases and other chemical compounds without ensuring their harmless property.

(ii) All acids turn blue litmus solution and methyl orange solution red.

Activity 7.2

Apparatus / Material required:

Test tubes (3), dilute hydrochloric acid or dilute sulphuric acid, blue litmus, methyl orange, phenolphthalein

Procedure:

- Take a little quantity of dilute HCl or H_2SO_4 solution in three separate test tubes.
- Label them as 1, 2 and 3.
- Add two to three drops of blue litmus, methyl orange and phenolphthalein (indicators) in the test tubes 1, 2 and 3 separately.

What changes in the colour of the solution do you observe?

Test tube	Acid solution	Original colour	Indicator used	Changed colour
1				
2				
3				

Activity 7.3

Apparatus / Material required:

Test tube, vinegar, blue litmus solution, sodium hydroxide solution

Procedure:

- Take 2cm^3 of vinegar in a test tube.
- Add two drops of blue litmus solution to it and observe the change, if any.
- Then add carefully sodium hydroxide solution drop by drop and observe the changes taking place in the solution.
- **What do you infer from this activity?**
- **Discuss your observation with your teacher?**

Conclusion: _____

_____

(iii) Strong acids are corrosive liquids. They burn skin and destroy fabrics and animal tissues.

(iv) Aqueous solutions of acids are good conductor of electricity.

(v) Acids react with reactive metals (Mg, Zn) to form salts and evolve hydrogen gas.

$$\underset{\text{Magnesium}}{Mg_{(s)}} + \underset{\text{Hydrochloric acid}}{2HCl_{(aq)}} \longrightarrow \underset{\text{Magnesium chloride}}{MgCl_{2(aq)}} + \underset{\text{Hydrogen}}{H_{2(g)}}$$

$$\underset{\text{Zinc}}{Zn_{(s)}} + \underset{\text{Sulphuric acid}}{H_2SO_{4(aq)}} \longrightarrow \underset{\text{Zinc sulphate}}{ZnSO_{4(aq)}} + \underset{\text{Hydrogen}}{H_{2(g)}}$$

Hydrogen gas produced in the reaction burns with pop sound (Figure 7.2). This is a test for identification of hydrogen gas.

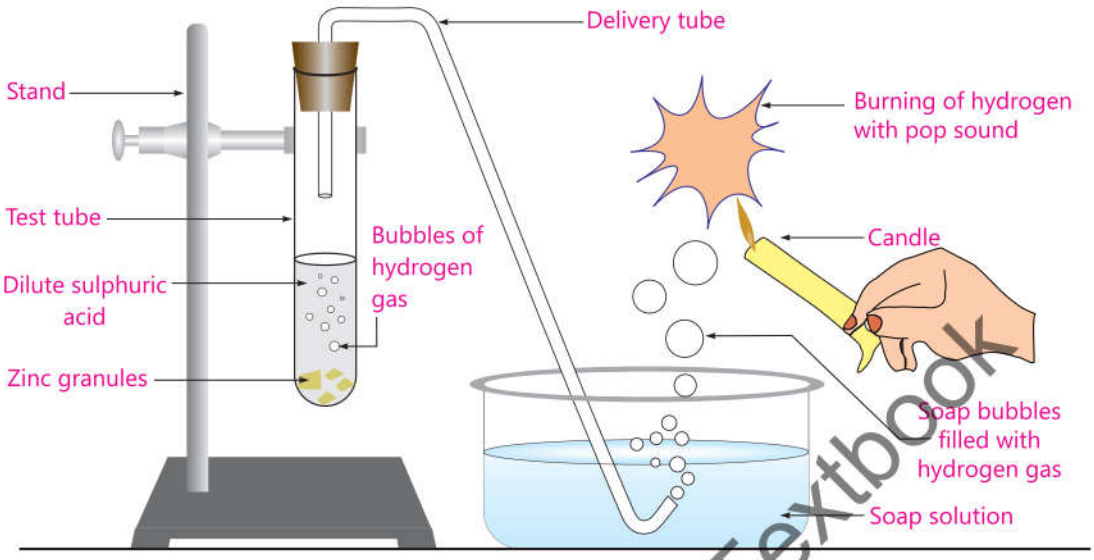


Figure 7.2 Reaction of zinc with dilute acid

(vi) Acids react with metal carbonates and metal hydrogen carbonates to liberate carbon dioxide.

$$\underset{\text{Calcium carbonate}}{CaCO_{3(s)}} + \underset{\text{Hydrochloric acid}}{2HCl_{(aq)}} \longrightarrow \underset{\text{Calcium chloride}}{CaCl_{2(aq)}} + \underset{\text{Water}}{H_2O_{(\ell)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}}$$

$$\underset{\text{Sodium hydrogen carbonate}}{NaHCO_{3(S)}} + \underset{\text{Acetic acid}}{CH_3COOH_{(aq)}} \longrightarrow \underset{\text{Sodium acetate}}{CH_3COONa_{(aq)}} + \underset{\text{Water}}{H_2O_{(\ell)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}}$$

Carbon dioxide produced in the reaction turns lime water milky (Figure 7.3). This is a test for identification of carbon dioxide gas.

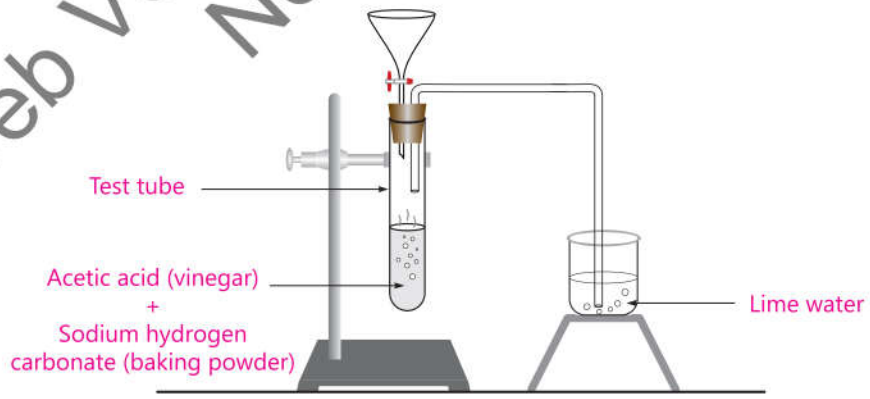


Figure 7.3 Reaction of acetic acid with sodium hydrogen carbonate

(vii) Acids react with bases to form salt and water. This process is called neutralization.

$$\underset{\text{Sulphuric acid}}{H_2SO_{4(aq)}} + \underset{\text{Sodium hydroxide}}{2NaOH_{(aq)}} \longrightarrow \underset{\text{Sodium sulphate}}{Na_2SO_{4\ (aq)}} + \underset{\text{Water}}{2H_2O_{(\ell)}}$$

Uses of Acids

Important uses of mineral acids are given below:

Hydrochloric Acid

Hydrochloric acid is used :

(i) for cleaning rust from the surface of metals.
(ii) for purification of common salt (NaCl).
(iii) to make Aqua Regia ($3HCl + HNO_3$) used to dissolve noble metals such as gold for their purification.
(iv) for making glucose from starch.
(v) for the proper digestion of food in our stomach.

Nitric Acid

Nitric acid is used:

(i) in the manufacture of fertilizers like ammonium nitrate.
(ii) for the manufacture of explosives.
(iii) in the manufacture of dyes, plastics and artificial silk.
(iv) for etching designs on metals like copper, brass and bronze.

Can you tell?

Which acid is added to produce fizz in soft drinks?

Sulphuric Acid

Sulphuric acid is used:

(i) as a dehydrating agent.
(ii) in the manufacture of fertilizers like ammonium sulphate, calcium ammonium phosphate, calcium super phosphate, etc.
(iii) in the manufacture of celluloid plastic, artificial silk, paints, drugs and detergents.
(iv) in petroleum refining, textile, paper, and leather industries.
(v) in lead storage batteries.

The uses of sulphuric acid are shown below.

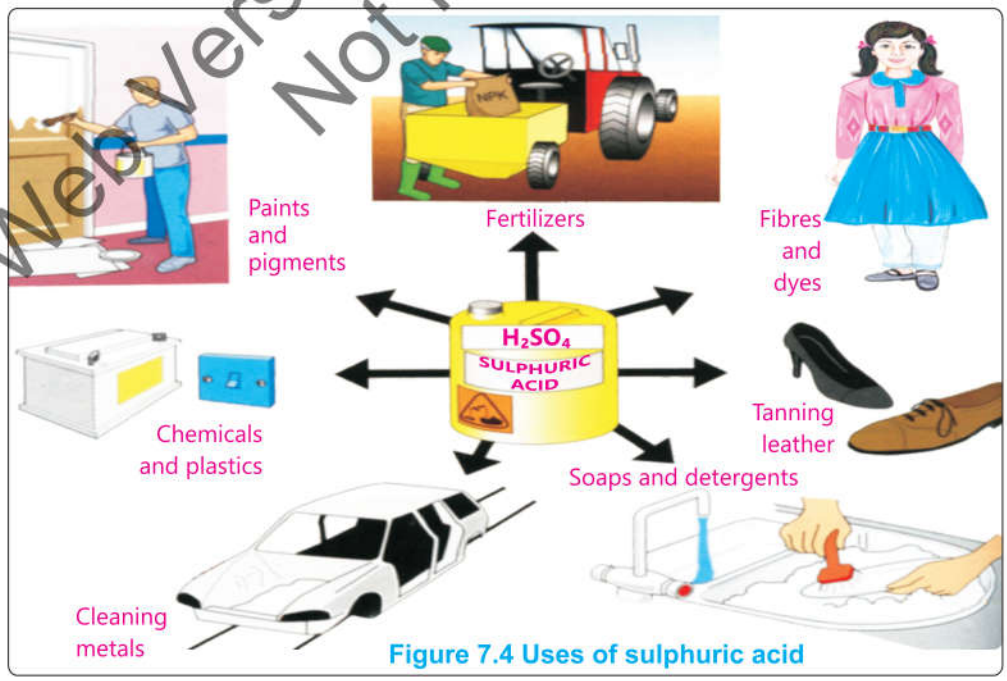


Figure 7.4 Uses of sulphuric acid

Acetic Acid

Acetic acid is used:

(i) in the preparation of pickles. (ii) in the manufacture of synthetic fibre.

7.2 BASES / ALKALIS

Many compounds have properties which are contrary to acids. Such compounds are termed as **bases**. The bases which are soluble in water are called **alkalis**. The word alkali has been taken from Arabic word "qali" which means "from ashes". Alkalis are obtained from the ashes of plants.

Alkalis/bases are the compounds which produce hydroxide ions (OH^-) in their aqueous solutions. Sodium hydroxide (NaOH), potassium hydroxide (KOH), calcium hydroxide $Ca(OH)_2$, etc., are the examples of bases / alkalis. Some important alkalis and their formulae are given in Table 7.3.

Table 7.3 Some common alkalis and their formulae

Alkali	Formula
Sodium hydroxide	NaOH
Potassium hydroxide	KOH
Calcium hydroxide	$Ca(OH)_2$
Ammonium hydroxide	NH_4OH
Magnesium hydroxide	$Mg(OH)_2$

Commonly used alkalis as laboratory reagents are shown below in reagent bottles (Figure 7.5).

Figure 7.5 Common alkalis used in laboratory

? Do you know?

All alkalis are bases but all bases are not alkalis.

Properties of Bases / Alkalis

(i) Aqueous solution of a base has a soapy touch.

Activity 7.4

Apparatus / Material required:

Test tube, sodium hydroxide, water, etc.

Procedure:

- Take 10 cm^3 of water in a test tube.
- Add a few pellets of sodium hydroxide and shake it.
- Touch the solution with your fingers.

How do you feel?

(ii) Bases turn red litmus blue, colourless phenolphthalein pink and methyl orange yellow. They turn turmeric paper brown.

(iii) Aqueous solutions of bases are good conductor of electricity.

(iv) Bases react with acids to form salts and water. The reaction is called neutralization reaction.

$$\underset{\text{Sodium hydroxide}}{NaOH_{(aq)}} + \underset{\text{Hydrochloric acid}}{HCl_{(aq)}} \longrightarrow \underset{\text{Sodium chloride}}{NaCl_{(aq)}} + \underset{\text{Water}}{H_2O_{(\ell)}}$$

Activity 7.5

Apparatus / Material required:

Test tube, sodium hydroxide solution, dilute hydrochloric acid, phenolphthalein, etc.

Procedure:

- Take 3 cm^3 of sodium hydroxide solution in a test tube.
- Add a drop of phenolphthalein solution to it. It turns pink.
- To this, add dilute hydrochloric acid slowly until the colour is discharged. Transfer the solution to a china dish and evaporate it to dryness.

What do you observe?

(v) Alkalis when heated with ammonium salts produce ammonia gas (Figure 7.6). We can identify ammonia gas by its pungent smell. Ammonia also turns moist red litmus paper blue.

$$\underset{\text{Calcium hydroxide}}{Ca(OH)_{2(aq)}} + \underset{\text{Ammonium chloride}}{2NH_4Cl_{(aq)}} \xrightarrow{\text{heat}} \underset{\text{Calcium chloride}}{CaCl_{2(aq)}} + \underset{\text{Water}}{2H_2O_{(\ell)}} + \underset{\text{Ammonia}}{2NH_{3(g)}}$$

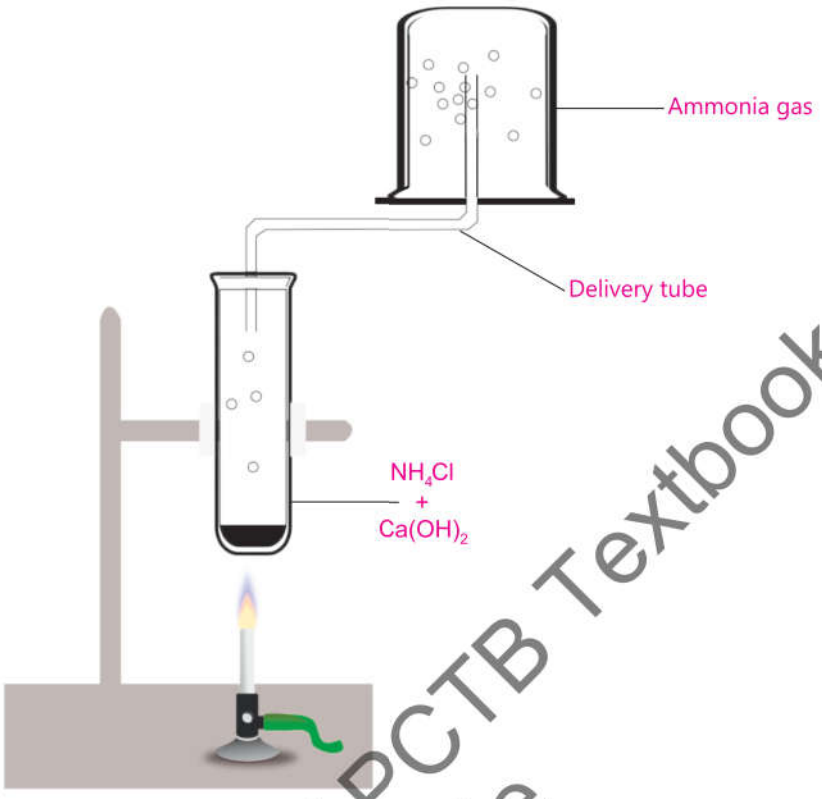


Figure 7.6 Reaction of calcium hydroxide with ammonium chloride

(vi) Alkalis react with fats to form soap and glycerine.

Uses of Bases / Alkalis

Some common uses of bases are:

Sodium hydroxide (NaOH)

Sodium hydroxide is largely used in:

(i) soap, textile and plastic industries.
(ii) petroleum refining.
(iii) making rayon.
(iv) the manufacture of paper pulp and medicines.
(v) opening blocked drains

Calcium hydroxide

Calcium hydroxide is called slaked lime. It is used:

(i) in the manufacture of bleaching powder.
(ii) as a dressing material for acid burns.
(iii) in making lime sulphur sprays to be used as fungicide.
(iv) as a water softener.

(v) for neutralizing acidity present in soil.

Ammonium hydroxide

Ammonium hydroxide is used:

(i) to remove grease from window panes.

(ii) to remove ink spots from clothes.

(iii) as a reagent in laboratory.

(iv) for the treatment of bees' stings.

7.3 SALTS

A **salt** is a compound formed by the neutralization of an acid with a base.

A large variety of compounds exists as salts. Sodium chloride is a common salt which we use in our food.

Some common salts and their formulae are given in Table 7.4 and shown in Figure 7.7.

Figure 7.7 Some common salts

Table 7.4 Some common salts and their formulae

Salt	Formula	Salt	Formula
Sodium chloride	NaCl	Sodium nitrate	$NaNO_3$
Potassium chloride	KCl	Potassium nitrate	KNO_3
Ammonium chloride	NH_4Cl	Ammonium nitrate	NH_4NO_3
Calcium chloride	$CaCl_2$	Calcium sulphate	$CaSO_4$
Sodium carbonate	Na_2CO_3	Calcium carbonate	$CaCO_3$
Sodium hydrogen carbonate	$NaHCO_3$	Copper sulphate	$CuSO_4$

Properties of Salts

(i) Salts exist in solid state. They are found in crystalline or in powder forms. They have high melting and boiling points.

(ii) Generally, salts are soluble in water. However, the salts like calcium carbonate, lead chloride and cadmium sulphate, etc., are insoluble in water.

(iii) Aqueous solutions of metal salts or their molten forms conduct electricity.

(iv) Many of the salts contain water molecules in their crystals which are responsible for the shape of the crystals.

(v) Carbonates and bicarbonates react with acids to liberate carbon dioxide gas.

$Na_2CO_{3(s)}$ + $2HCl_{(aq)}$ ⟶ $2NaCl_{(aq)}$ + $H_2O_{(\ell)}$ + $CO_{2(g)}$

Sodium carbonate — Hydrochloric acid — Sodium chloride — Water — Carbon dioxide

(vi) When salts of heavy metals react with alkalis, precipitates of heavy metal hydroxides are formed in the reaction mixture. Precipitates are the substances which appear as solid insoluble product in the liquid reaction mixture.

$FeCl_{3(aq)}$ + $3NaOH_{(aq)}$ ⟶ $Fe(OH)_{3(ppt)}$ + $3NaCl_{(aq)}$

Ferric chloride — Sodium hydroxide — Ferric hydroxide — Sodium chloride

(vii) The chemical reaction of water with a salt produces an acid and a base and the reaction is called hydrolysis.

$Na_2CO_{3(s)}$ + $2H_2O_{(\ell)}$ ⟶ $2NaOH_{(aq)}$ + $H_2CO_{3(aq)}$

Sodium carbonate — Water — Sodium hydroxide — Carbonic acid

Uses of Salts

(i) Role of salts in human body

Salts of sodium, potassium, calcium, magnesium and iron are needed for the normal working of our body (Figure 7.8). They perform the following functions:

(a) Sodium and potassium salts are needed for the proper functioning of muscles and the nervous system.

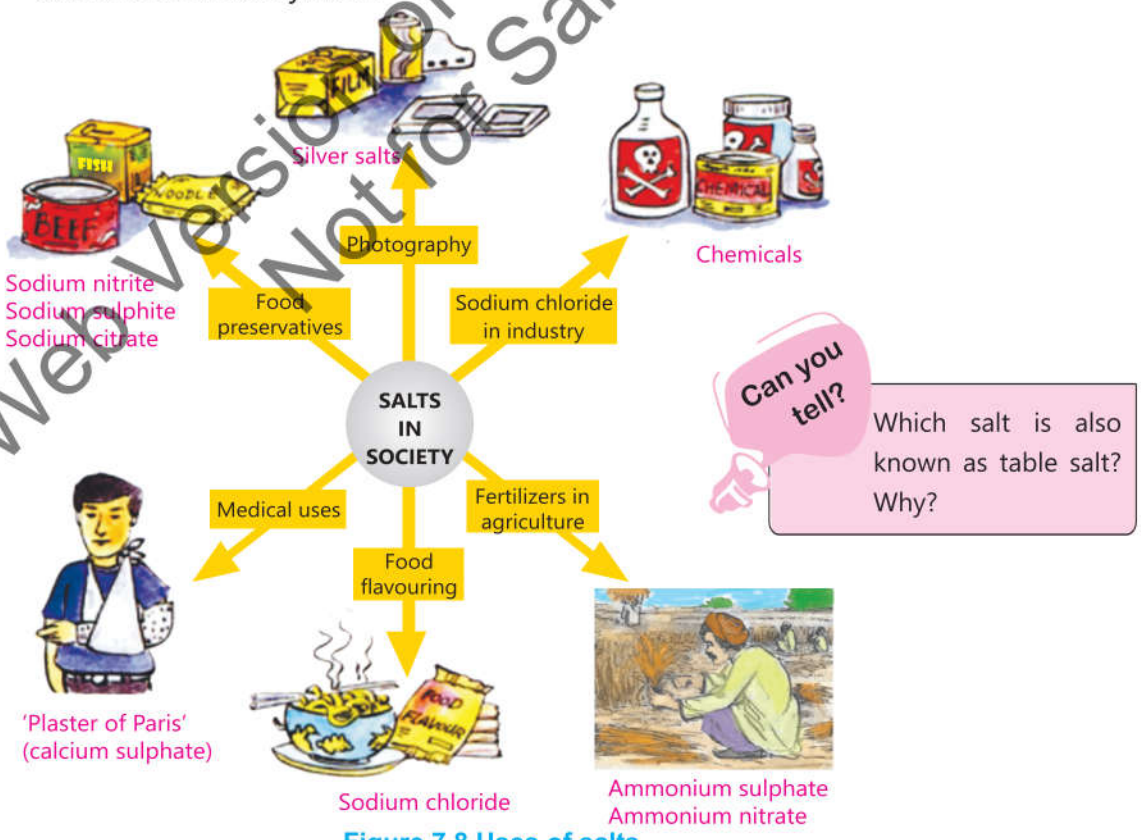


Figure 7.8 Uses of salts

Can you tell?

Which salt is also known as table salt? Why?

(b) Salts of calcium are present in bones. They are responsible for the strength of bones. These salts are responsible for preventing heart attacks. Plaster of Paris ($CaSO_4 . ½H_2O$) is used for broken limbs.

(c) Potash alum is used to coagulate the blood coming out of a wound. It is also used for the purification of water.

(d) Salts of iodine are needed for the proper functioning of thyroid glands. They are also used for the treatment of goiter.

(ii) Uses of salts in our daily life

(a) In our daily life, we use common salt for seasoning food. It is also used as a preservative for fish and pickles.

(b) Baking soda is used for giving softness to bread and cake.

(c) Washing soda is used for washing clothes.

(d) Sodium potassium tartrate is used as a laxative.

(iii) Uses of salts in industries

(a) Sodium chloride is used for the manufacture of chlorine, hydrogen chloride, caustic soda, washing soda and sodium hydrogen carbonate.

(b) Sodium carbonate is used for softening hard water and for the manufacture of glass and soap.

(c) Potassium nitrate is used for the preparation of gun powder and fireworks. It is also used as a fertilizer.

(d) Potash alum is used for purification of water, in dyeing cloth and for tanning hides.

(e) Copper sulphate is used as a fungicide, in calico printing and in electroplating.

7.4 pH SCALE

The scale which is used to measure the strength of acidic or alkaline solution is known as **pH scale**. The pH of a solution can be determined with the help of universal indicator or pH paper. A universal indicator paper has a mixture of several dyes coated on it. It shows different colours for different pH values of the solutions. In an acidic solution, colour changes from yellow to orange and then red as the pH decreases. The colour changes from indigo to violet when pH changes from 7 to 14.

Activity 7.6

Apparatus / Material required:

pH paper, sodium hydroxide, ammonium hydroxide, vinegar solution, dilute hydrochloric acid

Procedure:

- Add separate strips of pH paper in different solutions.
- Observe the change in colour of the strips and record your observations.

You will observe that different shades of colour appear on each strip of pH paper. By comparing the colours with the chart provided with the pH paper you can find the pH of different solutions. Strong acids have pH value 0 to 2. pH of weak acids is in between 3 and 6. pH of weak alkalis is 8 to 11. pH of strong alkalis is 12 to 14.

Activity 7.7

Material required: Universal indicator paper, dilute NaOH, dilute NH_4OH, dilute HCl, dilute H_2SO_4, vinegar, distilled water

Procedure:

- Take 1cm^3 of dilute HCl, dilute H_2SO_4, dilute CH_3COOH (vinegar), dilute NaOH, dilute NH_4OH solutions prepared in distilled water in different test tubes.
- Add 1.5 cm^3 of distilled water.
- Dip separate universal indicator paper strips in each tube and match the colour with colour given on the strip.
- Note the observations.

Sample	Colour of univeral indicator paper	pH of the solution
Dilute HCl		
Dilute H_2SO_4		
Dilute CH_3COOH		
Dilute NaOH		
DiluteNH_4OH		
Distilled H_2O		

7.4.1 pH and its Range (0 –14) in Aqueous Medium

Pure water ionizes very slightly into hydrogen (H^+) and hydroxide (OH^-) ions. However, the concentrations of hydrogen ions (H^+) and hydroxide ions (OH^-) in pure water are equal. Hydrogen ion concentration increases, when acids are dissolved in water. Alkalis on dissolving in water decrease the concentration of hydrogen ions in water as compared to hydroxide ions. The greater the concentration of hydrogen ions (H^+) in a solution, the stronger the acid is. The lesser the concentration of hydrogen ions as compared to hydroxide ions in a solution, the stronger the alkali is.

Hence, the scale which is used to measure the strength of an acid or alkali in an aqueous solution is based on the concentration of hydrogen ions (H^+) which is termed as pH.

pH values range from 0 – 14 (Figure 7.9). The solutions having equal concentrations of hydrogen ions (H^+) and hydroxide ions (OH^-) are neutral solutions. They have pH = 7. pH = 7 is the mid point of the pH scale.

The solutions with higher concentration of hydrogen ions will have lower than 7 value of pH. The solutions with lower concentration of hydrogen ions than that of hydroxide ions will have greater than 7 value of pH. Solution with lower pH values are stronger acids. The solutions with higher pH values are stronger alkalis. The higher the pH value of the solutions, the stronger the alkalis they are.

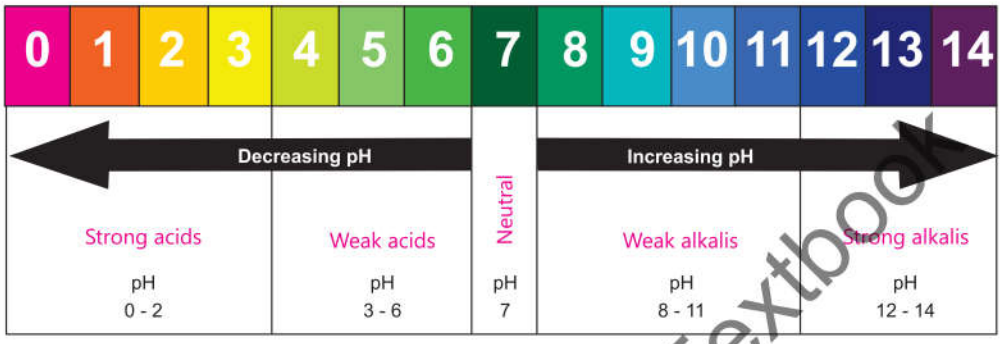


Figure 7.9 pH Scale

pH values of some common substances are given in Table 7.5.

Table 7.5 pH values of some common substances

Substance	pH	Substance	pH
Pure sulphuric acid	0	Pure water	7
Gastric juice in the stomach	1	Cleaning fluid	9
Lemon juice	2	Baking powder	10
Vinegar	3	Milk of magnesia	11
Tomato juice	4	Household ammonia	12
Acid rain	5	Strongest alkalis such as potassium hydroxide	14

PH Meter

The instrument which is used to measure the exact pH of the solutions is called pH meter (Figure 7.10). When the electrode of pH meter is dipped in the solution, the reading of its pH appears on the digital display of pH meter.

Figure 7.1 pH meter

7.5 INDICATORS

Majority of acids and alkalis are colourless. It is not possible to identify them by their appearance. In order to identify whether a substance is an acid or an alkali, indicators are used.

An indicator is a substance that shows different colours in acidic and basic solutions (Table 7.6). Some examples of indicators are phenolphthalein, methyl orange, litmus, turmeric, china rose and red cabbage.

Table 7.6 Indicators and their colours in acidic and alkaline solutions

Indicator	Original colour	Colour in acid	Colour in base
Litmus	Violet	Red	Blue
Phenolphthalein	Colourless	Colourless	Pink
Methyl orange	Orange	Red	Yellow

Activity 7.8

Apparatus / Material required:

Dilute HCl, soap solution, lemon juice, tap water, sodium hydroxide, ammonia solution and household bleach.

Procedure:

- Put the above samples separately in clean test tubes.
- Add a few drops of red and blue litmus solution in separate test tubes containing the same solution.
- Record your observations in the following Table.

Sample	Colour change		Nature of solution
	Red litmus	Blue litmus	
Dil HCl	Remains red	Turns red	Acidic
Soap solution			
Tap water			
Sodium hydroxide	Turns blue	Remains blue	Basic
Household bleach			
Ammonia solution			

Test the above samples with methyl orange and phenolphthalein and record the observation.

7.5.1 Natural Indicators

Red cabbage, turmeric, china rose and litmus.

Turmeric (Haldi Powder)

Activity 7.9

Apparatus / Material required:

Turmeric powder, water, filter paper, different solutions as in the activity 7.8.

Procedure:

- Make a paste of turmeric powder with water.
- Apply the paste on the filter paper and allow it to dry.
- Remove the dry powder from the filter paper.
- Cut the filter paper into small strips.
- Pour different solutions separately on the strips and note the colour changes.
- Record the observations in tabular form as in the activity 7.8.

You will observe that:

Turmeric paper remains yellow in acidic and neutral solutions but turns brown in alkaline solution.

Red cabbage

Activity 7.10

Material required:

Red cabbage, water, filter paper, different solutions

Procedure:

- Put some chopped red cabbage in hot water for sometime.
- Filter the coloured solution.
- Purple coloured cabbage indicator is ready for use.
- Test the sample of activity 7.8 with this indicator and record the results.

You will observe that:

The purple colour of cabbage indicator turns red in acidic solutions and green in basic solutions. Neutral solutions do not change the colour of red cabbage indicator.

KEY POINTS

- Acids are substances which have sour taste. They change blue litmus red. They also react with active metals producing salts and hydrogen gas.
- Acids act on metal carbonates and hydrogen carbonates liberating carbon dioxide.
- Acids neutralize bases to form salts and water.
- Acids have many uses in laboratories and industries.
- Hydroxides like NaOH, KOH, $Ca(OH_2)$, NH_4OH are examples of alkalis.
- Alkalis have bitter taste and turn red litmus blue, colourless phenolphthalein to pink.
- Alkalis neutralize acids to form salts and water.
- Alkalis have many uses in laboratories in homes and in industries.
- Many salts are commonly used in our daily life.

QUESTIONS

1. Encircle the correct option.

(i) The king of chemicals is:

(a) KOH (b) HCl

(c) H_2SO_4 (d) NaCl

(ii) Sodium hydroxide solution in water will:

(a) turn blue litmus red

(b) give pink colour with phenolphthalein

(c) give red colour with methyl orange

(d) not affect the phenolphthalein indicator

(iii) When carbon dioxide gas is passed through lime water, the milkiness is due to the compound:

(a) $Ca(HCO_3)_2$ (b) $CaCO_3$

(c) H_2CO_3 (d) CaO

(iv) Lactic acid is found in:

(a) grapes (b) tomatoes

(c) ant's string (d) yogurt

(v) Sodium carbonate is an important salt used for many purposes in industries. Which acid is reacted with sodium hydroxide to get it?

(a) Oxalic acid (b) Citric acid

(c) Carbonic acid (d) Acetic acid

2. Write short answers.

(i) Define an acid.

(ii) Name three mineral acids.

(iii) State three properties of acids.

(iv) Mention the uses of two salts in industries.

(v) Name a salt which can reduce the acidity in our stomach.

(vi) What happens when a salt like copper sulphate reacts with water?

(vii) Is soda water acidic or basic?

(viii) Which alkali is commonly used to open a drain?

(ix) Write down the chemical equation showing the reaction of ammonia and water.

(x) How is litmus solution prepared?

3. Mention the sources of the following.

(i) Citric acid (ii) Tartaric acid

(iii) Acetic acid

4. Describe how are salts useful for the human body.

5. What happens when:

(i) magnesium reacts with dilute HCl?

(ii) sodium hydrogen carbonate reacts with dilute H_2SO_4?

(iii) copper oxide reacts with dilute sulphuric acid?

(iv) sodium reacts with chlorine?

6. Why are the aqueous solutions of $NaHCO_3$ and Na_2CO_3 basic in nature?

7. How does the soil become acidic?

8. Sulphuric acid (H_2SO_4) molecule can give two protons in water whereas hydrochloric acid molecule can give only one proton. Does that mean sulphuric acid is twice as strong acid as hydrochloric acid?

9. Indicate in front of each salt the acid and the base which have been used to prepare them.

Name of salt	Acid	Base
Calcium acetate		
Potassium hydrogen sulphate		
Magnesium nitrate		
Ammonium oxalate		
Sodium potassium tartarate		
Ferric chloride		

10. Constructed response questions

(i) Keeping in view the definitions of acids and bases why water is called a neutral compound?

(ii) Suppose your garden soil is acidic and you want to grow vegetables which do not grow very well in an acidic soil. How will you make your soil fit for growing vegetables?

(iii) Citric acid, tartaric acid and acetic acid are used in food items whereas hydrochloric and sulphuric acid are very dangerous for human health. Give reason.

11. Investigate

(i) Sodium bicarbonate ($NaHCO_3$) is used as baking soda. Can potassium bicarbonate ($KHCO_3$) be used for baking cakes?

(ii) Which common salt of copper is used to kill fungus and algae in plants and trees?

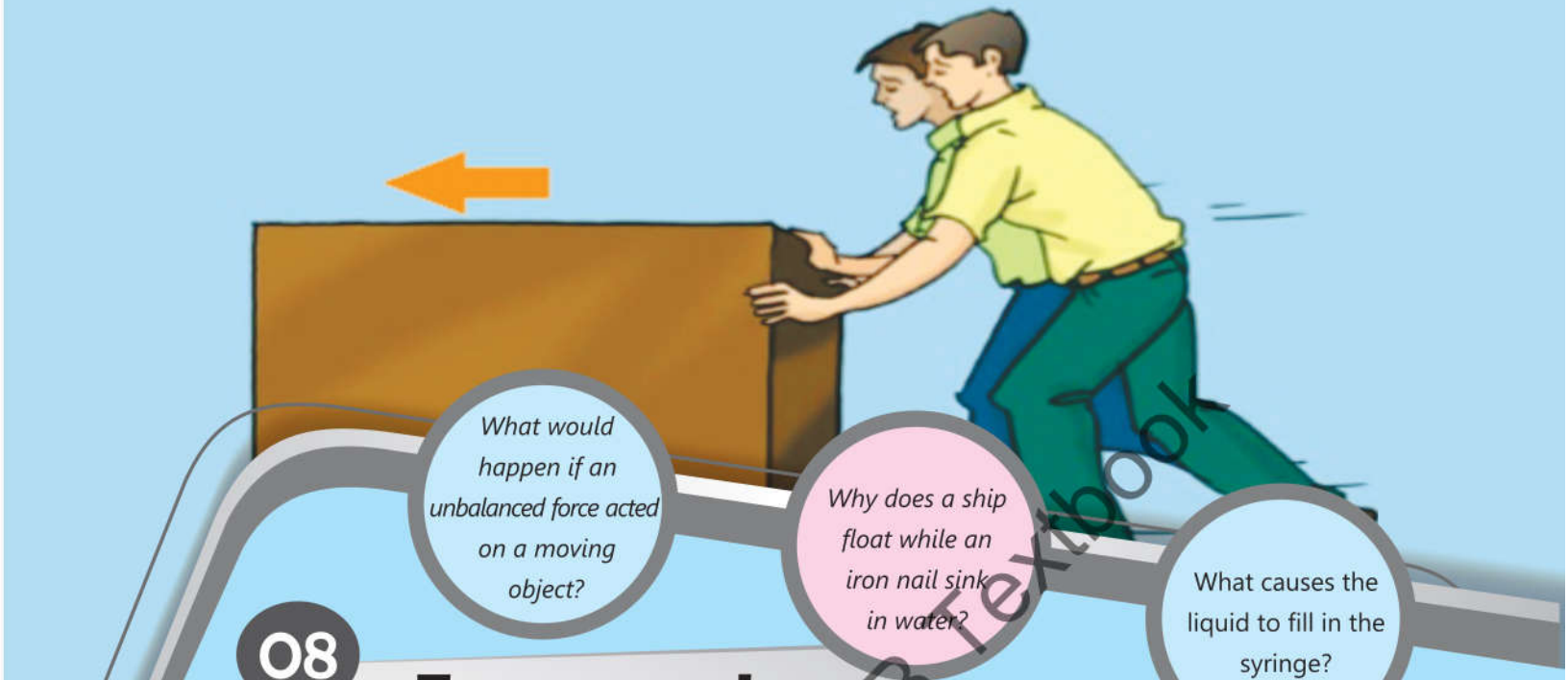
(iii) Why common salt found in Khewra mines is pink in colour?

(iv) With the help of pH paper find out the pH of following liquids:

Milk, cooking oil, common salt solution and vinegar

Project

Some times when you water the plants in your kitchen garden white crystals of salts appear on the surface of the soil. This problem is called salinity of soil and the plants do not grow very well in such a soil. With the help of your teacher and your friends find out a method to overcome this problem.



08 Force and Pressure

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Recognize that several forces may act on an object and that they may or may not balance each other.
- Examine the effect of an unbalanced force on an object.
- Differentiate between floating and sinking objects in terms of density.
- Define pressure with examples and its unit.
- Relate pressure with force and area.
- Investigate effects related to pressure (e.g., water pressure increasing with depth, a balloon expanding when inflated, etc.).
- Examine the effect of force in the presence of air pressure.
- Make a hydraulic elevator. (STEAM)
- Build a two-stage rocket model. (STEAM)

We have already learnt that a force causes or tends to cause change in the direction or state of motion of an object. In this chapter, we will study about balanced and unbalanced forces, floating and sinking, pressure, their effects and applications.

8.1 BALANCED AND UNBALANCED FORCES

Consider a book lying on a table. There are two forces acting upon it as shown in Figure 8.1 (a) Since these two forces are of equal magnitude and in opposite directions, they balance each other. As a result, the book remains stationary.

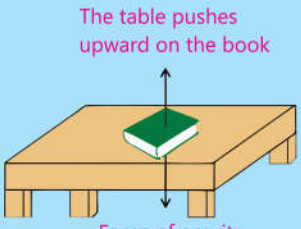


Figure 8.1(a)

Now consider the book sliding towards right across the table top after having been pushed hard. The book is in motion even during the interval when there is no force pushing it. Now the forces acting

upon the book are shown in Figure 8.1 (b). As the book moves to the right, the force of friction acts to the left. The weight acting downwards and the force of the table pushing upwards are of equal magnitude and in opposite directions. These two forces balance each other. However, there is no force present to balance the force of friction. As the book moves to the right, the friction acting towards left slows down the book. This is a case of unbalanced forces.

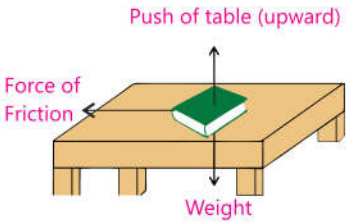


Figure 8.1(b)

When a number of forces are acting on a body, these can be balanced or unbalanced forces. In case of balanced forces, there is no change in the speed or direction of the body. The unbalanced forces means that the force acting in one direction is greater than the force or forces acting in the opposite direction.

We can also consider the example of a tug-of-war. Team 'A' pulls the rope in one direction and the team 'B' pulls it in the opposite direction. If the total force of team 'A' is greater than that of team 'B', the rope will move towards team 'A'. In case of the force applied by team 'B' is greater than that of team 'A', the rope will move towards team 'B'. In both the cases, forces are unbalanced. If the forces of both the teams are equal in magnitude, the rope will not move and we will say that they have balanced each other.

Figure 8.2

An unbalanced or a net force acting on a stationary object could make the object start moving. A net force acting on a moving object could make the object change speed, change direction, or stop it moving.

8.2 FLOATING AND SINKING WITH REFERENCE TO DENSITY

The density of a substance relates the mass of the substance and how much space it occupies (volume). The density of a substance is defined as its mass per unit volume.

i.e;
$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Commonly, we can say that density is a measure of how heavy something is compared to its size (volume). Let us explore whether a substance which sinks or floats in water, depends on its density.

Activity 8.1

Material Required

Play dough or a ball of clay of the size of a ping pong, a glass half filled with water.

Procedure:

1. Put the clay ball in water. Does it sink? Pick the ball out.
2. Remove half of the clay from the ball and form it again into a ball shape. Put the ball in the water. Does it sink in water?
3. Repeat the process with a very small ball of clay. Does it also sink in water?

What do you conclude from this activity? Is clay denser than water or less denser than water?

Let us perform another experiment.

Activity 8.2

Material Required:

10 ice-cream sticks, rubber band, clear plastic or glass container, water.

Procedure

1. Put one ice-cream stick in the water. Observe if it sinks or floats in water.
2. Tie all 10 sticks together using rubber band and put it in the water. Does the bundle of sticks sink or float?

Do you think wood is denser than water?

Let us explain some basics about density by the following experiment:

Activity 8.3

1. Fill water in a beaker up to brim. Drop a ball of clay in it. Collect the spilt over water in a container as shown in Figure. This water has the volume equal to that of ball.
2. Take two identical transparent beakers.
3. Put the ball of clay in one beaker and water of volume equal to that of clay in the second beaker.
4. Place the beakers on the pans of a beam balance as shown in the figure. In this way, you can compare weight of the same volume of clay with that of water. As the clay weighs more than the same volume of water, we can say that clay is denser than water.

Since clay is more dense than water, a ball of clay sinks in water, no matter how big or small is the ball of clay.

If we compare the weight of a piece of wood and equal volume of water, the piece of wood would weigh less than water.

Figure 8.3

Since wood is less dense than water, the wood floats in water, no matter how big or small the piece of wood is.

Here a question arises that why a boat or ship made of metal can float in water as the metal is denser than water.

Figure 8.4

In fact, an object floats when it displaces a volume of water that has a

mass equal to the mass of the object. Therefore, if a material like iron is shaped into a boat and made larger and larger, it will displace more and more water. When it is large enough to displace a volume of water that has a mass equal to the mass of the boat, it will float. A good example of this is the empty steel vessel. It floats in a tub of water.

Point to Ponder!

Why does a person keep floating in the dead sea?

8.3 PRESSURE, FORCE AND AREA

To understand the term pressure, let us perform an activity.

Activity 8.4 - Pressure exerted by the same force on different areas

Material Required

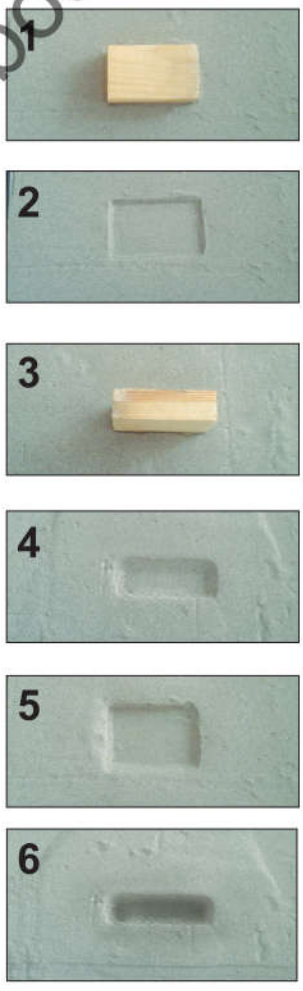
A wooden block, a tray, a ruler, sand, 1 kg and 2 kg weights.

Procedure

i. Fill the tray with dry sand and make its surface plane with the help of a ruler.
ii. Place the wooden block on it with its wider side downward (Figure 1).
iii. Put a 1 kg weight on the block.
iv. Pick the block up from the surface of sand carefully and watch the depth of the mark made by block on the sand (Figure 2).
v. Make the surface of sand plane again. Now place the block edgewise on the surface of sand (Figure 3).
vi. Put 1 kg weight on the block and watch the depth of the mark made by it. Is this more than that made by block at its wider side with 1 kg weight? What do you think about the pressure exerted by the same force (weight) on different areas of sand (Figure 4)?
vii. Now place the block again at its wider side. Put 2 kg weight on the block.
viii. Pick up the block and watch the depth of the mark (Figure 5). Is it more than before?
xi. Similarly, place the block edgewise on the plane surface of sand and put 2 kg weight on the block. Pick up the block and watch the depth of the mark (Figure 6).

What do you think about pressure exerted by different forces on the same area?

You will see that when same force is applied, the pressure exerted on smaller area is greater than that on the larger area. When different forces are applied on the same area, the larger force will exert greater pressure than that of smaller force.



Pressure can be defined as the force acting normally on unit area of a surface.

Mathematically;

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

If pressure is denoted by P, force is denoted by F and area is denoted by A, then the above relation can be expressed as:

$$P = \frac{F}{A}$$

Example of Pressure

We can push a drawing pin into a wooden board by pressing it with our thumb. It is because the force we apply on the drawing pin in confined just at a very small area under its sharp tip of the drawing pin. A drawing pin with a blunt tip would be difficult to push into the board due to the larger area of its tip. In this example, we find that the effect of a force is increased if the effective area for the force is reduced. The area of the tip of the pin is very small and hence increases the effect of the force. Thus, the pressure depends upon the force and increases with a decrease in the area on which force is acting.

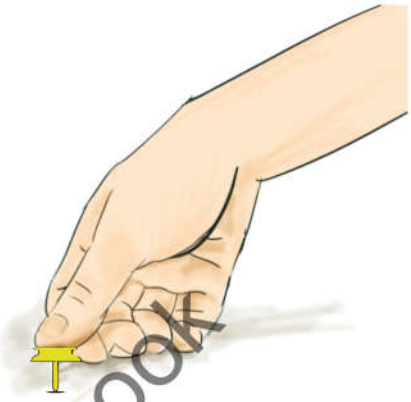


Figure: 8.5

For your information

A woman wearing high heel exerts more pressure on the carpeted floor as compared to a man having same weight but wearing broad heel shoes.

Units of Pressure

Pressure is a physical quantity whose units can be expressed in terms of units of force and area. The unit of force is newton (N) and unit of area is square metre (m^2). As pressure is equal to force per unit area, hence, its unit is newton per square metre. It is the SI unit of pressure. It is also known as pascal, denoted by Pa.

For your information

- When a force of one newton (equal to the weight of a 100 g mass) acts perpendicularly on an area of one square metre, the pressure on this area will be one newton per square metre or one pascal (1 Pa).
- 1 Pa is a very small unit. It is approximately equal to the pressure exerted by a ten rupee currency note lying flat on a table. For this reason, pressure is usually measured in kilo pascals (kPa), a bigger unit of pressure.
- 1 kPa = 1000 Pa

Mini Exercise

Ali's weight is 500 N. He is standing on the ground with an area 0.025 m^2 under his feet. We can find pressure exerted by Ali on the floor as:

$$\text{Pressure} = \frac{\text{Force (weight)}}{\text{Area}}$$

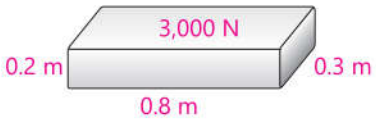
$$= \frac{500\ \text{N}}{0.025\ \text{m}^2} = 20{,}000\ \text{N/m}^2 = 20{,}000\ \text{Pa}$$

What will be pressure exerted by Ali in kilo pascal?

Mini Exercise

A metallic box placed on the floor (as shown in figure) weighs 3000 N.

- What is the pressure exerted by the block lying in this position?
- What will be the pressure exerted by the box if it stands vertically on the smaller face?



8.4 WATER PRESSURE

We observe that the speed of water from a tank coming out of tap on ground floor is greater than the speed of water coming out of a tap on upper storey of our house. Actually, water contained in the tank exerts pressure on its walls. The speed of the water coming out of the tap depends upon the water pressure in the pipe. Moreover, the water pressure of the tap depends upon the height of the water tank above the ground floor. That is why, the water tanks are placed on the roof of the top floor. This pressure is transmitted through the pipes to the tap. We will study different characteristics of water pressure or liquid pressure with the help of following activity:

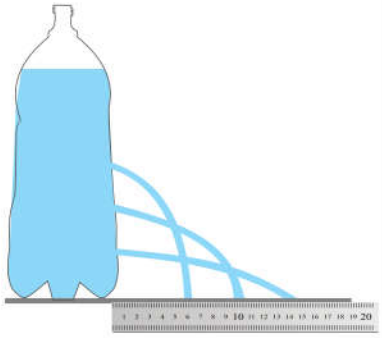
Activity 8.5

Material Required:

2.5 litre plastic bottle, iron nail, insulation tape, metre rule.

Procedure:

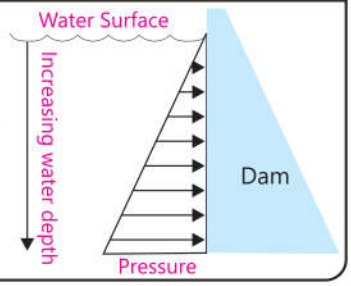
- Punch three holes at different heights on the side of plastic bottle using a nail as shown in the figure.
- Close these holes by pasting insulation tape.
- Fill the bottle with water up to brim and place it on the table..
- Remove the tape and observe the streams of water coming out of the three holes.
- Note the distances of the streams of water striking the table from the bottle.
- Note the angle which each stream of water makes with the surface of the vessel as it emerges out of the hole.



In what direction does water come out of the holes? We can infer from this activity that the greater the depth of the water in the vessel, the greater is the pressure of water. Such liquid pressure which increases with the depth of the liquid in a container is called hydrostatic pressure.

Point to Ponder!

Why the supporting wall of a dam is built very broad at the bottom?



Interesting information.

- Water pressure increases by 10,000 Pa for every one metre down in a lake or in an ocean. That is why the divers feel an increase of pressure on their eardrums even a few metres below the surface of water.
- The deeper you go underwater, the greater is the pressure of the water pushing down on you.

What happens to the balloon when it is inflated by blowing air into it?

Gas particles exert pressure on the walls of the container in which the gas is filled. For example, when a balloon is inflated, the air is added into it. Hence, pressure inside the balloon increases as compared to pressure outside. As a result, the size of the balloon increases.

Figure 8.6

8.5 HYDRAULIC LIFT (ELEVATOR)

Figure 8.7 shows a hydraulic system called hydraulic lift. In this system, a small force F_1 is applied on a small piston which produces pressure P on the oil. Pressure P is transmitted through the oil to a very large cylinder fitted with a piston. Since area of this piston is very large, hence, a very large force is produced by pressure P at this bigger piston. This force may be used to lift very heavy object such as a car.

Since $F_1 = PA_1$ and $F_2 = PA_2$

Dividing the equations: $\frac{F_2}{F_1} = \frac{A_2}{A_1}$

$As\ A_2 >> A_1,\ so\ F_2 >> F_1$

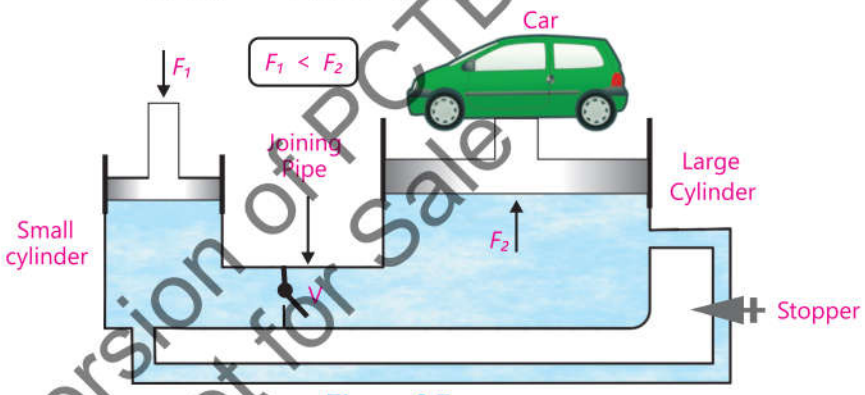


Figure 8.7

The valve V prevents the back flow of oil to the small cylinder so that heavy load remains raised up. When the oil stopper is opened, the oil in the large cylinder flows back to the small cylinder and the load is brought down.

Activity 8.6 - Making a Two-stage Rocket

Material Required:

- Two modeling balloons
- Two straws
- Two large binder clips
- Paper towel tube
- Fishing line or string
- Scissors
- Masking tape
- Balloon pump

Preparation for Work

- Thread the fishing line through the two straws.
- Tie the ends of a fishing line to two sturdy pieces of furniture and keep it tight.
- Cut a small ring from the cardboard tube.
- Stretch the balloons to loosen them before inflating.

Instructions

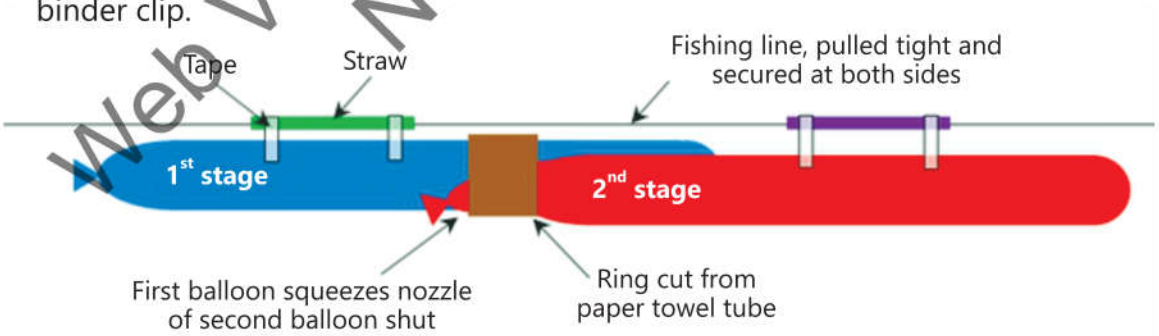
i. Inflate the first balloon about three quarters full. Use a binder clip to pinch the nozzle and prevent the balloon from deflating.

ii. Pull the first balloon's nozzle through the cardboard ring and press it up against the side.

iii. Thread the second balloon partially through the cardboard ring, so its nozzle is facing the same direction as the first balloon

iv. Inflate the second balloon about three quarters full.

v. Keep the nozzle of the second balloon pinched shut, either with your fingers or a binder clip.



vi. Tape the balloon to the drinking straws, with the balloons pointing along the fishing line.

vii. Pull the balloons to one end of the line and release both nozzles.

You will observe that your two balloons behave like the two stages of a rocket. One balloon keeps the other balloon's nozzle pinched shut at first, preventing them both from deflating at the same time. So, that first balloon deflates first, acting like the first stage of the rocket and pushing both balloons along the string. After it has deflated, the second balloon's nozzle is released, and it acts like second stage of the rocket.

8.6 EXAMINE THE EffECT OF FORCE IN THE PRESENCE OF AIR PRESSURE

Air exerts pressure. The air pressure can be felt by blowing air into a balloon or pumping air into a bicycle tyre as it inflates. The greater the amount of air is pushed in, the greater becomes the air pressure. If the air is filled in excess of a certain limit, the balloon or tyre may even burst. When air is filled in a balloon or tyre, the air molecules within it are free to wander about. In the course of their movement, they collide with one another and with the walls of the container. Thus, they exert force against every part of the wall area. The idea of pressure takes into account the force, as well as the area over which the force acts. The pressure has no direction. In other words, the pressure exerts force in all the directions at a point. Because of its pressure, the air in a tyre applies a force to any surface with which it is in contact. We know that air is present over the Earth's surface. It exerts pressure which is known as atmospheric pressure. Let us explore the effect of force in the presence of air pressure by the following activities:

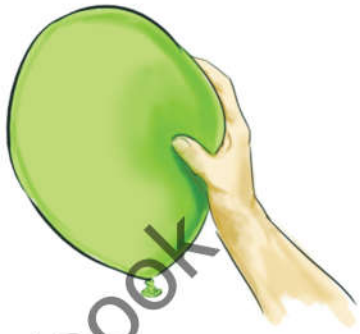
Do you know?

When a paratrooper jumps down into air from a certain height, he opens the parachute a few moments after the jump. During this short interval, the paratrooper gains some speed downwards due to force of gravity that is the weight.

In the absence of air, the paratrooper should fall down with acceleration due to gravity and his speed go on increasing. But in fact, after a short time the paratrooper gains a constant speed and lands on the ground safely. The air provides an opposing force to the downward force of gravity and a stage comes when the opposing force become exactly equal to the downward force in magnitude. In this way, the effect of downward force of gravity becomes zero. Therefore, no net force acts on the paratrooper and he/she falls down with constant speed.

Activity 8.7

1. Take an inflated balloon.
2. Hold it in your hand and press it gently. Do you feel any opposing force (resistance) by the balloon?
3. Now press the balloon a bit harder. Do you feel some greater opposing force?



Yes, when you apply a certain force in the presence of air pressure, you face an opposing force or resistance.

Thus, the effect of the applied force decreases.

KEY POINTS

- When balanced forces are acting on an object, there is no change in its direction and speed of an object.
- The unbalanced forces mean the force acting in one direction is greater than force acting in the opposite direction.
- Density is mass per unit volume.
- An object floats when it displaces volume of water that has a mass equal to the mass of the object.
- The force per unit area acting normally on the surface of an object is called pressure.
- The SI unit of pressure is called pascal which is denoted by Pa.
- Water contained in a vessel exerts pressure on the walls of the vessel.
- The water pressure in a vessel increases with the increase in depth.
- The branch of science which deals with the transmission of pressurized liquids through pipes as a source of mechanical force is called hydraulics.
- The particles of a gas in a container collide all the time with each other and with the walls of the container. The force of these collisions produces pressure on the walls of container.
- The weight of the air column per unit area on a surface is called atmospheric pressure.
- Atmospheric pressure decreases with the height above the ground.

QUESTIONS

1. Encircle the correct option.

(i) Two equal forces act at the same time on the same stationary object but in the opposite directions. Which statement describes the object's motion?

(a) The object changes direction
(b) The object accelerates
(c) The object remains stationary
(d) The object moves at a constant speed

(ii) A student pushes against a tree with a force of 10 newtons (N). The tree does not move. What is the amount of force exerted by the tree on the student?

(a) 0 (b) 5 N (c) 10 N (d) 20 N

(iii) What causes objects to move?

(a) Velocity (b) Unbalanced forces
(c) Balanced force (d) Friction

(iv) The pressure at the bottom of the tank containing a liquid does not depend on:

(a) area of the bottom surface (b) height of the liquid column
(c) nature of the liquid (d) acceleration due to gravity

(v) The SI unit of pressure is:

(a) watt (b) joule (c) pascal (d) newton

(vi) When same amount of force is applied on different areas, it exerts:

(a) low pressure on small area (b) no pressure on small area
(c) high pressure on small area (d) high pressure on large area

(vii) A force of 1800 N is acting on the surface area of 0.06 m^2. The pressure exerted by the force will be:

(a) 3 kPa (b) 30 kPa (c) 300 kPa (d) 3000 kPa

(viii) People on hills experience atmospheric pressure:

(a) more than that at the sea level
(b) less than that at the sea level
(c) same as that at the sea level
(d) four times more than that at the sea level

(ix) As we go up in the air:

(a) atmospheric pressure increases
(b) atmospheric pressure decreases
(c) atmospheric pressure does not change
(d) atmospheric pressure becomes zero at the height of 1 km

2. Write short answers.

(i) Can a balanced force produce change in motion?

(ii) How can a normal force be balanced?

(iii) Does a car slowing down experience a balanced force?

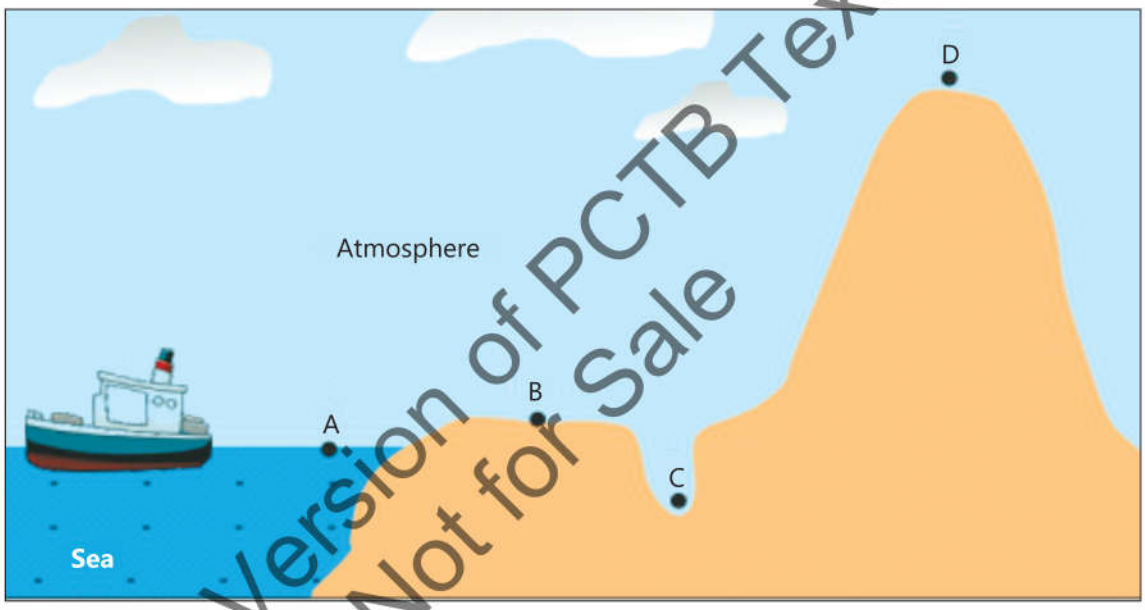
(iv) Define pressure.

(v) If two forces act in the opposite directions on an object, what will be the net force acting on it?

3. Constructed response questions

(i) Does the size of an object affect its ability to float / sinking?

(ii) In the figure shown below, indicate the location where atmospheric pressure is expected to be the lowest.



(iii) Sketch the forces acting on a paratrooper.

Are these forces balanced or unbalanced?

(iv) If the forces acting on the paratrooper are balanced forces, how does the paratrooper then fall down?

(v) Describe how does a bulky camel easily travel in deserts.

4. Project

Demonstration of basic principle of hydraulic push.

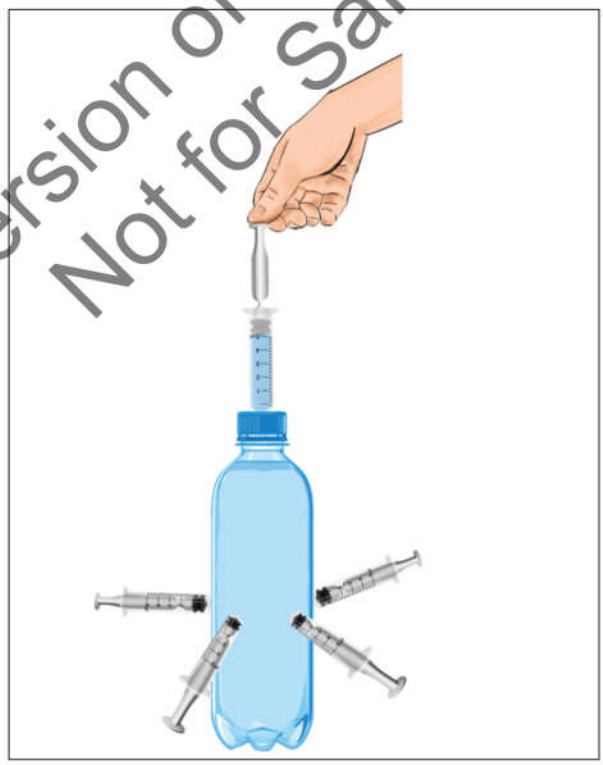
Background: In vehicles, hydraulic brake system is used. When the piston of master cylinder is pushed in by our foot, the pressure is applied on the brake fluid inside it. The fluid transmits the pressure equally to all the four cylinders attached to the brake drums of the wheels. As a result, brake shoes are pressed.

Let us make a project to demonstrate this phenomenon by an experiment.

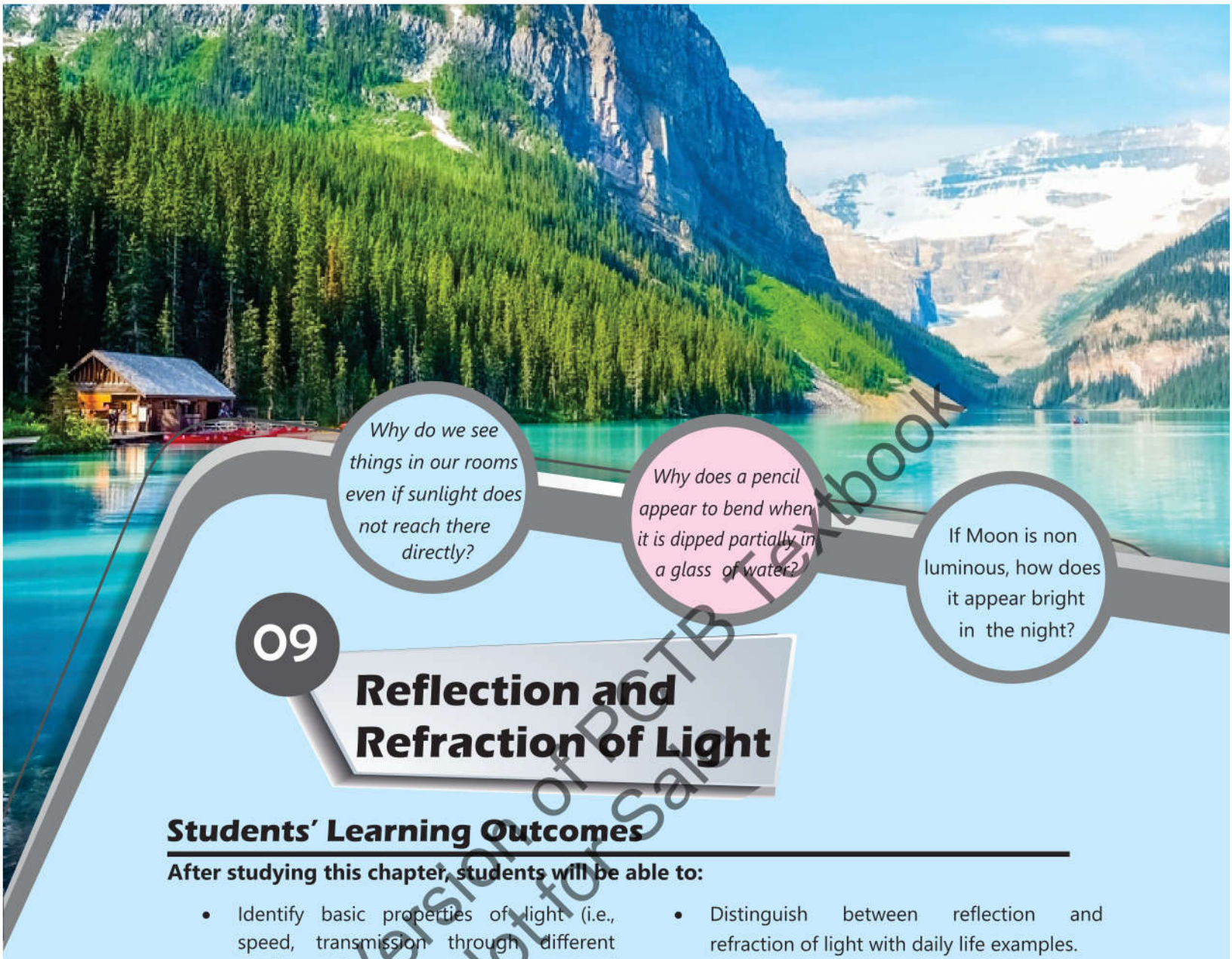
Material Required

1 syringe (10mℓ) without needle, 4 syringes, glue and scotch tape.

Using the materail, make a hydraullic brake system as shown in the figure.



This shows that the pressure applied on one point on an incompressible fluid in a closed container is transmitted equally to all the points of the fluid.



09

Reflection and Refraction of Light

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Identify basic properties of light (i.e., speed, transmission through different media, absorption, reflection and dispersion).
- Describe and show how an image is formed by the plane mirror.
- State the laws of reflection.
- Describe different optical instruments which use curved mirrors.
- Relate the apparent colour of objects to reflected or absorbed light.
- Explain that light is refracted at the boundary between air and any transparent material.
- Distinguish between reflection and refraction of light with daily life examples.
- Illustrate the characteristics of image formed by plane mirror.
- Investigate that light is made up of many colours. Relate the apparent colour of objects to reflected or absorbed light.
- Identify spherical mirror. Describe the characteristics of image(s) formed by concave mirrors and convex mirrors.
- Describe use of different optical instruments in which spherical mirrors are used.

Light is a form of energy that enables us to see objects around us. When light from a source falls on an object, some of the light gets reflected. The reflected light enters our eyes and we are able to see that object (Figure 9.1).

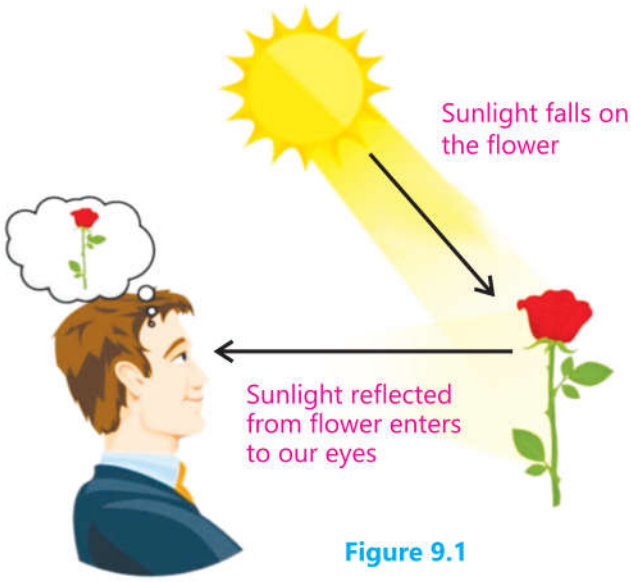


Figure 9.1

Interesting information.

It takes about eight minutes for light from the Sun to reach the Earth.

9.1 SPEED OF LIGHT

Nothing can travel faster than the **speed of light** in space. It travels straight with a speed of 300,000 kilometres per second (km/s). It is denoted by "c". The light passing through a material such as air, water or glass however, travels relatively slowly. It is because the light scatters and is slowed down by the atoms in the material as it passes through them.

Do you know?

- The speed of light through air is about 300,000 km/s.
- The speed of light through water is about 225,000 km/s.
- The speed of light through glass is about 200,000 km/s.

9.1.1 Transmission, Absorption and Reflection

Light does not need a material medium to travel. It can travel through a vacuum too. When light emerging from a source hits an object, it can be transmitted, absorbed, reflected, refracted or dispersed.

When light falls on transparent objects such as air, water, glass, etc., it passes through them unchanged (Figure 9.2). It is called **transmission** of light. That is why, we can see across the transparent objects. Translucent objects such as frosted glass, thin curtain, tracing paper etc. allow only some part of light to pass through them. That is why we do not see clearly across them.

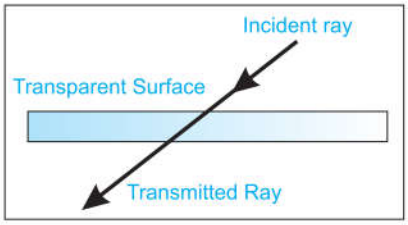


Figure 9.2

When light falls on an opaque object, most part of the light is absorbed (Figure 9.3). That is why we cannot see through them. When light is absorbed, heat is generated. Black substances absorb most of the light. What do you see when you look at the mirror? You see your image. It is due to **reflection**. The

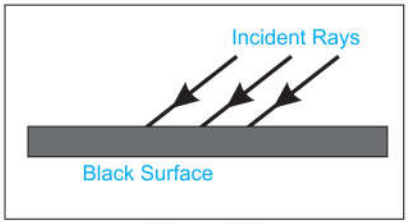


Figure 9.3

bouncing back of light from a smooth shiny surface is called reflection (Figure 9.4). Some surfaces absorb and reflect sunlight partially. Mirror, however, reflect almost all the light that hits it. That is why, you see your reflection in it. If an object reflects all colours it appears white. If an object absorbs all colours, it appears black.

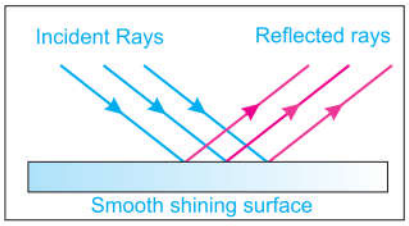


Figure: 9.4

Can you tell? Why can you see your reflection in some surfaces and not in others?

9.2 OCCURANCE OF REFLECTION

Reflection occurs when the ray of light strikes a smooth and shiny surface and bounces off in a particular direction. The ray of light that strikes the reflecting surface is called the **incident ray**. The ray that bounces off after striking the reflecting surface is called the **reflected ray**. The point at which incident ray strikes is called the point of incident. Imagine a line that is drawn perpendicular to the surface at point of incidence. This line is called Normal. It is denoted by 'N. The incident ray and the normal form an angle called the angle of incidence, denoted by '∠i'. The reflected ray and the normal form an angle called the angle of reflection, denoted by '∠r'.

9.2.1 Laws of Reflection

There are two laws of reflection.

1. The angle of incidence is equal to the angle of reflection, i.e; ∠i=∠r (Figure 9.5)
2. The angle of incidence, the angle of reflection and the normal all lie on the same plane.

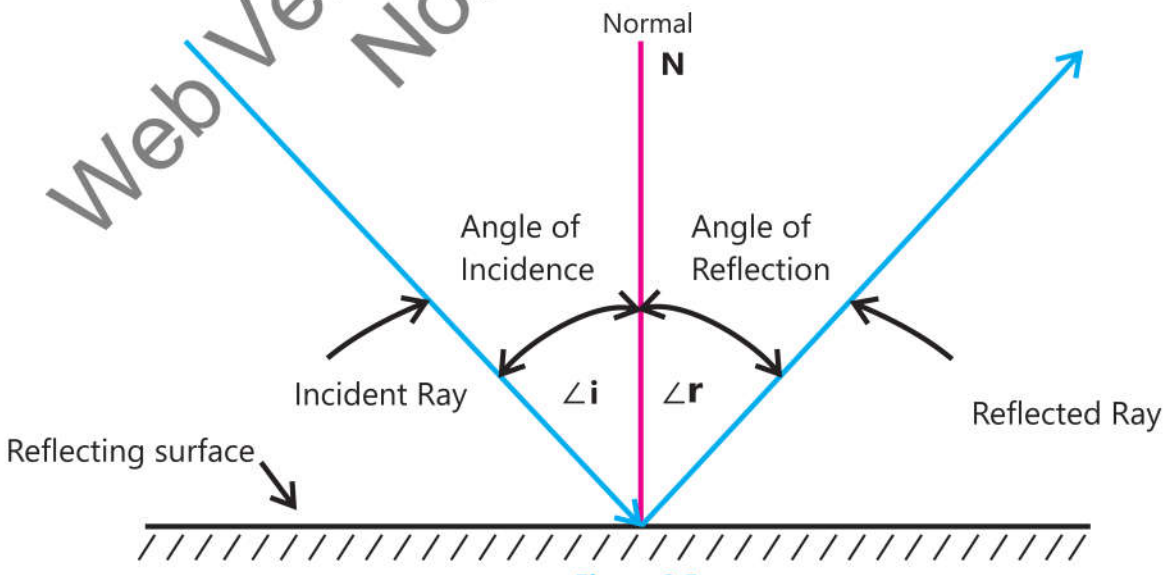


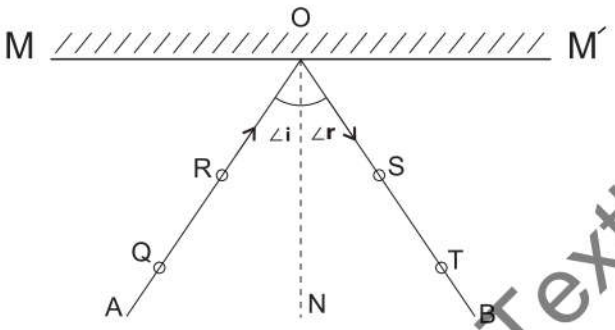
Figure 9.5

Activity 9.1

Experimental Verification of Laws of Reflection

Material Required

- white paper
- drawing board
- common pins
- drawing pins
- plane mirror strip



Procedure

1. Take a sheet of white paper and fix it on a drawing board using the drawing pins.
2. Draw a straight line MM′ on the paper.
3. Place a small plane mirror strip vertically with its silvered surface on the line.
4. Fix two common pins Q and R on the paper in front of the mirror.
5. Observe the image of Q and R through the other side of the mirror and fix two more common pins S and T in such a way that the image of all the four common pins Q, R, S, and T appears in a straight line.
6. Remove the common pins from the board and mark their positions.
7. Draw a normal ON at the point O.
8. Draw line AO joining QR and BO joining ST with MM' on the point O.
9. Measure the angle of incidence ∠AON and the angle of reflection ∠BON.
10. Repeat the activity with different angles of incidence and measure the corresponding angles of reflection. Note the angles in the given table.

Sr No.	Angle of incidence i=∠AON	Angle of reflection r=∠BON
1.		
2.		
3.		

Observation

The angle of incidence is the same as that of angle of reflection i.e; ∠i =∠r. This verifies the first law of reflection. As the activity performed on a sheet of paper being fixed on the drawing board so the lower tips of all the four common pins lie on the same plane (i.e., the plane of the paper). Therefore, the incident ray, the reflected ray and the normal, all lie on one plane. This verifies the second law of reflection.

Note: Angle between surface and normal is always equal to 90 degree.

Find out

1. What will be the angle of reflection for the incident angle 45^0?

Ans. Angle of incident $\angle i = 45^0$

Angle of reflection $\angle r = ?$

We know that: $\angle i = \angle r$

Therefore

$\angle r = 45^0$.

2. What will be the angle of incidence for the reflected angle 40°?

Ans. Angle of reflection $\angle r = 40^0$

Angle of incidence $\angle i = ?$

We know that: $\angle i = \angle r$

Therefore

$\angle i = 40^0$

3. What will be the angle of incidence if the angle between the mirror surface and the incident ray is 40°?

Ans. Angle between the mirror surface and incident ray = 40°

Angle of incidence $\angle i = ?$

We know that:

$\angle i$ + Angle between mirror and incident ray = 90^0

Therefore, $\angle i + 40^0 = 90^0$

$\angle i = 90^0 - 40^0$

$\angle i = 50^0$

Hence, the incident angle $\angle i$ is 50^0.

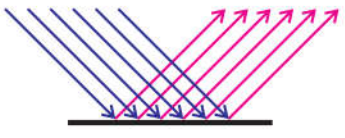
9.2.2 Regular and Diffused Reflection

There are two types of reflection:

1. Regular Reflection 2. Diffused Reflection

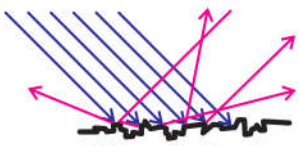
In regular reflection, the reflected light rays are also parallel if the incident light rays are parallel. The regular reflection is always clear. Smooth surfaces reflect the rays of light to form the regular reflection (Fgure 9.6). For example, the reflection by mirror is **regular reflection.**

In diffused reflection, the reflected light rays are not parallel. The diffused reflection is not clear. Rough surfaces reflect the rays of light in different directions and form the diffused reflection (Fgure 9.7). For example, the paper, cardboard, plastic, wood, etc. produce diffused reflection.



Regular Reflection (Smooth surface)

Figure 9.6



Diffuse Reflection (Rough surface)

Figure 9.7

Can you tell?

Why we cannot see our images in a plastic sheet clearly?

Do you know?

According to the law of reflection, the incident ray, normal and the reflected ray all lie on the same plane. Do you think diffused reflection is the failure of the law of reflection? No, diffused reflection is not the failure of law of reflection because the normal for each ray is in different direction, each ray obeys the law of reflection.

Interesting information.

In case of regular reflection, an image can be obtained. In case of diffused reflection image cannot be obtained because reflected rays are not parallel even if incident rays are parallel.

9.2.3 Application of Regular and Diffused Reflection

There are many applications of regular and **diffused reflections** in everyday life. We look our image in the mirror due to regular reflection of light. We can turn the sunlight towards the dark places by the regular reflection of light with the help of shiny surfaces. We can see things on cloudy day due to diffused reflection of light. We can see things before the sunrise and even after sunset due to the diffused reflection of light.

9.2.4 Image Formation by a Plane Mirror

Whenever you see in a mirror, you probably look at your reflection in a plane mirror. How does a plane mirror form an image? What is a plane mirror?

A plane mirror is a smooth flat reflecting surface made up of sheet of glass with a shiny metallic coating on the back. The mirror shows the image of the object that is placed in front of it. The appearance of an image in the mirror is called a reflection. The reflection happens when light (incident ray) coming from the object placed in front of the mirror hitting the reflecting surface (mirror) bounces off (Figure 9.8).

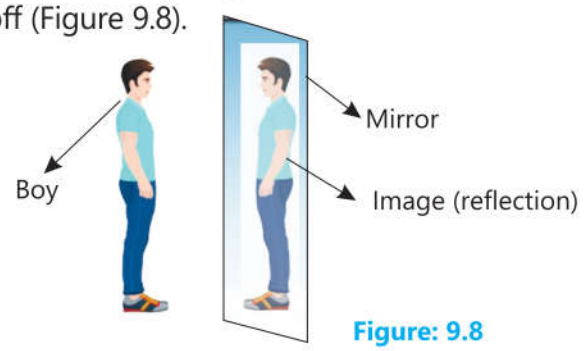


Figure: 9.8

An image formed by a plane mirror has following characteristics:

- The image is formed behind the mirror.
- The image size is equal to the object size.
- The image distance from the mirror is equal to the object distance from the mirror.

- The image is virtual (not real).
- The image is upright (straight).
- The image is laterally inverted (left to right).

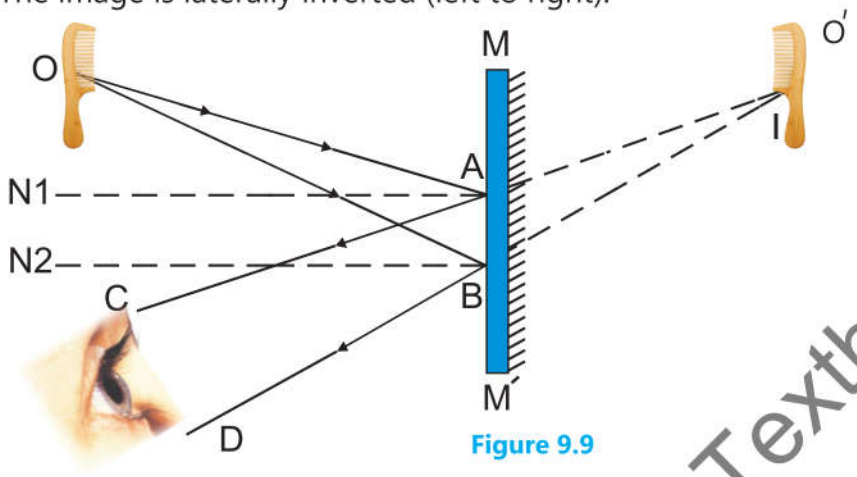


Figure 9.9

O = Object
I = Image
OA = incident ray
OB = incident ray
AC = reflected ray
BD = reflected ray
N1 = normal 1
N2 = normal 2

Suppose an object O is placed in front of a mirror MM′. The rays from object O hit the mirror at points A and B. A ray from point A reflects and goes to direction of AC. Similarly the ray from point B reflects and goes to direction of BD. Both the rays AC and BD do not meet and keep moving farther away from each other. When these reflected rays are extended behind the mirror, they appear to meet at point I and form the image. The formation of the image is behind the mirror. It is virtual, upright and laterally inverted. Image size and distance size are also equal (Figure 9.9).

Do you know?

Silver and aluminium are used to coat the backside of the mirror. This process is called silvering. After silvering a thin layer of red lead oxide is also applied at the back of the mirror.

Interesting information

The image formed behind the plane mirror is laterally inverted. It means if you raised your left hand, it would appear that you have raised your right hand in the mirror.

Can you tell?

At what distance your image will be formed behind the mirorr if you are standing at a distance of 3 metres from the plane mirror?

9.3 OPTICAL INSTRUMENTS USING PLANE MIRROR

"Plane mirror is used in many optical instruments like periscope and kaleidoscope, etc.

9.3.1 Periscope

We can see objects which are higher than our eyes with the help of a periscope in a crowd or behind a wall. A simple **periscope** consists of a tube, at the ends of which are fitted two plane mirrors. The first mirror turns light coming from the object towards the second. The

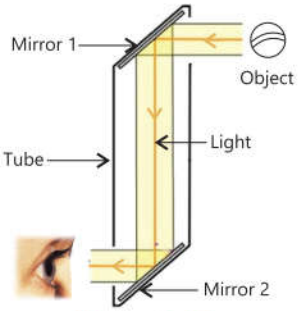


Figure 9.10

second mirror turns it to our eyes. As shown in the Figure 9.10. Periscopes are used in submarines, tanks, etc.

9.4 REFRACTION

Have you ever observed, when a pencil is dipped partially in a glass of water, it appears to be bent and short? Why does coin kept at the bottom of a bowl appear to be raised? Why do fish in an aquarium appear bigger than their original size? It is all due to **refraction**. What is refraction?

Figure 9.11

The change in direction of light when it enters from one medium to another is called refraction. Light travels slower in air than in vacuum and even slower in water. As light travels into a different medium, the change in speed bends the light. For example, light travelling through air refracts when it hits water. This makes a pencil in a glass of water, to appear bend.

9.4.1 Refraction In Different Mediums (Air and Glass)

Normally, light travels in a straight line. However, it is refracted at the boundary between air and any other **transparent** material. For example, when light passes from air to water or a glass, it bends towards the normal. The angle of incidence is greater than the angle of refraction $\angle i > \angle r$ (Figure 9.12 a). When light passes from water or glass to the air, it bends away from the normal. In this case, the angle of refraction is greater than the angle of incidence. $\angle r > \angle i$ (Figure 9.12 b).

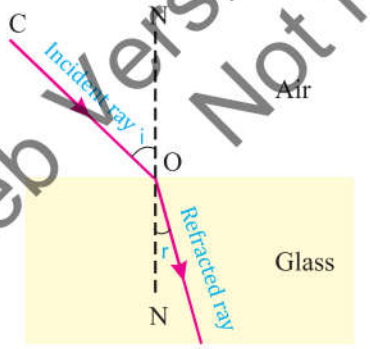


Figure 9.12 a

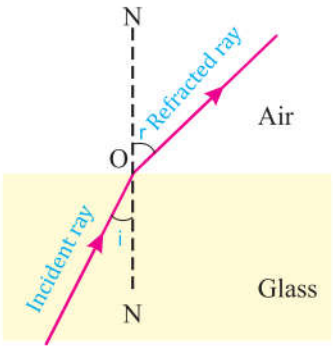


Figure 9.12 b

9.4.2 Laws of Refraction

There are two laws of refraction:

1. The incident ray, the refracted ray and the normal all lie on the same plane.
2. The ratio of speed in vacuum or air to its speed in another transparent medium is always constant. This constant is known as refractive index of that medium.

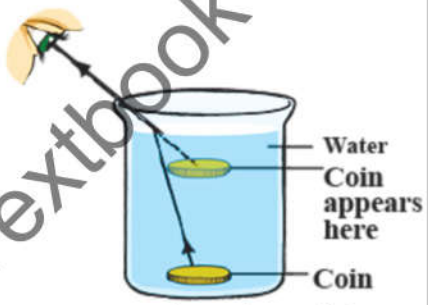
Activity 9.2

Place an empty clear drinking glass over a piece of a newspaper. When you look through the side of the glass near the bottom, you can see the printing on the newspaper. What would happen, if you fill the glass with water? Try it and observe. How can you explain the result?

Activity 9.3

Effect of Refraction:

Place a coin at the bottom of a beaker. Position your eye so that the coin is just not visible to you. Without displacing your eye, fill the beaker with water. What do you see?



Observation: You will see the coin clearly.

Conclusion

When there was no water in the beaker, you were not able to see the coin because no rays of light could reach your eye. The edge of the beaker blocked the rays. When you filled beaker with water, the change of medium occurred. Now light travels from water into air. Due to refraction, the ray bends and enters into your eyes. This makes coin visible to you.

9.4.3 Examples of Refraction from Daily Life

You can find examples of refraction all around you. Let's consider a few examples of refraction from daily life.

Twinkling of stars

In reality the stars do not twinkle but they appear to twinkle when they are seen from the surface of the Earth (Figure 9.13).

Figure 9.13

The twinkling of the stars takes place due to refraction. The starlight rays pass from the stars to the Earth. In between they have to pass through vacuum and atmosphere. The atmosphere contains different layers of air having different densities and temperatures. Due to this the starlight rays bend (refracted) many times in random direction before they reach the Earth. Hence the stars look twinkling.

Seeing a fish under water

A fish in water appears to be closer to the surface than it actually is. It is due to the refraction of light rays as they travel from water to air (Figure 9.14).

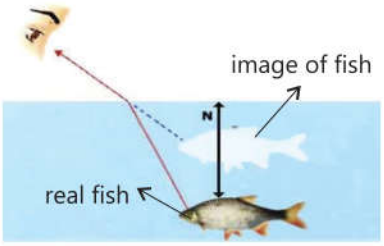
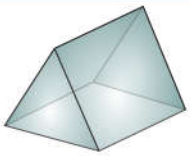


Figure 9.14

Interesting information.

A prism is a piece of glass or other transparent material having 3D shape with two identical shapes facing each other. These identical shapes are called bases. The bases can be triangle, square, rectangle of any other shape. Other faces of a prism are rectangles.



Dispersion of light

The phenomenon of splitting light into its component colours is called dispersion of light. It is also seen in **rainbow** (Figure 9.15).

The light of the Sun looks white but it is a mixture of different colours. When white sunlight passes through a prism, it splits into seven colours due to dispersion. The band of seven colours obtained through dispersion of light is called spectrum. These colours are red, orange, yellow, green, blue, indigo and violet.

Interesting information

You can remember the order of the spectrum by the name ROYGBIV

R = Red O = Orange

Y = Yellow G = Green

B = Blue I = Indigo

V = Violet

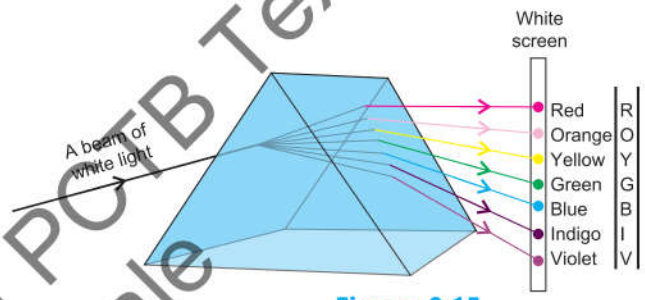
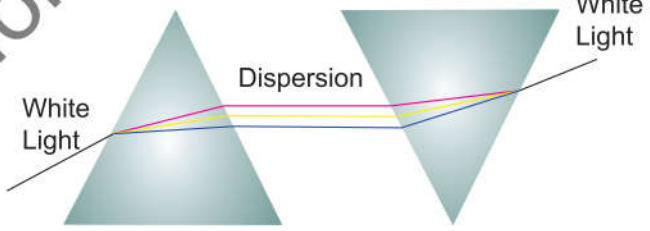


Figure: 9.15

Interesting information

When we place a prism through which spectrum of light is coming out, in combination with another prism, the seven colours of light recombine forming a white light.



Activity 9.4

To View Spectrum of Light Through Prism

Take a glassprism and place it on the table facing an open window so that the sunlight falls on any of the three faces of the prism. Look into the prism. Move yourself to a side till you view the spectrum of light through the prism. Can you identify the colours of the light?

9.4.4 Rainbow

A rainbow is a natural demonstration of refraction. It appears in the sky after a rain. It is always formed in a direction opposite to that of the Sun. After the rain there are millions of droplets of water in the air. Each droplet acts like a prism. When the Sun rays enter the droplets, they are

refracted and dispersed. They are then reflected internally and finally refracted again when they come out of the droplets and rainbow is visible to the observers. Since red colour bends the least and violet colour bends the most from their original path, so in the rainbow, the red colour remains at the top and violet colour remains at the bottom.

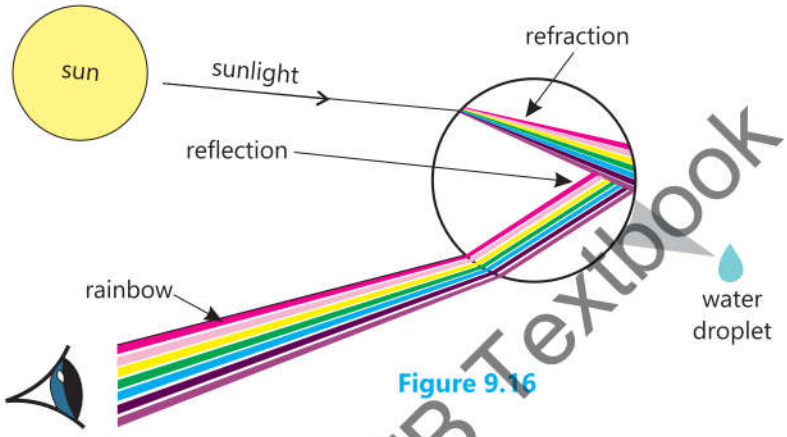


Figure 9.16

Can you tell?

Why a rainbow is only observed after rain fall?

Do you know?

Isaac Newton in 1665 suggested that white light is a mixture of seven colours.

Interesting information.

Rainbow is seen after rain in the sky in the morning or evening. It forms a complete circle. However, only half is seen. It consists of seven colours. The arrangement of the colours in the rainbow is same as in the spectrum obtained when a ray of light falls on a prism.

Why do objects have Colour?

Have you ever thought why does grass look green or a rose look red? It is because everything reflects light. When light strikes an object that is not transparent, the object absorbs some of the light. The light that is not absorbed is reflected. The colour of an object that we see is the light that is reflected from the object. For Example, if we look at green grass, it absorbs all other colours but reflects only green, that we see. Similarly, a red rose absorbs all colours but reflects only red. An object that reflects all the light that strikes it looks white, while one that reflects none of the light that strikes it looks black.

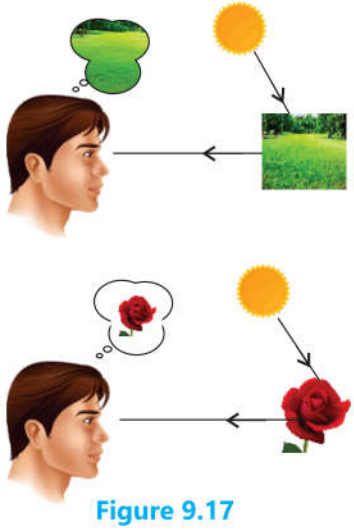


Figure 9.17

9.5 SPHERICAL MIRRORS

Spherical mirror is a type of mirror that has the shape of a piece cut out of a spherical surface. It has a curve. There are two types of spherical mirrors:

- Concave mirror
- Convex mirror

Each type of spherical mirror reflects images in a different way. This is due to the curved surface of the mirror

9.5.1 Concave Mirror

Concave mirror is like the inside of the spoon. Its inner curved surface is reflecting. It produces different kinds of images, depending upon the distance of the object from the mirror. The image may be smaller, larger or same size of the object. Images are seen inverted (Figure 9.18 a). The centre of the curved surface is called pole P. The centre of the spherical surface whose part is the concave mirror is called centre of curvature C. A straight line joining P and C is called the principal axis.

9.5.2 Convex Mirror

Convex mirror is like the outside of the spoon. Its outer curved surface is reflecting. It produces smaller images. Images always appear erect and virtual(Figure 9.18 b).

Figure: 9.18 a

Figure: 9.18 b

9.5.3 Image Formation in Concave and Convex Mirrors

A concave mirror can form real as well as virtual image, but a convex mirror only forms a virtual image.

Images with a concave mirror

When light rays strike a concave mirror parallel to its principal axis, after reflection they pass through a common point infront of the mirror. This common point is called the **principal focus**. It is denoted by 'F' (Figure 9.19). A concave mirror has a real principal focus 'F'. That is why it can form real images on a screen. The characteristics of an image depend upon the distance between the object and the mirror.

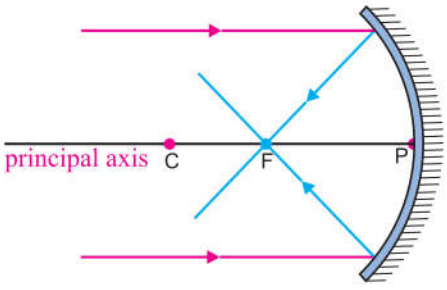
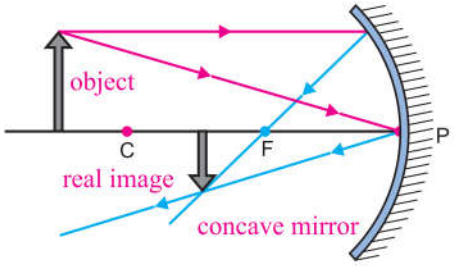


Figure 9.19
Reflection of light from a concave mirror

1. If the object is beyond the principal focus (F), the image formed is real, smaller and upside down (inverted).



2. If the object is very near to the concave mirror, the image forms behind the mirror. It is virtual, upright and bigger in size.

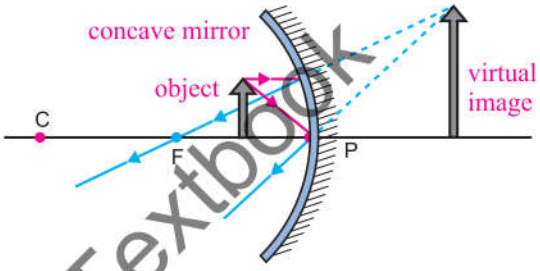


Image with a convex mirror

Convex mirror always diverge light rays. When light rays parallel to the principal axis strike a convex mirror, after reflection they diverge in such a way that they appear to come from a point behind the mirror. This common point is called the principal focus 'F' of the convex mirror (Figure 9.20).

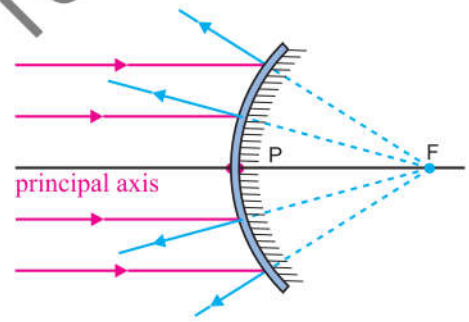


Figure 9.20
Reflection of light from a convex mirror

A convex mirror always produces a virtual, upright and smaller image of the object at any distance in front of it. The image is located behind the mirror (Figure 9.21).

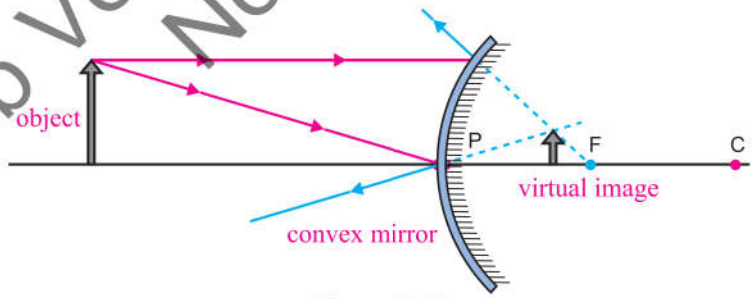


Figure 9.21

9.5.4 Uses of Spherical Mirrors

Spherical mirrors are used for different purposes in our daily life. Lets have a look.

1. Concave mirrors are used as shaving mirrors or make up mirrors.
2. Concave mirrors are used by the dentist to examine the teeth of the patient.
3. Concave mirrors are widely used in the headlights of automobiles and motor vehicles, torchlights, railway engines, etc.

Shaving Mirror

Dentist Mirror

Torch Mirror

4. Convex mirrors are used as rear-view mirrors in vehicles to see the traffic behind for safe driving.
5. Convex mirrors are used as security mirrors in shops.
6. Convex mirrors are used as blind corner mirrors on the roads to help the drivers view traffic around the sharp corners.
7. Convex mirrors are used in street lamps as reflector. So, the light from the lamps diverges over a large area.

Rear view mirror of a vehicle

Blind Corner Mirror

Security Mirror

KEY POINTS

- Light is a form of energy that enables us to see objects around us.
- Speed of light is 300,000 km/s. It is denoted by c.
- When light falls on transparent objects, it passes through them . It is called transmission of light.
- When light is absorbed and converted into heat energy, it is called absorption of light.
- The bouncing back off light from a smooth shiny surface, is called reflection of light.
- The ray of light that strikes the reflecting surface is called incident ray.
- The ray of light that bounces off after striking is called reflected ray.
- The angle between incident ray and normal is called angle of incidence.
- The angle between reflected ray and normal is called angle of reflection.
- The first law of reflection is that the angle of incidence is equal to the angle of reflection i.e., $\angle i = \angle r$
- Whenever light reflects, it obeys 'Laws of Reflection'.
- Transparent objects transmit, rough opaque objects absorb and shiny surfaces reflect the light.
- A plane mirror has a smooth and flat surface to reflect the light regularly.
- A periscope and a kaleidoscope are devices which use reflection for their working.
- A curved mirror is a part of a curve. Curved mirrors are of two types: concave mirror and convex mirror.
- A convex mirror forms a virtual image while a concave mirror mostly forms real images.

QUESTIONS

1. Encircle the correct option.

(i) Through which of the following the light travels the fastest?

(a) Air (b) Vacuum
(c) Water (d) Prism

(ii) What is the colour of an object that absorbs all the light that hits it?

(a) Black (b) Green
(c) White (d) Red

(iii) Which of the following type of mirror can form an image larger than the object?

(a) Concave (b) Convex

(c) Plane (d) All of these

(iv) Which of the following is true for an image in a plane mirror?

(a) It is formed when light is blocked by an opaque object.

(b) It is formed when light passes through a transparent object.

(c) It is of the same shape, size and colour as the object.

(d) It is always black.

(v) What happens when light hits a shiny or smooth surface?

(a) It is disappeared (b) It is refracted

(c) It is absorbed (d) It is reflected

(vi) How is the angle of incidence related to the angle of reflection?

(a) It is greater (b) It is smaller

(c) It is same (d) None of these

(vii) Which of the following describes the image of the boy formed by the plane mirror?

(a) It will be upside down

(b) It will be in front of the mirror

(c) It will be larger than the boy

(d) It will be horizontally reversed left to right

2. Write short answers.

(i) Write the difference between

(a) transmission and absorption (b) reflection and refraction

(ii) State the laws of reflection.

(iii) What is the dispersion of white light? What is the cause of such dispersion?

(iv) Name the process which is involved in the formation of a rainbow. Which two conditions are necessary for the formation of rainbow?

(v) Describe applications and uses of spherical mirrors in daily life.

(vi) Give examples of refraction in daily life.

(vii) Name three types of mirrors about which you have studied, and state the characteristics of the image formed in each one of them.

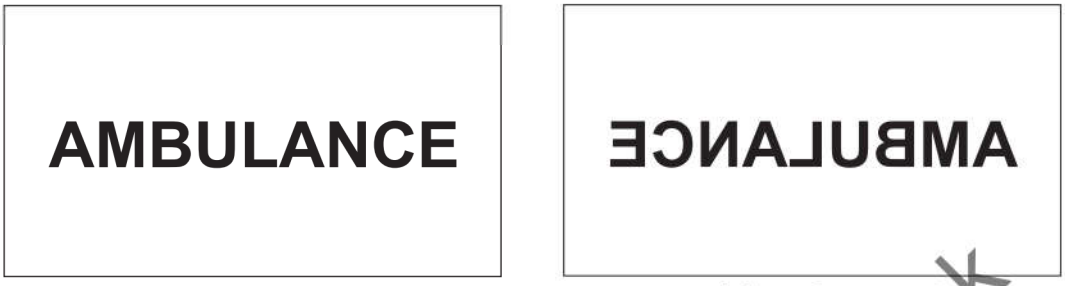
3. Constructed response questions

(i) How will you use two identical prisms so that a narrow beam of white light incident on one prism emerges out of the second prism as white light?

(ii) Explain the phenomenon taking into consideration that the angle of incidence is equal to the angle of reflection.

(iii) Why the rainbow is not seen at noon even there is Sun in the sky and moisture in the air?

(iv) Look at the following images:



Real Image Mirror Image

On vehicles the word "**AMBULANCE**" is written in the form of mirror image. Explain the reason.

(v) Why dispersion can take place from prism but not through a glass slab?

(vi) What does make the black words written in a book visible to you?

4. Investigate

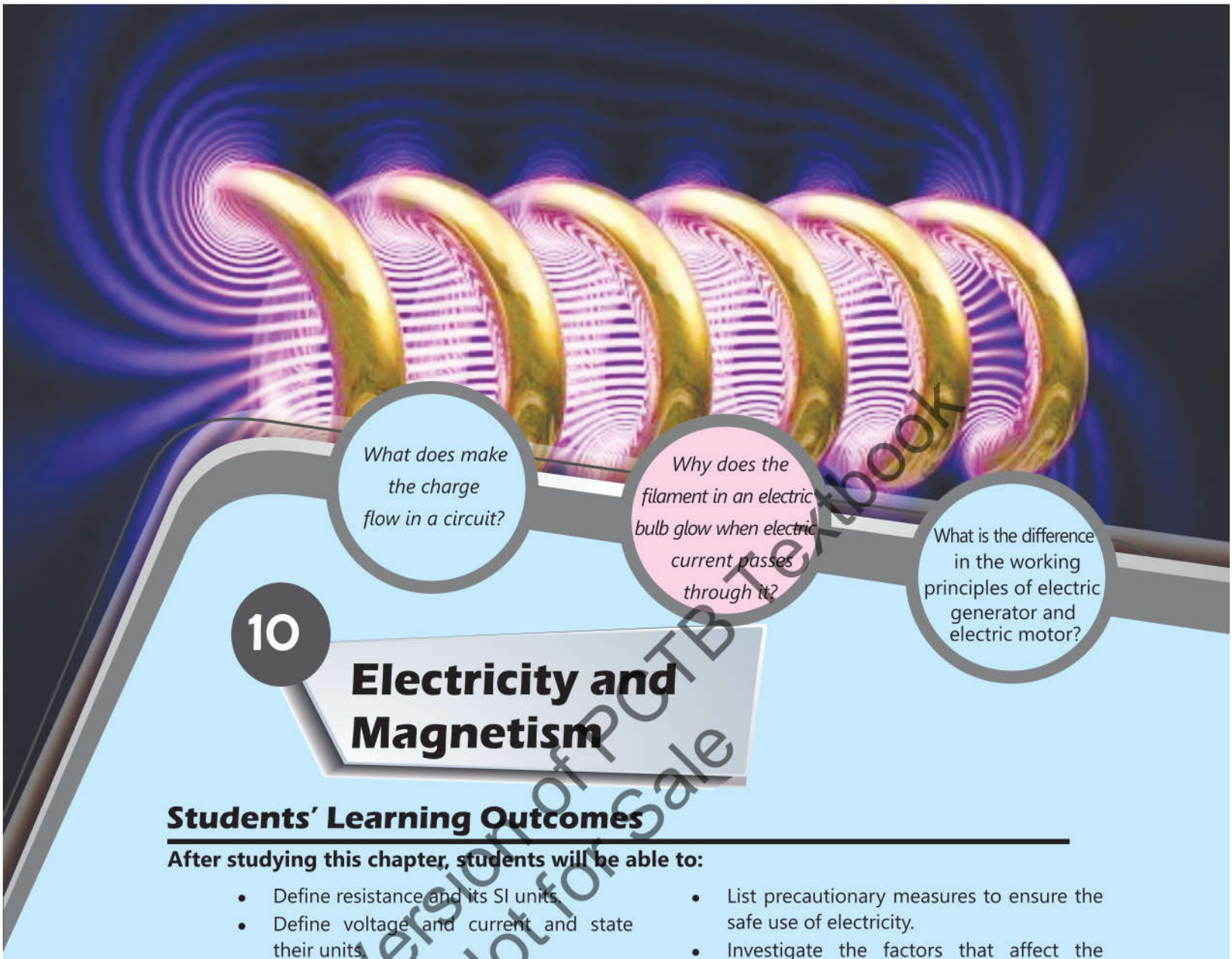
(i) Place a black plastic bowl and a white plastic bowl containing the same amount of water in the sunlight. After 15 minutes, check the temperature of both the bowl. Which bowl absorbs more light and which bowl reflects less light?

(ii) A and B are two bodies facing the mirror. They are standing in such a way that A can see B and B can see A. Explain the phenomenon. Make a ray diagram.

Mirror

Project

Make a kaleidoscope by using three plane mirror strips, a hollow tube, colours beads, glue or cellotape.



What does make the charge flow in a circuit?

Why does the filament in an electric bulb glow when electric current passes through it?

What is the difference in the working principles of electric generator and electric motor?

10

Electricity and Magnetism

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Define resistance and its SI units.
- Define voltage and current and state their units.
- Formulate that resistance is the ratio of voltage to current.
- Define electric power and state its units.
- Recognize the electric power of various electrical appliances.
- Recognize the terms earth wire, fuse and circuit breaker.
- Analyze the danger of overloading and short circuit and identify the importance of earth wire, fuses and circuit breakers.
- List precautionary measures to ensure the safe use of electricity.
- Investigate the factors that affect the strength of an electromagnet.
- Describe the properties that are unique to electromagnets (i.e., the strength varies with current, number of coils, and type of metals in the core; the magnetic attraction can be turned on and off; and the poles can switch).
- Describe briefly the working principles of electromagnetic devices such as speaker, doorbell.

Everyone of us is familiar with electricity. It is a kind of energy. It is used to light up electric bulbs and tubes. The electric appliances like electric fan, washing machine, refrigerator, television (TV), electric iron, air conditioner, etc. work with electricity. It is commonly known as electric current which moves through metal wires. Charge, electric current, voltage, resistance and electric circuit are the basic terms and tools used to investigate further in this field.

10.1 ELECTRIC CURRENT

When oppositely charged ends of an electric cell are connected through a metal wire, charge begins to flow through the wire. The rate of flow of charge is known as **electric current**. Electric cell or a battery provides force to move electric charge through metal wires or other metal objects.

The unit of electric current is ampere symbolized as (A). Smaller units of electric current are milliampere (mA) and microampere (μA). Thus:

1000 μA = 1 mA 1000 mA = 1 A

The instrument used to measure electric current is called ammeter (Figure 10.1). It has a pointer that moves over the scale. The position of the pointer on the scale gives the reading of the current passing through the circuit.

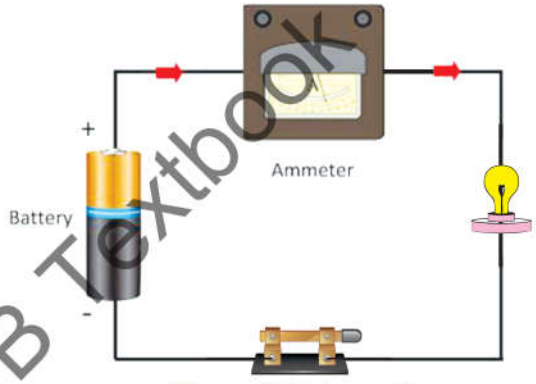


Figure 10.1 Ammeter

10.2 VOLTAGE AND RESISTANCE

The ability of an electrical source (battery or cell) to push the electric charge depends on its **voltage**. The voltage of an electrical energy source (battery or cell) is a measure of its ability to push the charge in an electric circuit. It is measured in volts (**V**). A torch cell has 1.5 volts (V). In order to increase the voltage of an electrical source, two or more cells are connected one after the other in series (Figure 10.2).

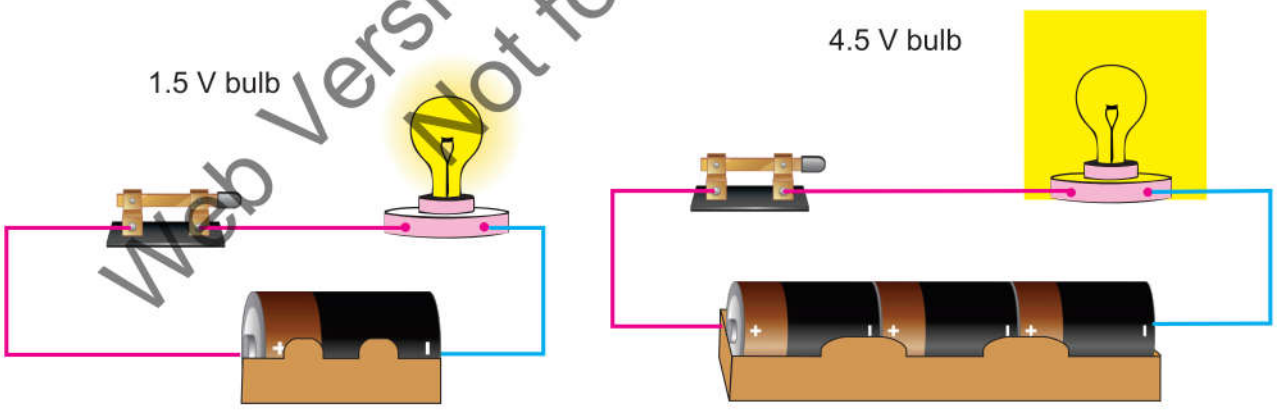


Figure 10.2 Cells connected to increase the voltage of Electric energy source

Voltage is measured by an instrument called **Voltmeter**. A voltmeter as shown in Figure10.3(a) has two terminals. Red port is its positive terminal while black port is its negative terminal. It has pointer that moves over a scale. The position of the pointer on the scale tells the voltage across which it is connected.

Figure 10.3 (a) Voltmeter

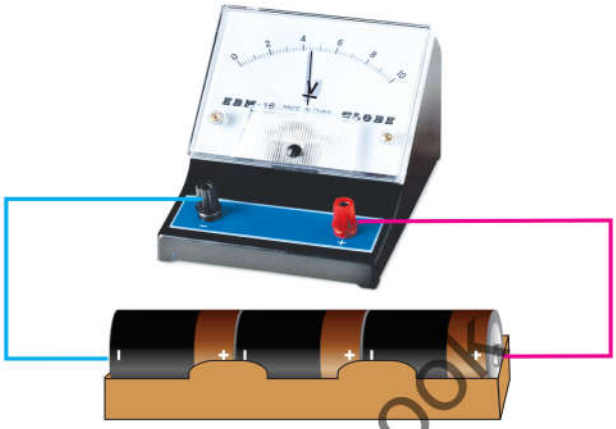


Figure 10.3 (b) Voltmeter reads 4.5V across the series combination of three cells

A voltmeter is always connected with its correct terminals across a device in the electric circuit as shown in Figure 10.3 (b). It is not connected in series like ammeter. The voltmeter shows the voltage across the device. We can also measure the voltage across a combination of cells.

Activity 10.1

Take a cell, connect the positive terminal of a cell at the red port of the voltmeter and its negative terminal at its black port. Note the voltmeter reading. Now place three cells in series as shown in Figure 10.3 b. Connect the positive terminal of the combination at the red port of the voltmeter and the negative terminal at its black port. Note the reading of the voltmeter.

Reverse any one of the cell in the above combination and note the difference in voltmeter reading.

What is the voltmeter reading across a cell?

What is the voltmeter reading across the combination of three cells?

What is the voltmeter reading across the combination with one cell reversed?

Mini Exercise

1. What actually flows when we say current is flowing in a circuit?
2. Why switches are connected in circuits?
3. Name a device that produces heat.
4. Name two devices that produce light.
5. What is the unit of electric current?

Activity 10.2

Material Required: A dry cell, bulb, switch, connecting wires, 10, 20 and 30cm long pieces of nichrome wire.

(1) Make a simple electric circuit as shown in the Figure.

(2) Switch on the circuit and observe the brightness of the bulb.

(3) Replace one piece of connecting wire with 10 cm long nichrome wire. What is your observation?

(4) Repeat step 3 with 20 cm length of nichrome wire. Note your observation.

(5) Repeat Step 3 again with 30 cm length of nichrome wire. Note again, the brightness of the bulb.

You must have noticed that when a piece of connecting wire is replaced by a piece of nichrome wire, the brightness of the bulb decreases. On increasing the length of the nichrome wire, the brightness is reduced further,

It means that the current passing through bulb has decreased. This is because the nichrome wire opposes the flow of current thereby decreasing its value. This opposition increases more as a longer piece of nichrome wire is used.

The measure of the hindrance to the flow of electric current in an electrical circuit is called resistance.

Resistance is measured in ohms, symbolized by the Greek letter omega (Ω). Ohm is the SI unit of resistance. According to Ohm's law, the resistance **"R"** is the ratio of the voltage **"V"** across a conductor and the current **"I"** flowing through it. Mathematically, it is written as:

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

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

The above relationship is discovered by a German Scientist, George Simon Ohm. It is therefore called Ohm's law.

Do you know?

The resistance of different material is different. The copper wire has minimum resistance. Hence, it is used as a connecting wire in all electric circuits.

For your information

The resistance of a wire depends upon its length, thickness and material. The nichrome wire has much more resistance than copper wire. It is known as a resistance wire.

Activity 10.3

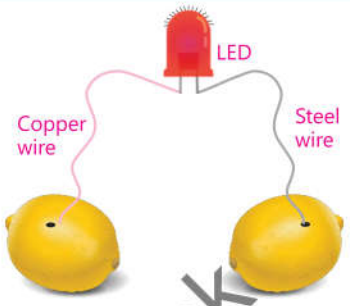
Material Required

Copper wire, steel wire, 2 lemons, LED.

Procedure

- Take two small pieces of steel and copper wires.
- Push the wires into the lemons as shown in the figure.
- Connect other ends of the wires to the terminals of a LED.

What do you observe?



For your information

Lemon produces a very small current of about one milliampere. This current is very weak to light up a bulb. However, this current is sufficient to run a calculator.

10.3 ELECTRICAL POWER

Electrical devices (Figure 10.4) such as electric fans, blenders, hair dryers, computers, washing machines, electric heaters, refrigerators convert electrical energy into other forms of energy. Electrical power is the rate at which a device converts electrical energy into other form of energy. Its unit is watt (W).

10.3.1 Kilowatt-hour (kWh)

One kilowatt-hour is one unit on our electricity meter. It is the amount of electrical energy used up when a 1000 watt electrical appliance works for one hour. The electrical energy used in our homes and shown in our electricity bills is taken in kilowatt-hours (kWh).

Figure 10.4 Electrical appliances of different electrical powers

10.4 DANGERS OF OVERLOADING AND SHORT CIRCUIT

Overload and short circuits are liable to cause wiring to overheat which could melt the wire insulation and lead to a fire. They also cause electrical burns and damage to appliances. Even home electrical system is damaged. In order to avoid the dangers due to overloading and short circuits, safety devices like earth wire, fuse, circuit breakers, etc. are used in household electrical wiring.

10.5 EARTH WIRE, FUSE AND CIRCUIT BREAKER

10.5.1 Earth Wire

Electrical circuits are connected to the Earth through a wire called **earth wire**. It conducts the excess or leaking current from any electrical appliance to the ground. In this way, it protects us from electric shock.

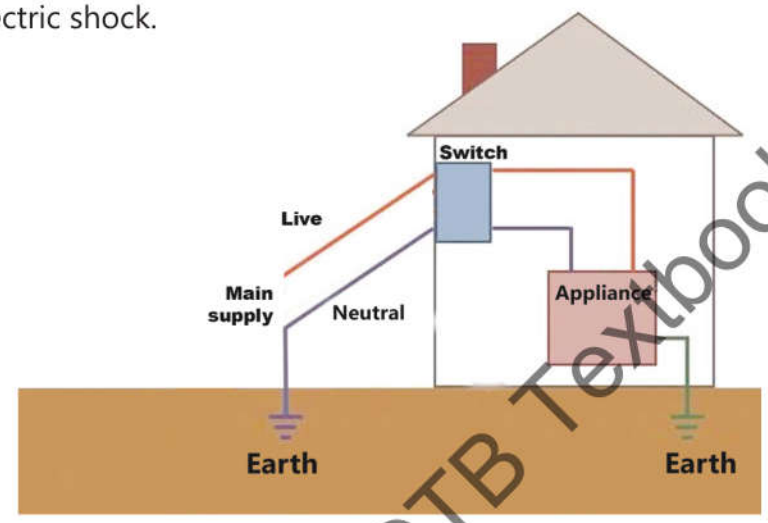


Figure 10.5 Earth wire

10.5.2 Fuse and its Uses

Wires are heated up when electric current flows through them. If the current is too large, the wires can get hot enough to start a fire. A fuse is a safety device connected in electrical circuits that interrupts flow of excessive electric current to prevent from damage by overheating or fire. It is simply a thin metal wire designed to get hot and melt when too much current flows through it. When the fuse wire melts and breaks the circuit, we say that the fuse has blown.

Figure 10.6 Fuse

The use of fuse is good for the reasons as follows:

- A high current may damage the components of the circuit. A simple fuse blowing can save a lot of money.
- Very high current can cause fire. A fuse can prevent a house from burning down and people dying.
- A fuse can stop current flowing if an electrical appliance has a fault. This can help to prevent us from getting an electric shock.

Warning

Never touch wires or other metal parts connected to main electricity.
Never touch electric switches with wet hands.

10.5.3 Circuit Breaker

Circuit breaker (Figure 10.7) is an automatic switch in an electric circuit. Its function is similar to that of a fuse. It breaks the circuit if excess current flows. It is a safety device that protects electrical circuit from damage caused by excessive current/overload or short circuit. Now-a-days, circuit breakers are widely used in place of fuses to protect electrical systems in homes.

Figure 10.7
Circuit Breaker

10.6 PRECAUTIONARY MEASURES TO ENSURE THE SAFE USE OF ELECTRICITY

There are some simple ways to ensure the safe use of electricity.

1. Check all electrical equipments in good working order.
2. Avoid overloading sockets.
3. Never repair cuts with insulating tape. Use proper connectors to join lengths of cable.
4. Replace damaged sections of cable completely.
5. When disconnecting electrical equipment, gently pull it by plug instead of jerking electrical cord.
6. Switch off and unplug equipment before you clean it.
7. Ensure that the person carrying out the electrical work is competent to do so.
8. Always use circuit breaker or fuse in circuit with appropriate current rating.
9. Never touch or try repairing any electrical equipment or circuits with wet hands.
10. Always use insulated tools while working.

Activity 10.4

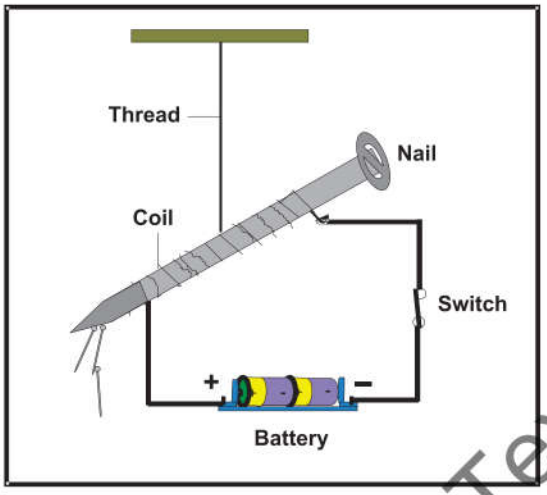
Material Required

Cotton covered copper wire, iron nail, two celled battery, electric switch, sticky tape, thread, iron filings or paper pins.

Procedure

1. Cut a small piece of cotton covered wire and connect its one end with negative terminal of the battery using sticky tape and other end with one point of the electric switch.
2. Wind a long piece of cotton covered copper wire around an iron nail forming a coil.
3. Connect one end of the coil with positive terminal of the battery and its other end with the second point of electric switch.
4. Suspend the coil with the help of a thread tied to its centre as shown in the figure.

Activity 10.4



Electromagnet

5. Turn the switch on and bring some paper pins near one end of the nail. Paper pins will stick to the nail. This shows that the nail has become a magnet.
6. Now turn the switch off. The paper pins will detach and fall down.

Inference

The iron nail becomes electromagnet when electricity flows through the coil around it. The magnetic property of the nail is lost when the current flowing through the coil stops. It is a temporary magnet.

The best material to use as a core in the coils is soft iron. It is so because, it is easily magnetized and loses its magnetism when the current in the coils is turned off. As the current flows through the coils, a magnetic field is produced which organizes the tiny magnets within the iron and makes the magnetic field stronger. When the current flowing in the coils is turned off, the organization of tiny magnets within the iron is lost and the soft iron loses its magnetism. Hence, the magnetic properties of an electromagnet are temporary. The strength of electromagnets can also be increased by increasing the current or by increasing the number of turns in the coils.

Do you know?

Hans Oested, a Danish Scientist was the first to explore the electromagnetic effect. This discovery brought a revolution in the world of science and engineering.

Think Tank!

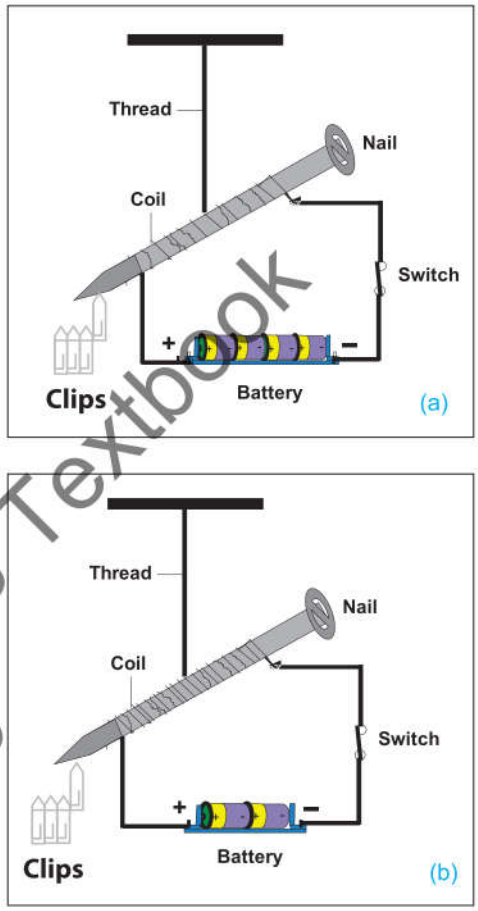
- We have learnt that the magnetic force works through the paper. Can it act through other material also? You can test different material like plastic, aluminium, steel, etc. by keeping their sheets one by one between a magnet and the paper clips.
- The force of a magnet does not work through a sheet of steel. Why?

Activity 10.5

Take a paper clip.

1. Straighten its one end. Bring it close to one pole of the electromagnet which was made in activity 10.4. Clip will stick to it.
2. Now suspend another clip over the straight end of the first clip.
3. Do they fall down? If not, suspend more clips one by one until they fall down.
4. Count the number of clips held by the electromagnet.
5. Now double the number of cells and repeat the above action.
6.. Can the electromagnet hold more number of clips now? Count their number.
7. Reduce the number of cells to two again and double the number of turns of the coil in the same length.
8. Repeat the above activity. How many clips are held by the electromagnet this time?
9. What can we infer from it? More number of clips held means the strength of the electromagnet has increased.

The strength of the electromagnet increases with the increase in electric current or increase in the number of turns of the coil.



10.7 USES OF ELECTROMAGNETS

Electromagnets attract the iron objects. Due to this property they are used in a large number of electrical devices called electromagnetic devices.

10.7.1 Electric Bell

In electric bell when push button (switch) is pressed, electric circuit is completed and current starts flowing through the coil. Coil becomes electromagnet and attracts the spring metal arm instantly. The hammer which is attached to the metal arm strikes the gong of the bell and produces sound. In doing so the metal arm is detached from the screw, electric circuit breaks and current stops flowing. The coil is no longer electromagnet, the metal arm moves back and comes in contact with the screw. This completes the circuit again and action is repeated. The hammer continues to strike the gong as long as the push button is kept pressed.

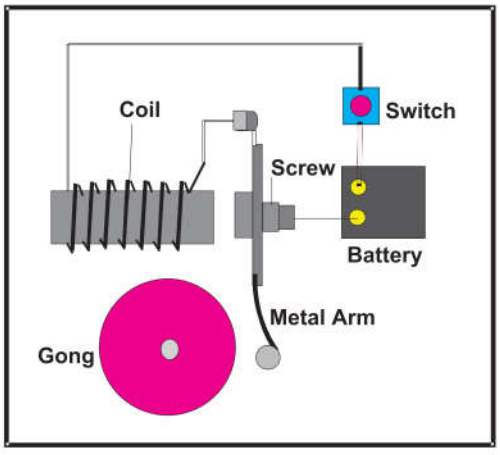


Figure. 10.8 Electric Bell

For your information

In electromagnetic cranes, electromagnet is used in lifting heavy weights and picking up iron scrap from the scrap yards.

10.7.2 Speaker

A loud speaker is mainly composed of a permanent magnet, a coil and a vibrating cone. One side of coil is attached with the cone and its other side lies near the permanent magnet. When electric current flows through a coil, it becomes electromagnet and is pulled towards permanent magnet, then quickly repelled from it. This makes the cone attached with the coil move. As this process repeats rapidly, the cone vibrates. As the cone moves, it pushes and pulls the surrounding air. By doing so it creates pressure waves in the air, called sound.

A microphone converts sound (mechanical wave energy) into audio signals (electrical energy). Sound waves hit a diaphragm that vibrates, moving a magnet near a coil.

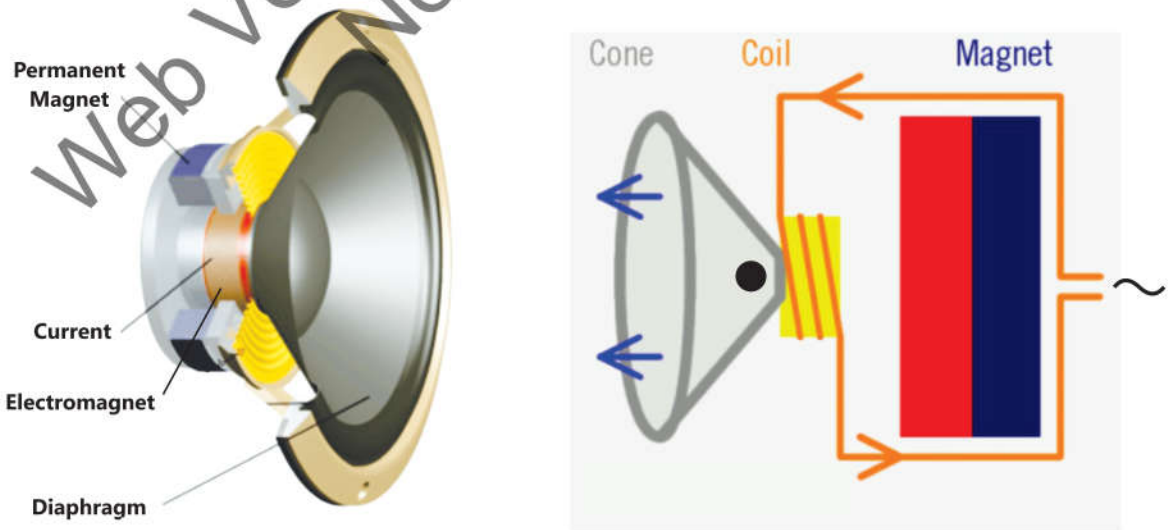


Figure. 10.9 Speaker

KEY POINTS

- Flow of charge is called electric current. The SI unit for electric current is ampere (A).
- The path along which electric charge flows is called electric circuit.
- A fuse is a safety device connected in electric circuits which interrupts flow of excessive current to prevent from damage by over heating or fire.
- Earth wire and circuit breakers are also safety devices used in household electrical wiring.
- Flowing electricity has also magnetic effects and causes magnetic field. This property of electricity is used to make electromagnets.
- An electromagnet is simply a coil of a wire wound around an iron core through which electric current is flowing.

QUESTIONS

1. Encircle the correct option.

(i) An electric circuit is the path along which
- (a) electrons revolve around the nucleus of an atom.
- (b) electric charge flows.
- (c) magnetic lines of force move.
- (d) electric motors move.

(ii) A closed circuit is the
- (a) complete path of electric current.
- (b) incomplete path of electric current.
- (c) broken path of electric current.
- (d) none of the above

(iii) Which of the following is non-magnetic substance?
- (a) Iron
- (b) Steel
- (c) Silver
- (d) Nickel

(iv) Which of the following is a magnetic substance?
- (a) Glass
- (b) Marble
- (c) Gold
- (d) Cobalt

(v) The best material to be used as a core in the coils for making electromagnet is:

(a) rubber (b) plastic

(c) steel (d) soft iron

2. Write short answers.

(i) Give three examples of the followings:

(a) magnetic materials

(b) non-magnetic materials

(ii) Define the following:

(a) Electric current

(b) Electrical circuit

(c) Magnetic field

(d) Electromagnet

(iii) Describe with the help of diagram.

(a) Closed circuit

(b) Open circuit

(iv) What is the basic working principle of:

(a) Electric bell

(b) Loud speaker

(v) Give three examples of electromagnetic devices in daily life.

3. Constructed response question

(i) What is electric switch? How it causes an electric circuit?

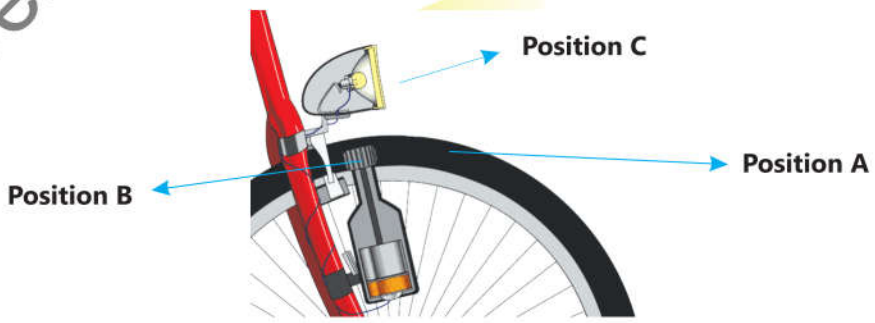
(a) Open

(b) Close

(ii) How can a dimmer switch make the same light bulb appear dim or bright?

(iii) Which type of electric circuit is used in our home supply:
Series circuit or parallel circuit and give reasons of your choice.

(iv) Look at the picture and answer the questions given below:



1. Name the form of energy produced at position A and tell where it comes from?
2. Name the form of energy produced at position B and tell where it comes from?
3. Name the form of energy produced at position C and tell where it comes from?

(v) Which of the following will pick more paper clips when an electric current pass through wire?.

(a) A coil of wire with 20 turns or a coil of wire with 50 turns

(b) Wire wound around a wooden stick or a wire wound around an iron nail.

4. Investigate

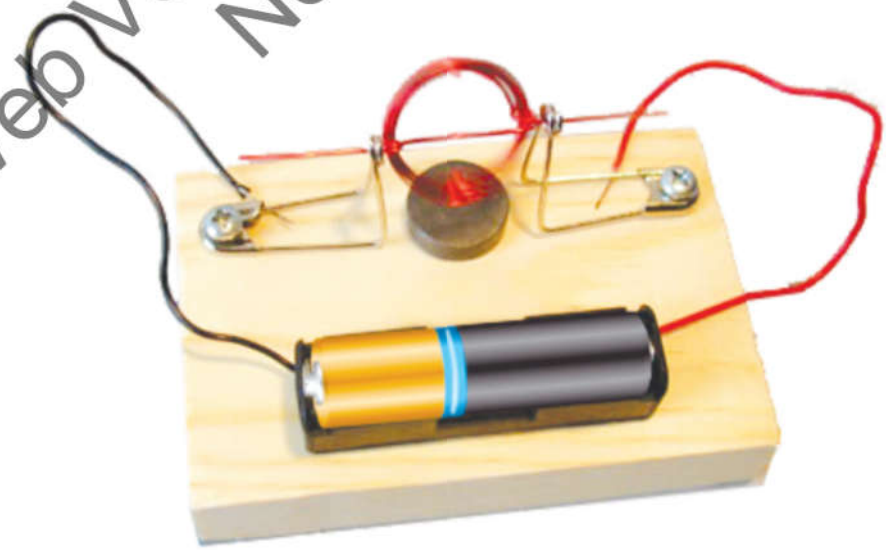
A student has two metal bars. He/She knows that metal bar 1 is a magnet.

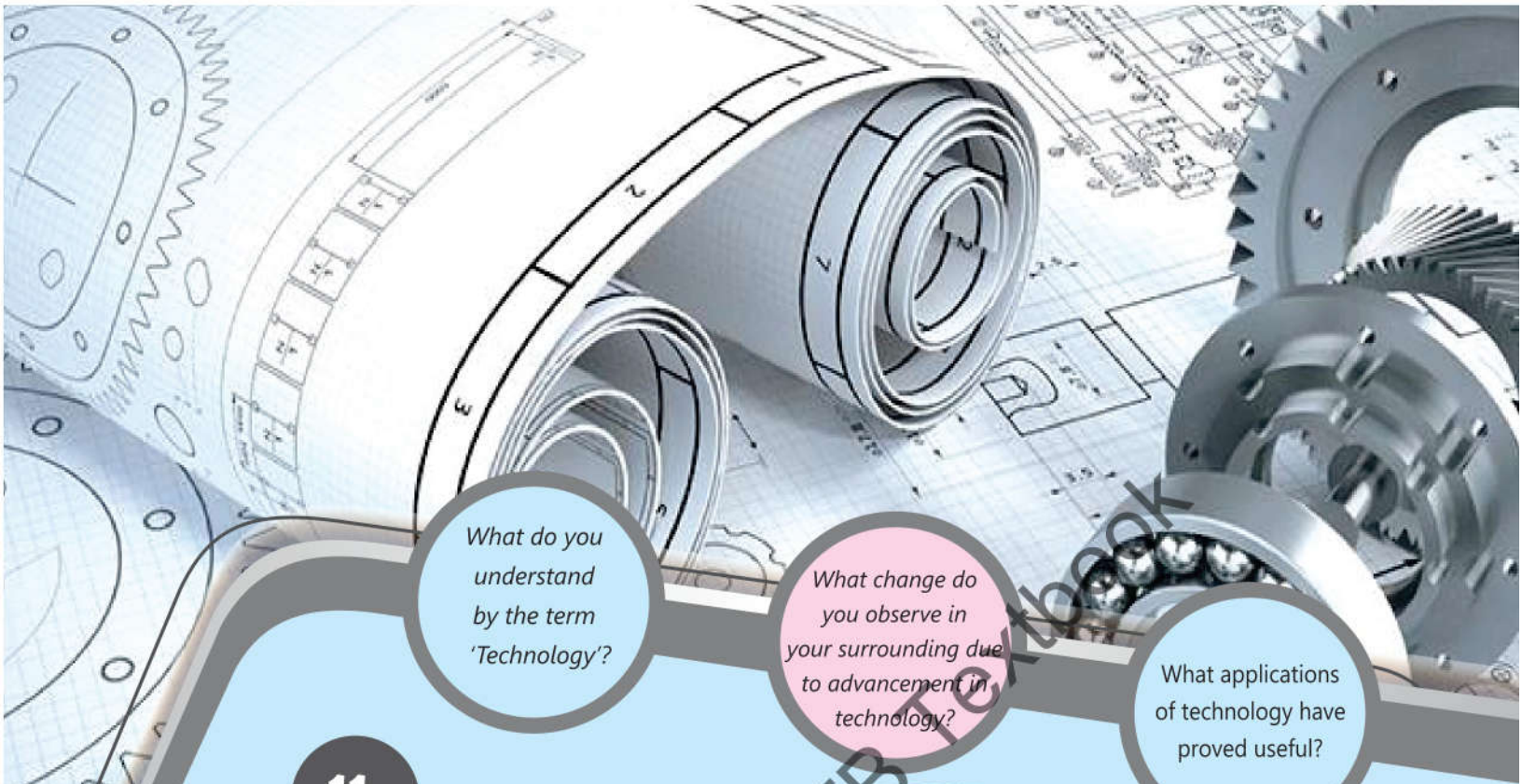
1. How could he/she use metal bar 1 to find out if metal bar 2 is a magnet?
2. What would he/she observe if metal bar 2 is a magnet?

Project

DC motor is an electromagnetic device. When a current carrying coil is placed in a magnetic field it starts rotating. Make your own electric motor as shown in the figure by using the following materials:

1. Insulated copper coil (25 gauge).
2. 1.5 volts battery
3. Ring or disk magnet
4. Two safety pins (Big size)
5. Connecting wires
6. Scissors
7. Cutter





11

Technology in Everyday Life

Students' Learning Outcomes

After studying this chapter, the students will be able to:

- Make bioplastic from milk and vinegar as an application of biotechnology.
- Make toothpaste, soap and detergent as an application of acids and bases in daily life.
- Assemble a concave mirror type solar cooker to convert solar energy into heat energy.
- Assemble and operate a simple wind turbine to produce electricity.
- Demonstrate the working of UPS and use it to operate a fan or energy saver bulb.

11.1 MAKING BIOPLASTIC

Plastic is a non-biodegradable substance. Accumulation of plastic waste has become a big cause of land pollution. Bioplastic is a substitute of plastic. It is the plastic made of biomass like starch in corn, banana peels, sugarcane, etc. It is being used as packaging material. It is widely used in consumer goods, e.g in automotive and transport, in building and construction, textile, agriculture, horticulture and electronics, etc. Let us discuss about the material required and procedure for making bioplastic.

Material required

Starch, glycerol and distilled water.

Procedure

- Mix 15 g corn starch powder with 5 g glycerol and stir it (Figure 11.1).
- Dissolve the mixture in 200 mL distilled water (Figure 11.2).

Figure 11.1 Mixture of corn starch and glycerol

Figure 11.2 Dissolution of mixture of starch and glycerol in water

- Heat the solution at about 70 °C with constant stirring (Figure 11.3).
- Continue heating until the mixture is gelatinized and thickened.

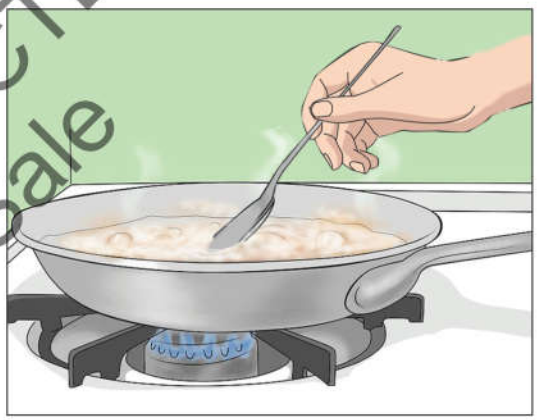


Figure 11.3 Heating the mixture

- Pour the mixture into mould for making required bioplastic item.
- Expose it to heat until it is a dry compact piece.

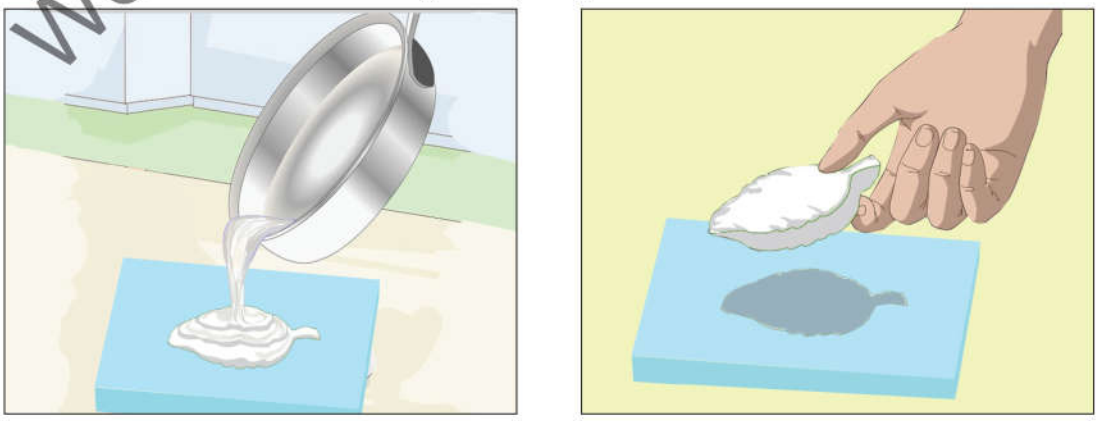


Figure 11.4 Making required item from bioplastic

Do you know?

- A plasticizer is one of the basic ingredients of all bio-plastics. It increases workability and flexibility.
- Glycerol is the most commonly used plasticizer in home-made bio-plastic recipes.

Activity 11.1

Follow the procedure given above and prepare bioplastic from potato starch.

- Add about 200 mL distilled water to the mixture of potato starch (15 g) and glycerol (5 g) and stir it gently.
- Leave to settle it and then decant the water, leaving the starch behind.
- Now use the starch to make a plastic film.

Making Bio-Plastic from Banana Peels

Material required

Banana peels, 0.2 molar sodium metabisulphite, distilled water, 0.5 molar HCl, 0.5 molar NaOH, glycerol, ceramic tiles.

Preparation of banana paste

Follow the steps given below for preparation of banana paste:

1. Remove peels from 6 bananas.
2. Cut the peels into small pieces .
3. Request your teacher to provide 200mL of 0.2 molar sodium metabisulphite solution.
4. Dip the pieces of banana peels in sodium metabisulphite solution for 45 minutes and drain the solution with the help of a sieve.
5. Boil the peels pieces in 200 mL distilled water for 30 minutes.
6. Decant the water and leave the peels to dry on filter paper.
7. Place the dried peels in the beaker and blend them with the help of hand blender to form a uniform paste.

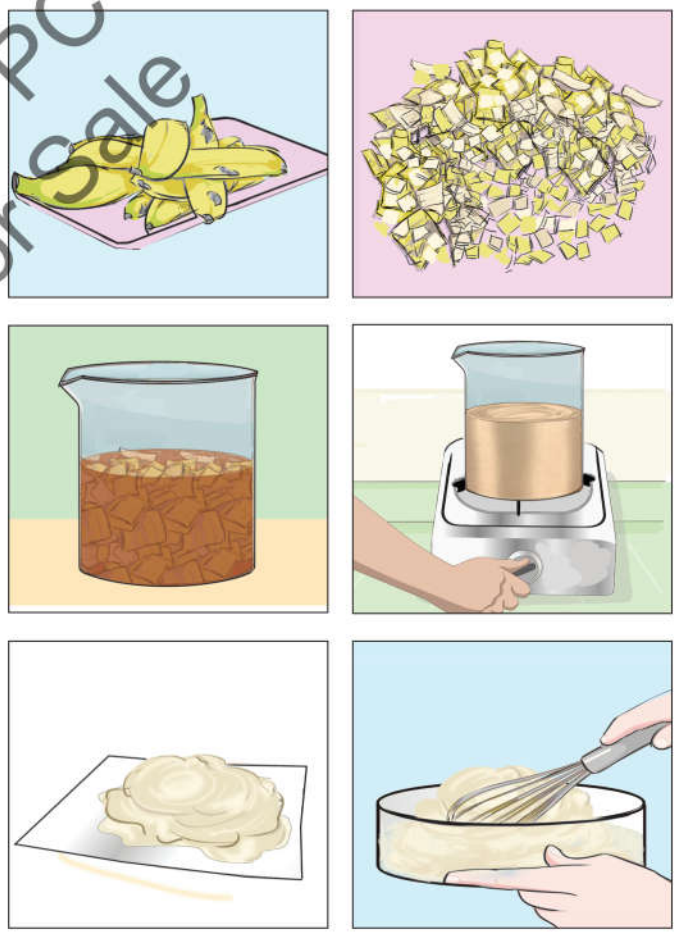


Figure 11.5 Making bioplastic paste from banana peels

Making Bio-plastic Sheet

1. Take a spoonful of banana peels paste in a beaker.
2. Add 6mL of 0.5 molar hydrochloric acid (HCl) and stir the mixture.
3. Add 4mL glycerol and stir it using a glass rod.
4. Add 6mL of 0.5 molar sodium hydroxide (NaOH).
5. Spread the mixture on a ceramic tile and put it in the oven and bake it at 120 C.
6. Cool the tile and remove the bioplastic film from it.

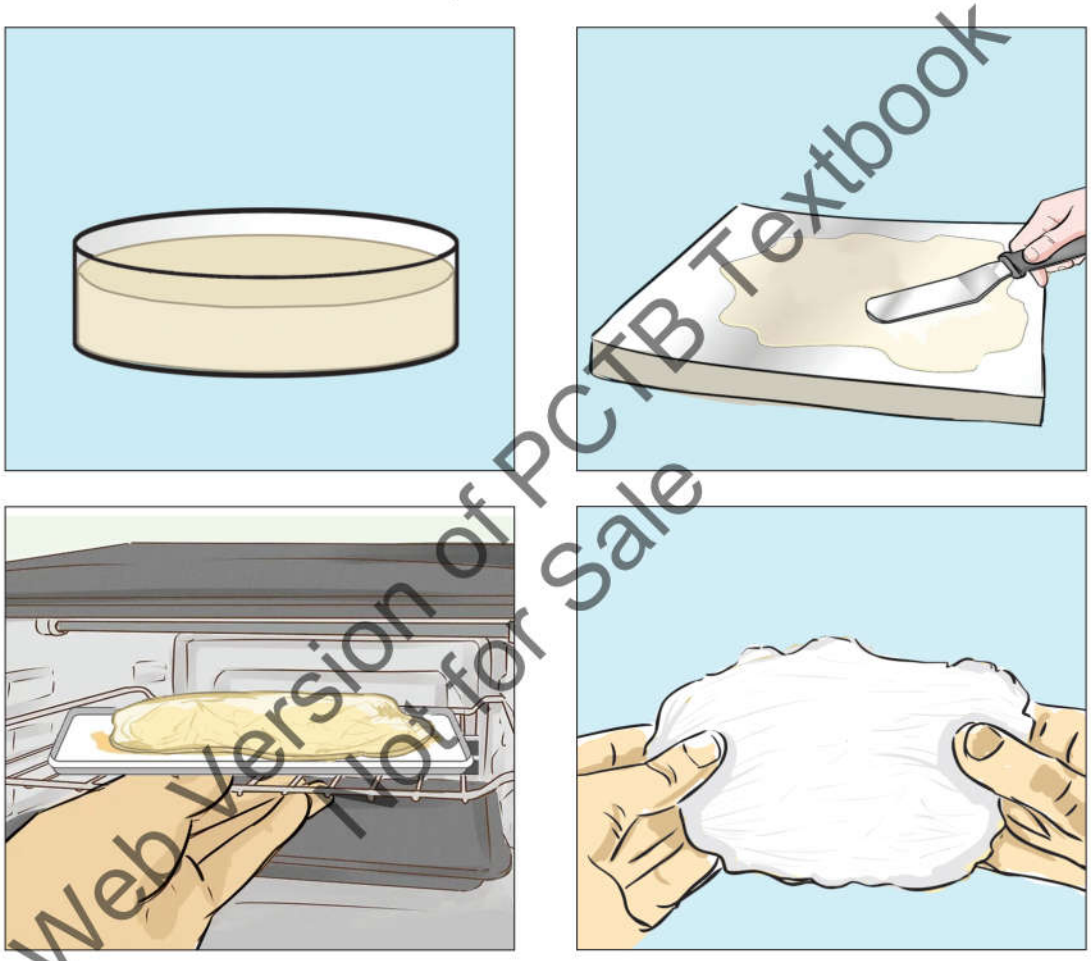


Figure 11.6 Making bioplastic sheet

Teachers' Guide

Facilitate students to understand the role of following material and processes:

- Sodium metabisulphite solution is an antioxidant and preservative.
- Amylopectin is a major component in all starches. HCl is used for hydrolysis of amylopectin into glucose and other starches in order to enhance the process of film formation due to hydrogen bonding.
- Glycerol is added as plasticizer to increase the flexibility and plasticity in the product.
- NaOH is used to neutralize the pH of the solution.

11.2 MAKING TOOTHPASTE

Toothpaste is a semi-solid paste like material used for cleaning and polishing teeth.

Raw materials as ingredients

Baking soda, sodium chloride, calcium carbonate and glycerin are usually used for making homemade toothpaste. The other commonly used ingredients include water, binders, abrasives, surfactants, flavours, sweeteners, fluorides, preservatives, colouring agents, etc.

Procedure

- Take 5 g baking soda, 1.5 g sodium chloride, and 1.5 g calcium carbonate in a plastic cup.
- Stir the mixture, add 4 mL glycerin in the mixture and stir it thoroughly. The mixture will become thick.
- Add distilled water with a dropper while stirring until the mixture has about the same thickness as commercial toothpaste.

Figure 11.6 Making toothpaste

- Add the other ingredients e.g edible oil, fluorides, flavour, sweetener, preservative, colouring agents, etc. and mix thoroughly by constant stirring.

Filling the tubes

After the ingredients are mixed together, the paste can be filled in the collapsible tubes.

Figure 11.7 Toothpaste fill in tube

11.3 PREPARATION OF SOAP AND DETERGENTS

Soap and detergents are used for cleaning purposes. These are prepared by heating fats or oils in a liquid alkali, e.g., NaOH. All soaps and detergents are biodegradable. The chemical process or reaction of making soap is called hydrolysis of fat or oil. This hydrolysis reaction has been traditionally called saponification and is known for centuries. Traditionally, soaps were made from animal fat and lye NaOH (Lye was traditionally made by pouring water through wood ashes).

Soap

Material required

The three key ingredients used in making soap are oil or fat, lye and water.

Procedure

Steps involved in the preparation of soap are:

1. Take a beaker with about 20 mL of castor oil in it.
2. Add 30 mL of 20% sodium hydroxide to the beaker.
3. Heat the mixture and stir it constantly until soap is formed.
4. Add 5-10 g of common salt to it and stir the mixture.

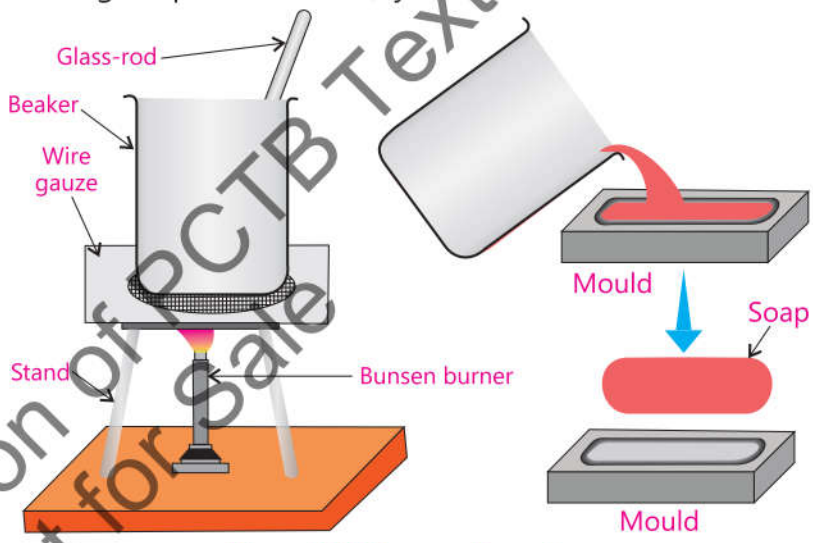


Figure 11.8 Preparation of soap

The final molecule of soap is called sodium stearate and is a type of salt.

Detergents

A detergent is a sodium or potassium salt of long chain fatty acids. It has cleansing action in water. Detergents are used to remove dirt, oil from skin and clothes, etc. Detergents have the same properties as soaps, but they are effective in hard water. Detergents are generally sodium or potassium salts of long chain carboxylic acids. Detergents are generally soluble in hard water. For this reason, detergents are used for cleaning clothes, etc. in hard water. Dish washing detergents are commonly in liquid form.

Figure 11.9 Detergent powder and liquid

Procedure for Making Detergent at Home

Ingredients required

1. Half cup Epsom salt ($MgSO_4$)
2. $1\frac{1}{2}$ cups baking soda ($NaHCO_3$)
3. $1\frac{1}{2}$ cups washing soda (Na_2CO_3)
4. $\frac{1}{4}$ cup sea salt
5. 20-25 drops Essential oil (Optional)

Mix all the ingredients well and store in a jar. You can use citrus, mint or lemon essential oil. Sea salt helps keep the colour from fading and helps remove stain. Epsom salt helps to soften the clothing.

11.14 ASSEMBLING A CONCAVE MIRROR SOLAR COOKER

As we have learnt that if a concave mirror is directed towards the Sun, the sunrays coming parallel to principal axis after reflection from the mirror converge at a point called principal focus. The combine effect of all the rays increases temperature at this point. If we place some metallic object at that principal focus, it will be heated up.

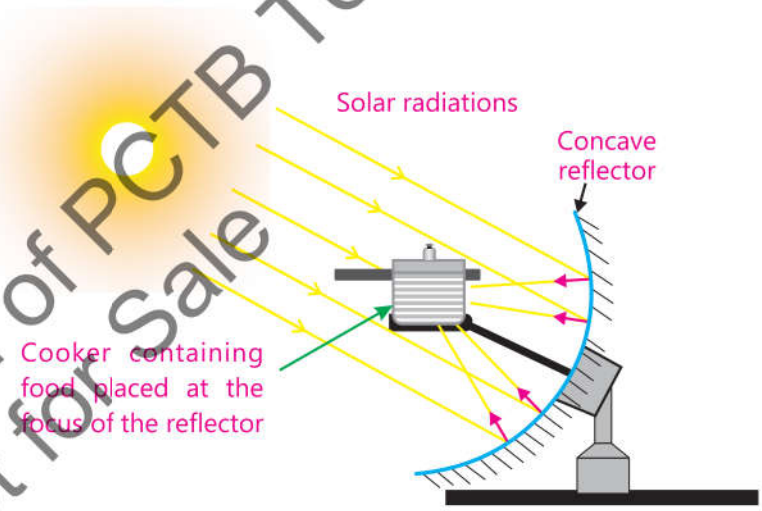


Figure 11.10 Solar cooker

Activity 11.2

- Take a concave mirror.
- Allow sunrays fall on its shiny surface and observe the bright spot formed by the sunrays after reflection from the mirror.
- Place a piece of paper at the point of bright spot so that the spot should fall on the paper.
- Hold the mirror for 1 to 2 minutes and observe what happens to the paper.
- Incident sunrays converaged by concave mirror meet on a point on the paper. This increases its temperature and makes the paper burn. This principle can be applied to assemble the solar cooker using a big concave mirror.

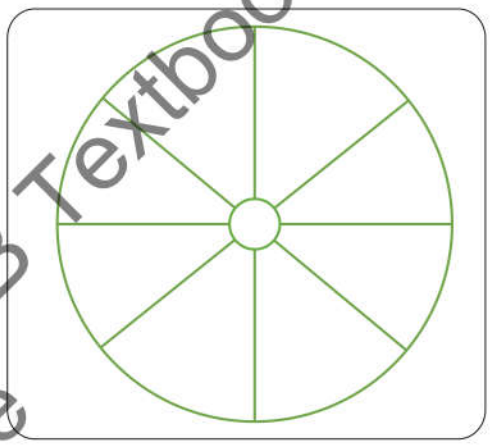
Activity 11.3

Assembling a Big Concave Mirror in the Solar Cooker

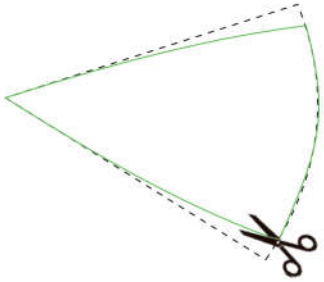
Teacher Guide

Facilitate students to make a concave mirror using cardboard and aluminium foil and use it to make solar cooker by following the steps given below:

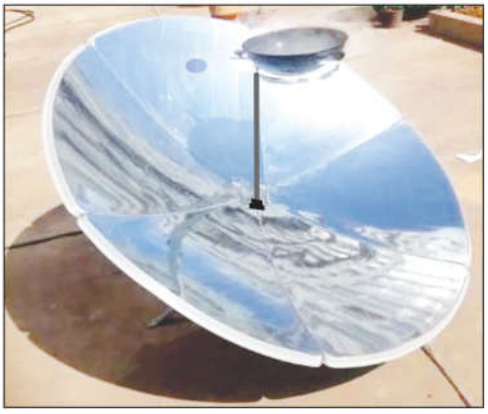
1. Cut a big piece of cardboard to make it round.
2. Draw 4 lines on the round cardboard each passing through its centre and divide the board into 8 equal sectors as shown in the Figure.



3. Draw a small circle around the central point of the cardboard.
4. Cut the cardboard into 8 pieces/sectors in such a way that all the 8 sectors are separated from each other from their outer region but are attached with each other at their central region.
5. Trim each sector from its outer edge to give it curved shape.
6. This will give curved shape to centrally attached 8 sectors.



7. Apply packing tape at the backside of the sectors to rejoin them in such way that they have curved surface. This will look like an umbrella.
8. Paste the pieces of aluminium foil keeping their shiny sides outwards on the inner side of the curved surface and get a concave mirror ready for use in solar cooker.
9. Place the concave mirror directed towards the Sun and hold a paper in front of it to locate the focus point by obtaining a bright spot formed on the paper.



10. Make a stand with iron frame fixed on its top.
11. Place the stand over the concave mirror.
12. Fix the height of the iron frame on the stand in such a way that it should lie just below the focus point.
13. Place the cooking pan containing food on the iron frame and cook the food in the solar cooker.

11.5 WORKING OF UPS TO OPERATE A FAN OR ENERGY SAVER

UPS stands for Un-interrupted Power Supply. It is installed in electrical wiring as an alternate source of power supply. Its main parts are AC/DC rectifier/charger, battery, DC/AC inverter, and an autoswitch. UPS installed in an electric circuit works as under:

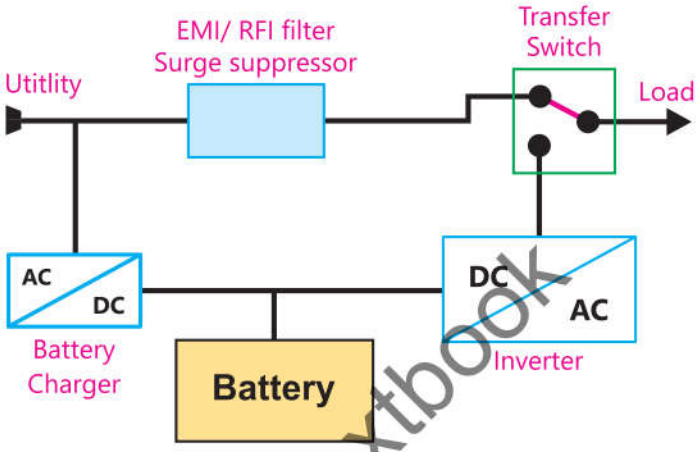


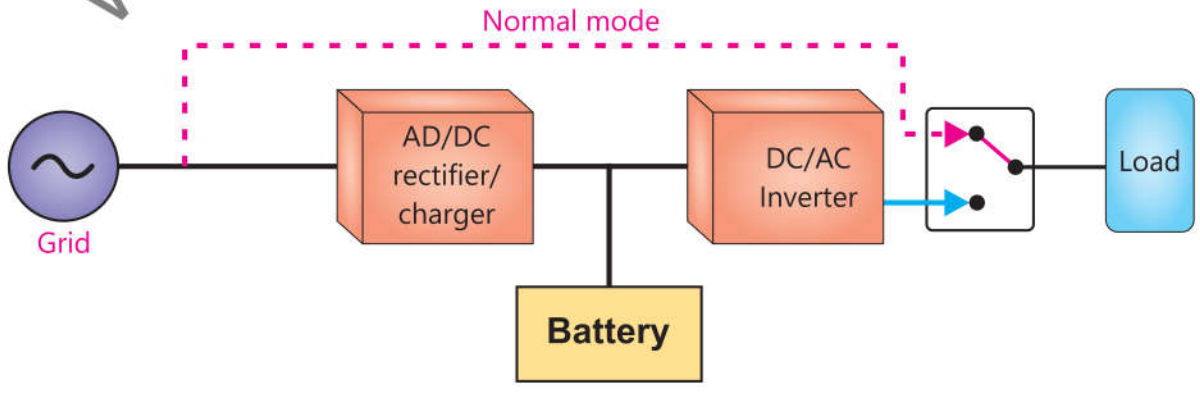
Figure 11.11 Block diagram showing working of UPS

- During routine supply of power to the electrical wiring, the battery of UPS gets charged by the AC/DC rectifier or charger, which converts the AC input of the main power supply to DC which is stored in the battery.
- When there is a sudden failure of main power supply, the battery supplies DC input to the inverter which converts it to AC and provides as an alternate power supply to the electrical wiring/circuits.
- The static switch of the relay coil becomes electromagnet which keeps the battery disconnected from the inverter and the inverter does not operate. On failure in main supply, the relay coil no longer remains electromagnet and releases the iron armature to be pulled back by the spring and connects the battery with inverter which starts function of converting DC to AC and provides power supply from the alternate source.

Activity 11.4

Teacher Guide

Introduce UPS system fitted in electrical wiring in your school and facilitate students learn and understand its working principle.



11.6 ASSEMBLING A SIMPLE WIND TURBINE TO PRODUCE ELECTRICITY

Material

A simple electric generator or dynamo, plastic fan blades, PVC-T, 3 m PVC Pipe, a small tin or plastic sheet, LED, etc.

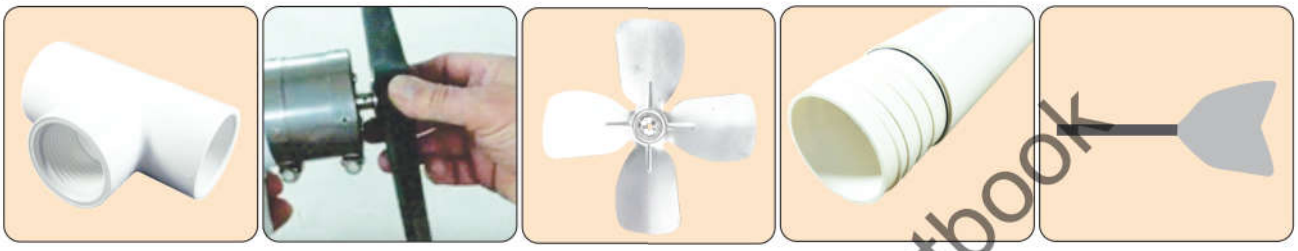


Figure 11.12 Material for assembling wind turbine

Procedure

1. Fix fan blades over the shaft of the electric generator.
2. Fix the electric generator into one limb of the PVC –T.
3. Cut a slot at one end of the small plastic pipe and fix tin sheet to serve as a weather-cock.
4. Fit the large plastic pipe straight upright on the ground.

Figure 11.13 Wind turbine

5. Finally fit the whole set up on the top of the long plastic pipe fixed on the ground.
6. Connect a bulb or LED lamp with the electric generator through insulated wires.
7. The simple wind turbine is ready to generate electricity.

KEY POINTS

- Technology is a front desk in now-a-days life and progress.
- Bio-plastic is a substitute of plastic. It is made from biomass like starch in corn, banana peels, sugarcane, etc.
- We can prepare tooth paste at home using the ingredients like baking soda, sodium chloride, calcium carbonate, glycerin, fluoride, sweeteners, flavors, etc.
- Soap and detergents are also the examples of home-made products which are used in our daily life.

QUESTIONS

1. Encircle the correct option.

(i) Bio-plastic is made of:

(a) glucose (b) proteins

(c) starch (d) fats

(ii) Baking soda, calcium carbonate, glycerin, fluorides, etc. are usually used for making:

(a) soaps (b) detergents

(c) toothpaste (d) banaspati ghee

(iii) Soap is ..... salt of long chain fatty acids:

(a) sodium or potassium (b) magnesium

(c) Iodine (d) halogen

(iv) _____ is used in solar cooker

(a) convex mirror (b) concave mirror

(c) convex lens (d) concave lens

(v) Which is used in UPS?

(a) Inverter (b) Electric generator

(c) Compressor (d) Electric motor

2. Write short answers.

(i) What does UPS stand for?

(ii) Which of the plastic and bio-plastic is environment friendly?

(iii) What is the role of glycerol in making bio-plastic from starch?

(iv) Which energy is converted into electricity by a wind turbine? .

(v) What is a concave mirror?

(vi) What is the difference between a soap and a detergent?

(vii) How bioplastic is good for healthy environment?

3. Constructed response questions

(i) What is DC/AC inverter? Describe its importance.

(ii) State the energy conversions in the following:

- Solar Cooker
- Windmills
- Electric Motor
- UPS

(iii) Why are detergents considered as more useful than soaps in everyday life?

(iv) Why is an ordinary plastic bag not biodegradable but bioplastic is biodegradable?

4. Investigate

(i) The advantages and disadvantages of UPS technology.

(ii) Which other naturally occurring material apart from starch and banana you will use to prepare bioplastic?

(iii) Which detergent is used in dry cleaning of woolen clothes?

Project

Make concave mirror type solar cooker for cooking food.

Why do elliptical galaxies contain fewer blue stars than spiral galaxies?

Can you see a black hole? How does a black hole look like?

What invention prompted scientists to think about entering space to explore it?

12

Our Universe

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Explore and understand the terms star, galaxy, Milky Way and the black holes.
- Compare the types of galaxies.
- Relate the life of a star with the formation of black hole, neutron star, Pulsar White Dwarf, Red Giant.
- Discuss the birth and eventual death of our Sun.
- Show how information is collected from space by using telescopes (e.g., Hubble Space Telescope) and space probes (e.g., Galileo.
- Describe advancements in space technology and analyze the benefits generated by the technology of space exploration.

Our universe comprises billions of heavenly objects in a vast empty space. There are galaxies, stars, planets, comets and many other mysterious objects. When we look up the night sky, we see numerous twinkling stars. A star is actually a gigantic ball of burning gases which emit heat and light. Most of the stars are so far away from the Earth that their light reaches us in years. Scientists believe that the universe is still expanding. Our Sun is the nearest star that is 15 millions kilometres away from the Earth.

12.1 GALAXIES

The word galaxy comes from the Greek word "gala" meaning "milk". Our galaxy looks like a milky cloud in the night sky. Hence, it is popularly known as Milky Way Galaxy. Its top as well as side view is shown in Fig.12.1. It is spiral type galaxy with mostly old stars at its centresurrounded by a halo of newly generated stars. The estimation is that there are more than a billion stars in this galaxy. This galaxy circles the whole sky. Our Sun along with its solar system is situated in one of its spiral arms. The stars which we see during the night are

all parts of the Milky Way Galaxy. There is still enough gas and other matter in its arms for many moregeneration of stars.

(a) Top view

(b) Side view

Figure 12.1 Spiral galaxy

Interesting information

Astronomy is a very old science. Overtimes, it was about the study of objects seen in the night sky. Now it is the study of the whole universe which includes many mysterious and unseen objects.

Do you know?

Stars are large distances apart. A new unit of distance has been defined known as a light year. It is the distance that light travels in one year. This distance is 9.5 trillion kilometres.

Do you know?

The astronomers through radio-telescope collect information about astronomical objects.

Interesting Information
Milky Way Galaxy

Age	13.6 billion years
Diameter	106,000 light years
Thickness of the centre	10,000 -15,000 light years
Speed in space	2,100,000 kilometre per hour
Revolving Speed	Once cycle in 225,000,000 years
Approximate distance of the Sun from the centre of the galaxy	21,000 light years

Andromeda is our neighbouring galaxy which we can see without a telescope during the clear night. It is bigger than our galaxy and situated about 2.5 million light years away form us.

12.1.1 Types of Galaxies

There are many types of galaxies. Some major types are given below:

Figure 12.2

1. Spiral galaxies

A galaxy that has a flat disklike shape with a bulge in the middle is called Spiral Galaxy. It rotates about its centre. Milky Way and Andromeda galaxies are spiral galaxies.

2. Elliptical galaxies

They look like flattened balls. They are oval shaped. They contain mostly old stars and do not rotate around their centres. They are most abundant type of galaxies in the universe. They are dim and old.

3. Jelly fish galaxies

Another amazing type is like a Jelly fish swimming across a sea of stars known as Jelly Fish Galaxy. They have giant tails looking as blue ribbons of young stars extended away from the galaxy disk. More than 30 such galaxies have been discovered.

4. Irregular galaxies

They do not have any district regular shape. They are mostly small galaxies of different shapes. They are most unusual galaxies.

12.1.2 Stars

Figure 12.3

A typical star consists of hydrogen gas. Huge gravitational forces squeeze the atoms together to form helium along with the release of tremendous amount of energy. The energy is radiated into space as heat and light. Stars can be classified by their size, mass, brightness, colour, temperature and age. There are yellow stars, red giants, blue giants, super giants, and white dwarfs. Our Sun is a yellow star of medium size and is often called a dwarf star. Its surface temperature is 6,000°C but at its centre it is 15 million degrees centigrade. It is shining for the last 5 billion years and is expected to shine still for another 5 billion years before it dies. After the Sun, the nearest star is Proxima Centauri located more than four light years away.

Hubble Space Telescope

This telescope is orbiting the Earth at a height of about 500 km. It has relayed detailed images of distant stars and galaxies. You can enjoy the fascinating images sent by Hubble Telescope on the Internet and share with the classmates.

For your information:

NASA has announced recently the observation of a rare event, the merger of three galaxies about 618 million light years away.

Interesting information

What the Earth would be like if there was no Sun and what would be its impact on the environment?

12.1.3 Birth and Death of a Star

Stars also undergo a life cycle. During the first stage, the gravity pulls the clouds of gas and dust resulting in a hot spinning ball. It is known as a protostar not giving light. In a process that takes million years, its further shrinkage causes huge build up of pressure and heat. At a temperature around 10 million degrees centigrade, the hydrogen starts changing into helium releasing enormous heat and light and a star is born.

During its second stage extending billion years, the shining star usually uses up its hydrogen fuel slowly. In the third stage when its fuel is depleted, the star expands and cools to form a red giant or super giant giving more red light for another million year. In the fourth stage, red giant will cool and gravity will squeeze further to form a white dwarf (Figure12.4.) It is a small hot dim star that is the leftover centre of a dying star. White dwarf slowly fades away over million years to form black dwarf. It will not emit light. Its material returns to space.

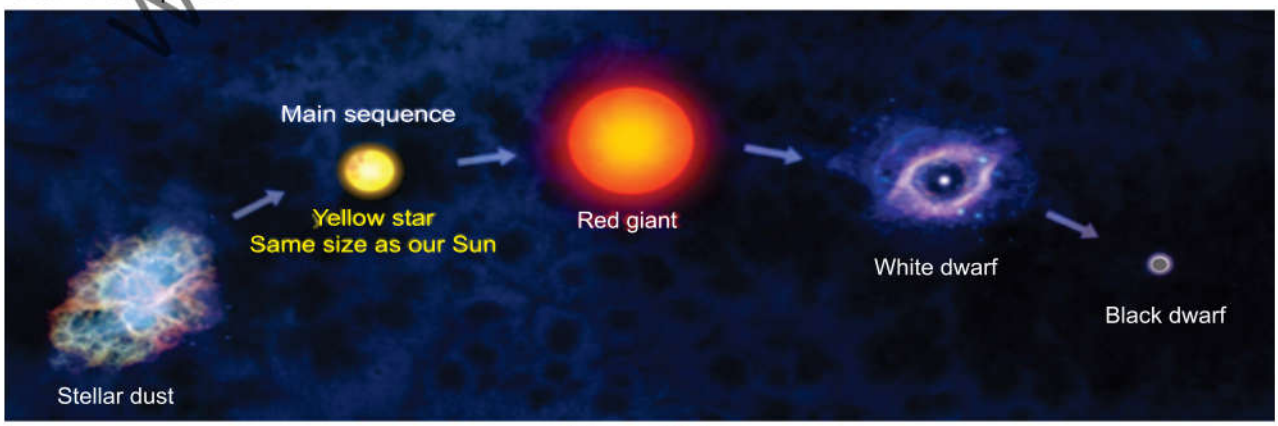


Figure 12.4

Activity 12.1

The teacher will arrange a 'play' or a class discussion about what will happen if they woke up one day and found out that the Sun has died.

12.1.4 Neutron Stars and Pulsars

The stars three or more times bigger than the Sun are called massive stars. Massive stars burn their fuel much faster. After only 50 million years, their hydrogen gas is exhausted. They become red super giants and their size increases. Sometimes the core of super giants suddenly collapses creating a huge explosion and much more light is emitted. If mass of the core is more than one and half to three times than the mass of the Sun, the left over core of the star entirely consisted of neutrons and is called neutron star (Figure 12.5). Neutron stars are extremely dense objects

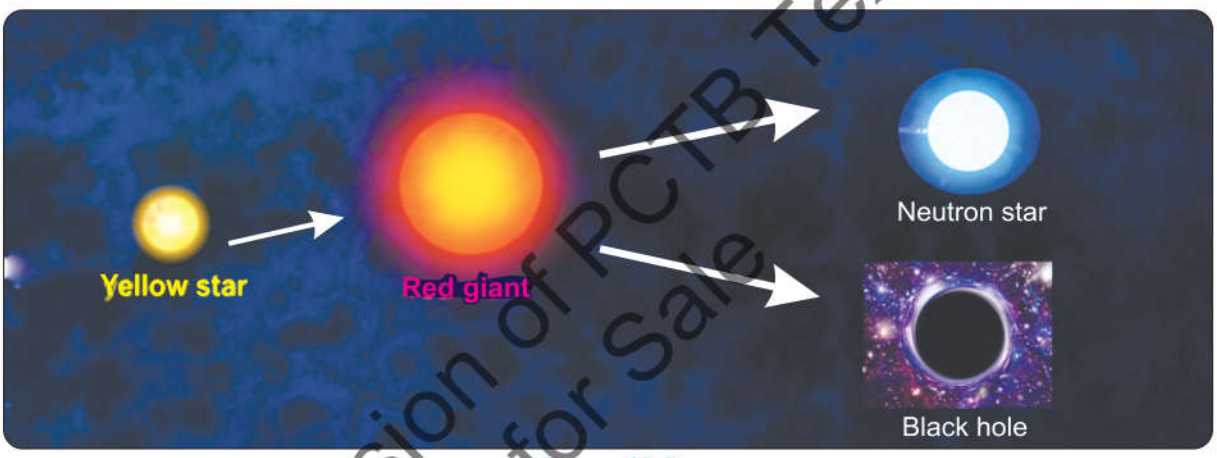


Figure 12.5

Do you know?

The William Hersched Telescope in the Canary Island (USA) is one of the biggest optical telescope. It can detect a single burning candle from a distance of 160,000 km away.

Neutron stars emit higher energy radiation such as X-rays. If a neutron star is spinning, it is called pulsar (Figure 12.6). It sends out radiation beam all around and is detected by radio-telescopes as rapid clicks and pulses.

Figure 12.6

Interesting information

Neutron stars are extremely dense stars usually of diameter 10 km to 16 km but their mass can be equal to the mass of our Sun.

12.1.5 Black Holes

Black Hole is an object so massive and dense that even light cannot escape from its pull. The chances of black hole formation are more when the mass of the core of the collapsing star is greater than three times the mass of the Sun. Due to intense gravity, the core of the star is crushed to such a small size that nothing, not even light escape and hence it cannot be seen. It is detected indirectly by the gravity waves. Another evidence of its existence is the stream of X-rays bursted away when it swallows nearby stars. It is believed that there is a black hole somewhere near the center of our Milky Way Galaxy.

12.1.6 Evidence that Black Holes Exist

Black Hole is an invisible object. Their existence can be verified by some effects caused by them:

i. It has been observed by tracking the stars near the center of Milky Way Galaxy orbiting a massive invisible object most likely a black hole about two million times the mass of the Sun.

ii. When the core of the massive star collapses, quick release of energy in the form of X-rays burst takes place which can be detected by radio-telescope. In fact, the radio-telescope on the Earth has detected many such events.

iii. When a star collapses to form a black hole or when two black holes collide, the violent event sends gravitational waves rippling out through space. It was a great triumph for the mankind when on 14th September, 2015, scientists of a special lab popularly known a LIGO detected a violent disturbance in space caused by gravitational waves generated by two colliding black holes 1.3 billion light years away from the Earth (Figure 12.7).

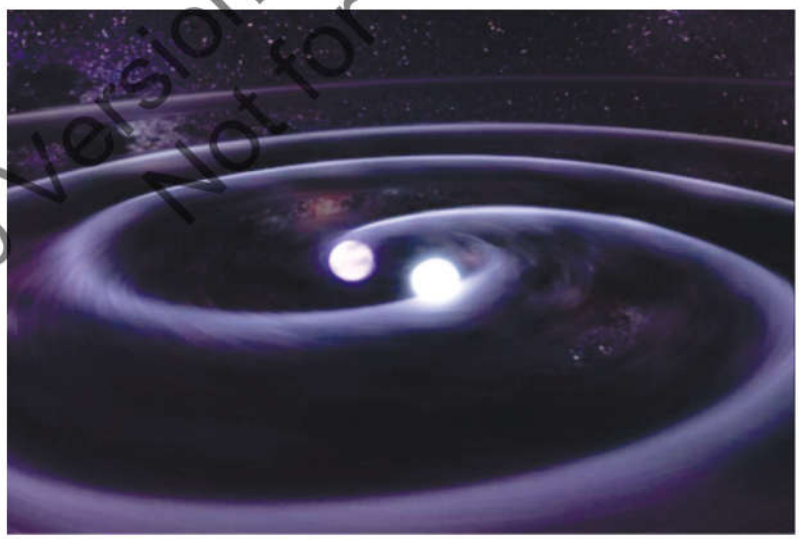


Figure 12.7

Interesting information

It is predicted that mostly the large galaxies do have one or more black holes near their centres.

Evolution of Telescope

1. Galileo 1609

2. Hubble 1990

3. James Webb 2021

James Webb Telescope: It is a space telescope launched on 25th December, 2021 to orbit the Sun at a distance of around 1.6 million kilometres as compared to Hubble which orbits the Earth at a height of about 500 km. It is expected to explore undiscovered mysteries from far off places of our universe by sending marvalous images even including neutron stars and possibly of black holes.

12.2 SPACE EXPLORATION

Scientific study of the space using especially developed technology is called space exploration. Common objectives for exploring space include advancing scientific knowledge, ensuring the future survival of humanity and developing defense capabilities.

Benefits of Space Exploration

Special technologies developed for space are now being used on Earth to improve the quality of life. A few examples are as follows:

1. Improving health care

In the field of health and medicine, space exploration has enabled man to develop medical diagnostic devices and treatment processes. Devices are used for getting instant relief in muscles, joint pains and arthritis (Figure 12.8).

- The infrared thermometer has been developed to measure the temperature of body without contact (Figure 12.9).
- Kidney dialysis machines and mini cameras for taking the photographs of internal organs of human body have been developed using the research output of space exploration.
- The materials used to keep our homes warm are based on the technology used for insulating the space stations.

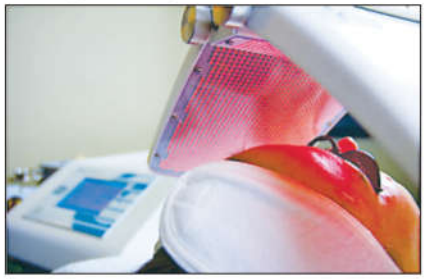


Figure 12.8 High intensity LED unit

Figure 12.9 Infrared ear thermometer

2. Global navigation

1. Geostationary Orbits and Global Positioning System (GPS) use the network of satellites orbiting the Earth to facilitate communication and essential navigation (Figure 12.10). This system helps our television receivers and mobile phones to receive signals from the satellites moving around the globe.
2. The travellers can use this system not only for knowing where they are travelling but also for selecting best route to their destination. Aeroplane pilots, sailors of the ships or desert hikers also use the GPS in mobile phones to find their positions and get information about the surroundings.
3. Ride Hailing companies such as Uber/Careem use space navigation services to manage quick location and calculate distances.
4. Help tracking of packages and their efficient delivery by courier services.

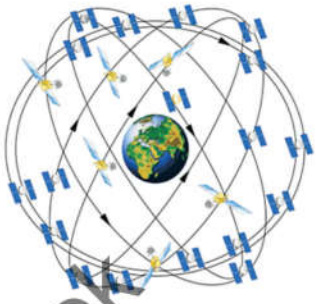


Figure 12.10
GPS satellites orbiting around the Earth

3. Weather forecast and prediction of natural calamities

- The accurate and reliable weather reports on hourly basis are possible because of the weather satellites in the space (Figure 12.11). These satellites have also made it easy to predict natural calamities such as floods, storms, tornadoes and hurricanes.

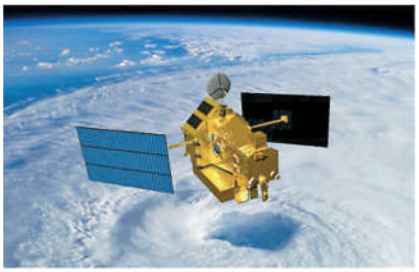


Figure 12.11: Weather satellite

4. Advanced electronics and computers

- Electronic and computer systems were developed mainly to facilitate space exploration. Satellites are fitted with electronic and computer systems which can perform many functions automatically. Now-a-days many items are made in factories automatically or by computer-controlled robots.

5. Locating minerals, fossil fuels and water reserves

1. Deeply buried precious ores of minerals, fossil fuels (coal, petroleum and natural gas) and underground water reserves can be located with the help of satellites (Figure 12.12). This study is known as remote sensing.
2. Protecting our environment and climate monitoring.
3. Aerial mapping of Earth surface provides data on climate change, measure pollution and scanning for greenhouse gases help to plan for the overall health of the planet and fixing climate change problems.
4. Adopting spacecraft technologies, the cabin pressure maintaining system are allowing people to travel comfortably in commercial airplanes

Figure: 12.12
Locating ores and resources

12.3 HOW DO ASTRONAUTS SURVIVE AND RESEARCH IN SPACE?

For living in space, astronauts need basic necessities (air, food, water, shelter and warmth) for survival, and a suitable compartment for personal comfort on the spacecraft. For this purpose, large space stations have been built in the space. Each space station consists of two main sections: (i) Pressurized section in which scientists work without space suits. (ii) Open-to-Space section on which equipment is mounted for observing the Earth and sky. Unprotected human body cannot survive more than a few minutes in space. As liquid boils at lower temperature and lower pressure, the water in human body can begin to boil at low pressure resulting immediate death. The astronauts wear a specially designed suit called space suit to protect from such hazards when they go out into space (Figure 12.13). For breathing in space, astronauts carry air tanks with them that contain pressurized oxygen and nitrogen. Their suits circulate the air to their helmets and throughout the suit so that they can breathe. Special foods are prepared and packed for easier transportation and a variety of tastes for the astronauts.

Figure 12.13
Astronaut wearing space suit

For your information

An astronaut is a scientist who is trained to travel in space.

12.4 TECHNOLOGICAL TOOLS USED IN SPACE EXPLORATION

A few of the tools which are used in space exploration programmes are as follows:

1. Space Rockets

Space rockets are the means of transporting spacecrafts, space shuttles and space stations into the space (Figure 12.14).

Figure 12.14 Space rocket

2. International Space Station (ISS)

It is habitable artificial satellite built with the collaborations of 18 countries including USA, Russia, Japan, Europe and Canada. The station serves as a gravity free and space environment research lab. Scientists from all over the world visit this space station and many of them stay in it for several months. Space shuttles are used to and back transportation of scientists and other goods. The ISS is an example that humanity can do when we agree to work together towards a single goal of human welfare, progress and prosperity.

2. Rocket Launching Pads

The sites from which rockets are launched into space are called Rocket Launching Pads (Figure 12.15). These are especially built platforms for firing rockets into the space. They can withstand extremely high temperature and large forces produced by rocket exhausts.

Figure 12.15 Rocket launching pad

4. Telecommunication System

Rockets and spacecrafts are provided with telecommunication system so that the space crew in the rocket capsule can communicate with each other and with the Earth stations.

5. Ground Mission Control Stations

Ground stations receive and process the information from satellites to monitor and guide their motion in space. The main tasks of ground mission control are as follows:

i. Tracking

Continuously reporting the position of the satellite or space probe.

ii. Monitoring

Receiving signals from a spacecraft and decoding them into useful information for the scientists is known as monitoring. Progress of a space mission is closely observed and necessary instructions are issued from time to time.

6. Space Probes

They are the spacecraft which are exploring space for more than fifty years. One of the spacecraft named Galileo was launched in October,1989 on Jupiter mission. It started orbiting around of Jupiter in December, 1995. It revealed many thunderstorms on Jupiter, larger than on Earth's surface. Voyager-1 and 2 launched in 1971 and Pioneers-10 and 11 are travelling through space with a speed of 40,000 km per hour.

They have visited all the planets of solar system as well as two dwarf planets Pluto and Ceres. They have sent many close up pictures of the heavenly objects. They have helped to discover more than 2400 comets. They are still transmitting data from far beyond the solar system.

Do you know?

In 1990, the spacecraft Voyager-1 captured view of our Earth as a pale blue dot from a distance of 6 billion kilometres away.

For your information

Achievements of LIGO

As of January 2022, the LIGO lab has undergone 3 search runs. First run was from 12th September to 19th January, 2016 in which three events were detected, all of black hole mergers in distant galaxies. In second run, from 30th November, 2016 to 25th August, 2017, 8 detections observed, 7 black hole mergers and first neutron star. In third run, from 01st April 2019 to 27th March, 2020, the first merger of neutron star with a black hole was observed.

12.5 NEW TECHNOLOGIES DEVELOPED ON THE EARTH AS A RESULT OF SPACE EXPLORATION

We have learnt in Section 12.2 about the technologies and benefits of space exploration. Some of the new technologies developed on the Earth as a result of space exploration are listed below:

1. Special types of metal alloys and ceramic materials developed for rocket engines and space shuttles can withstand very high temperature and pressure. These are now being used in Jet engines. Similarly, special foam seats developed for spacecrafts are now being used in aeroplane and car seats.
2. Solar cells were originally developed to provide electricity to spacecrafts. Millions of them are being installed on the Earth now-a-days to produce almost free electricity from sunlight.
3. Special Glues, adhesives, epoxies, aerogels, etc. were originally invented for space engineering but are now widely used in everyday life.
4. Advance robotics, automation and artificial intelligence needed by space exploration now have revolutionized the industrial production and many other processes. More space exploration promises to bring benefits to a variety of areas such as power generation, power transmission, and tackling many other threats to mankind.

Point to Ponder

What would happen to astronauts' blood if their suit or the space shuttle were not airtight?

KEY POINTS

- Star distances are measured in light years. A light year is a distance that light travels in one year.
- A star like Sun starts its life as a protostar. Then it changes to a star emitting light and heat.
- When the nuclear fuel of the star is spent, a star like Sun expands to become a red giant. Then collapses into a white dwarf.

KEY POINTS

- A black hole is the last stage in the life of a massive star. A black hole is so dense that not even light can escape form it.
- Global Positioning System (GPS) helps a television receiver, or a mobile phone to catch signals from the satellites moving around the globe for navigation and communication.
- Knowledge gained from space exploration has enabled man to develop technologies to serve the mankind in different fields like health and medicine, navigation, weather forecasting, locating minerals, fossil fuels and water reserves.
- Space rockets, rocket launching pads, telecommunication system, telescopes, spectroscopes, etc. are different technological tools used in space exploration.
- The application of space exploration technologies has improved business, industry and quality of life on the Earth.

QUESTIONS

1. Encircle the correct option.

(i) An instrument that helps in seeing heavenly objects:

(a) microscope (b) telescope
(c) periscope (d) kaleidoscope

(ii) Telescope on the Earth suffers from the defect that light coming from the stars has to pass through:

(a) space (b) water
(c) atmosphere (d) clouds

(iii) A vehicle designed to carry an artificial satellite in outer space is:

(a) rocket (b) airbus
(c) jet Plane (d) spacecraft

(iv) Star's distances are measured in:

(a) kilometres (b) nauticalmiles
(c) light years (d) miles

(v) The colour of hottest star is:

(a) red (b) blue
(c) yellow (d) white

(vi) Our Solar system is a part of:

(a) andromeda galaxy (b) milky way galaxy
(c) jelly fish galaxy (d) irregular shaped galaxy

(vii) Surface temperature of the Sun is:

(a) 3000 °C (b) 6000 °C (c) 15000 °C (d) 1,500,000 °C

(viii) The last stage in the life of massive star is:

(a) red giant (b) white dwarf
(c) super giant (d) black hole

(ix) Bright stars may appear dim stars because they are:

(a) old star (b) new Star
(c) far away from Earth (d) close to the Earth

(x) The nearest star after the Sun is:

(a) rigel (b) proxima centaurei
(c) aldebaran (d) sirius

2. Write short Answers.

(i) What is a galaxy? What are its main types?
(ii) Describe the birth and death of a star.
(iii) Describe the formation of a neutron star.
(iv) What is the advantage of putting telescope in space?
(v) What does GPS stand for?
(vi) What is the device that make far away objects appear closer to see its detail?
(vii) Describe the various benefits generated by technology of space exploration.
(viii) What is a space probe? Name at least two space probes.
(ix) What is the main differences between an optical telescope and a radio-telescope?
(x) What is space station? Write its benefits.
(xi) What is a black hole? Can it be seen?

3. Constructed response questions

(i) What are advantages of space telescopes such as Hubble and James Webb over the giant telescopes on the Earth's surface.
(ii) What are the problems faced by the Astronauts on space missions? How do they overcome these problems?
(iii) What is gravity free environment? How can it be achieved?
(iv) Why cannot we see the heavenly object "black hole" directly by any telescope?
(v) Comment one public opinion that; "Huge spending on space exploration is extravaganza".

Projects:

1. Teacher may arrange a telescope and help students to view sky on some clear night. Even a medium size telescope can view you fascinating moons of Jupiter and Saturn. The next day students should comment on their telescopic view of the night sky.
2. Library and Internet research: The students should browse Internet / Smart phone or find out article on advancement in space exploration in newspaper and magazines. They should prepare a small presentation to share with class.

GLOSSARY

Absorption of light: Absorption and conversion of light into heat energy.

Acid: A compound which produces hydrogen ion(H^+) in its aqueous solution.

Addition reaction: A chemical combination of two or more substances to form one compound.

Alkali: A compound which produces hydroxide ions in its aqueous solution.

Angle of incidence: Angle between incident ray and normal.

Angle of reflection: Angle between reflected ray and normal.

Axon: A long projection of the cell body which conducts message from the cell body.

Base: A compound which produces hydroxide ions (OH^-) in its aqueous solution.

Black Holes: Massive and dense objects in the space.

Bioplastic: A substitute of plastic.

Biotechnology: A technology which uses living cells and organisms in products and processes that can improve the quality of life.

Concave Mirror: A mirror whose inner curved surface is reflecting.

Cell body: Part of Neuron containing nucleus and most of the cytoplasm.

Cell division: A process in which a cell divides into two daughter cells.

Cerebrum: Top most and the largest part of the brain.

Chemical Equation: Representation of a chemical reaction in terms of symbols, formula and signs.

Chemical Reaction: A reaction in which atoms present in different substances rearrange substances rearrange themselves to form new substances.

Chromosomes: Thread like structures found in the nucleus of a cell.

Circuit breaker: An automatic switch in an electric circuit having function similar to that of a fuse.

Cloning: Biotechnological technique used in various types of genetic analysis.

Commensalism: Type of symbiosis in which one species gets benefit while the other species is neither benefited nor harmed.

Covalent Bond: Bond formed between two atoms of same or different elements by mutual sharing of electron or electrons.

Convex mirror: A mirror whose outer curved surface is reflecting.

Cranial nerves: Nerves arising from the brain.

Cytokinesis: Division of cytoplasm.

Daughter cells: Cells produced as a rest of cell division.

Decomposition reaction: A chemical change in which a compound splits up into two or more simple substances.

GLOSSARY

Deforestation: Destruction of forests as a result of human activities.

Dendrite: A fine projection of the cell body which receives messages.

Density: Mass per unit volume.

Dispersion of light: Phenomenon of splitting light into its component colors.

Detergent: A sodium or potassium salt of long chain fatty acids.

Earth Wire: A wire that connects electric circuits to the Earth.

Ecological Pyramid: A diagram that takes the shape of a pyramid.

Effector: A body part which receives message from brain or spinal cord and produces response.

Electric Circuit: Path along which electric charge flows.

Electric Current: Rate of flow of charge.

Electric power: Rate at which a device converts electrical energy into other form of energy.

Element: A substance which cannot be split into two or more substances by ordinary chemical changes.

Endothermic reaction: A chemical change during which heat is absorbed.

Environmental variations: Variations which are caused by environmental influence.

Exothermic Reaction: A chemical change during which heat is evolved.

Fermentation: A catabolic process in which partial degradation of sugar occurs without the help of oxygen.

Food Chain: Feeding relationship among organisms at different trophic levels.

Food Web: Feeding relationships or interactions between different organisms.

Fore brain: Largest part of the brain.

Fuse: A safety device connected in electrical circuits that interrupts flow of excessive electric current to prevent from damage by over heating or fire.

Gene: Basic unit of heredity.

Genetics: The science of heredity.

Genetic Modification: Removal, addition or repair of genetic material.

Genetically modified bacterium: Bacterium which takes in the recombinant DNA.

Genetically modified Organism: Organism whose genes are modified.

Gene testing: Biotechnological technique used for genetic diagnosis of inherited diseases.

Gene Therapy: Biotechnological technique used to cure genetic and acquired diseases.

Genetic Variations: Variations which arise due to change in genes.

GLOSSARY

Global warming: An increase in average temperature of the Earth.

Groups: Vertical columns in periodic table.

Heredity: Transmission of characters from parents to offspring.

Hydraulics: Branch of science which deals with the transmission of pressured liquids through pipes as source of mechanical force.

Hypothalamus: Part of brain that controls body temperature, hunger and thirst.

Ionic bond: Bond formed by the complete transfer of electron or electrons from one atom to the other atom.

Incident ray: Ray of light that strikes the reflecting surface.

Indicator: A substance that shows different colours in acidic and basic solutions.

Interspecific competition: Competition between different species.

Inter-neurons: Neurons that form a link between sensory and motor neurons.

Intraspecific competition: Competition among individuals within a population.

Medulla Oblongata: Part of brain that controls heartbeat, breathing and digestion.

Meiosis: Nuclear division during which the number of chromosomes in the daughter nuclear reduces to half as compared to that in the parent cell nucleus.

Mid brain: Part of brain that receives information from sense organs and passes to fore brain.

Mineral acids: Acids obtained from minerals.

Mitosis: Nuclear division during which the number of chromosomes in the daughter nuclei remains the same as that in the parent cell nucleus.

Motor Neurons: Neurons that carry nerve impulses from central nervous system to effectors.

Mutation: A change in the genetic material (genes).

Nerve impulses: Messages transmitted by neurons in the form of electrochemical waves.

Neuron: Basic structure and functional unit of the nervous system.

Neutralization: Chemical reaction of an acid with a base to form salt and water.

Nuclear division: Division of nucleus.

Ozone: A layer of gas in the upper atmosphere of the Earth that stops the ultraviolet rays coming from the sun to the Earth.

Ozone depletion: Decrease in the concentration of ozone in the atmosphere due to certain pollutant gases.

Periscope: Optical instrument used to see objects which are higher than our eyes.

Periods: Horizontal rows in periodic table.

Periodic table: Tabular display of the chemical elements.

GLOSSARY

pH: Negative logarithm of hydrogen ion concentration.

pH meter: Instrument used to measure the exact pH of the solution.

pH scale: Scale used to measure the strength of acidic or alkaline solution.

Plane mirror: A smooth flat reflecting surface made up of sheet of glass with a shiny metallic coating on the back.

Plasmids: Additional circular pieces of DNA in the cytoplasm.

Pons: Oval structure of brain that controls sleep, swallowing, equilibrium and taste.

Predators: Consumers that actively hunt other organisms.

Pressure: Force per unit area.

Prey: Organisms upon which a predator feeds.

Reflected ray: Ray of light that bounces off after striking.

Reflection of Light: Bouncing back off light from a smooth shiny surface.

Reflex action: An immediate and involuntary response to a stimulus.

Refraction: The change in direction of light when it enters from one medium to another.

Resistance: Ratio of the voltage across a conductor and the current flowing through it.

Salt: A compound formed by the reaction of an acid with a base / alkali.

Saponification: Chemical reaction of making soap.

Sensory neurons: Neurons that carry nerve impulses from receptors to CNS.

Space exploration: Scientific study of the space using especially developed technology.

Space probe: A vehicle designed to travel in outer space.

Spherical Mirror: A mirror having the shape of a piece cut out of a spherical surface.

Spinal nerves: Nerves arising from spinal cord.

Stimulus: Environmental change that provokes a response in the body.

Symbiosis: A relationship where two species live together closely.

Telescope: An instrument used to see far objects.

Thalamus: Part of forebrain that controls many sensory functions.

Transmission of light: Passing of light after falling on transparent objects.

Tropic Levels: Different feeding levels of organisms in an ecosystem.

Vaccines: A material containing weakened or killed pathogens used to produce immunity against a disease.

Virtual image: Image that cannot be obtained on the screen.

Voltmeter: Instrument used to measure voltage.