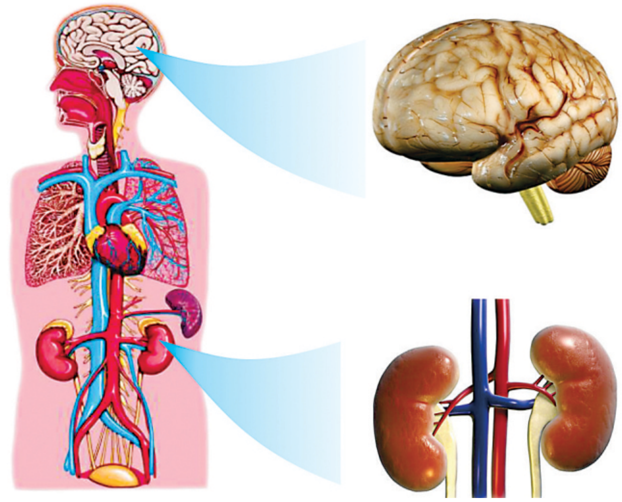
Chapter
1

HUMAN ORGAN SYSTEMS



STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Describe the structure and functions of the nervous system.
- ☑ Describe the working of the nervous system.
- ☑ Explain reflex action with an example.
- ☑ Differentiate between voluntary and involuntary actions.
- ☑ Define excretion.
- ☑ Draw and label human excretory system.
- ☑ Describe the role of kidney in excretion of nitrogenous wastes.
- ☑ Investigate the possible causes of malfunctioning of kidneys.
- ☑ Suggest techniques to cure problems of kidneys.

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 constitutes **nervous system**. Kidneys, their role in excretion, kidney problems and their treatment will also be discussed.

1.1 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 1.1). 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.

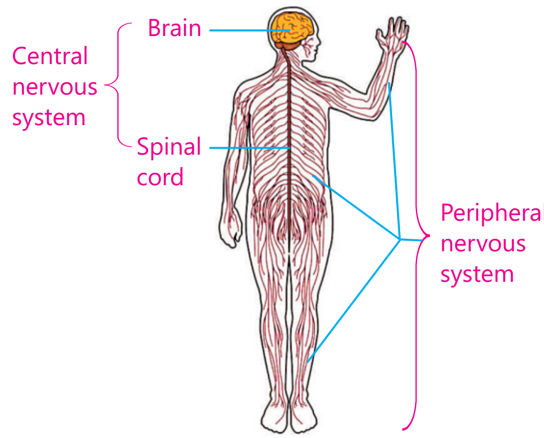


Figure 1.1: Human nervous system

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**.

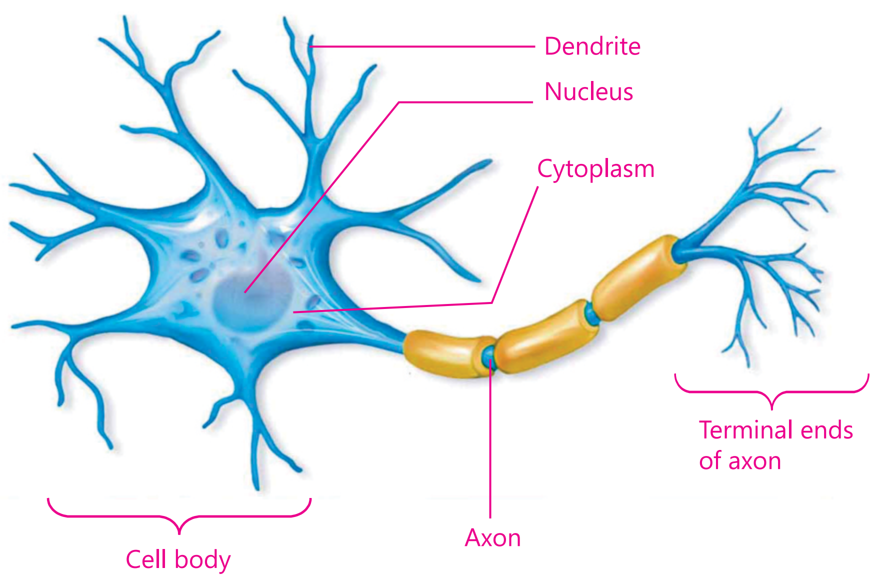


Figure 1.2: Nerve cell or neuron

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 1.2). Terminal ends of the axons transmit the messages to the next cells.

Interesting information

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

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 inter-neurons. **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 1.3).

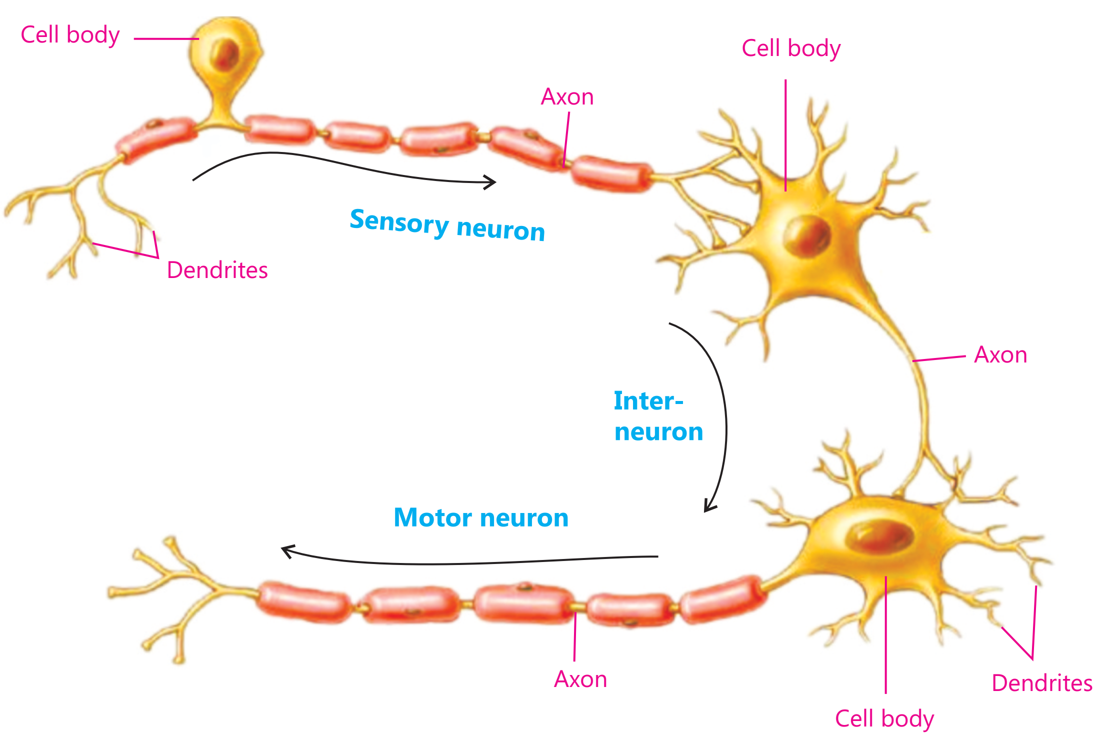
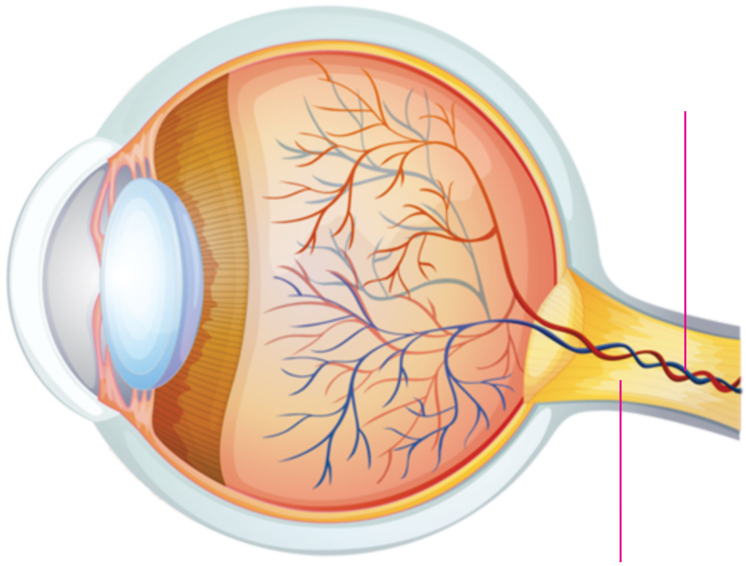


Figure 1.3: Sensory neuron, Inter-neuron and Motor neuron

Activity 1.1 - Identification and Labelling

Identify the following diagram and label the parts which are indicated.



Mini Exercise

Make the diagram of a neuron or nerve cell and label its different parts.

1.1.1 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 1.4) 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. Cerebrum controls many actions like thinking, feelings, emotions, seeing, hearing, perceptions, memory, speech, decision making, etc.

Inside cerebrum there is small structure called **thalamus**. It controls many sensory functions. **Hypothalamus** lies at the base of thalamus. It controls body temperature, hunger and thirst.

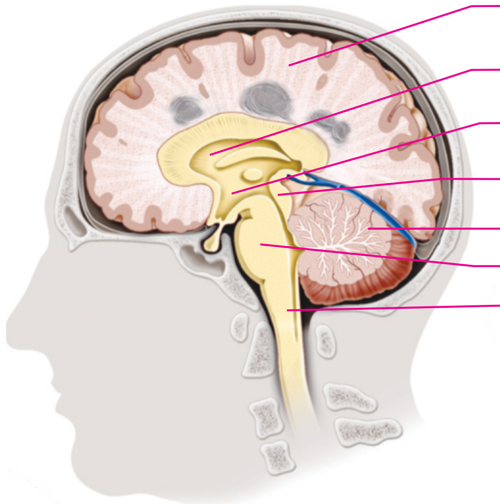


Figure 1.4: Section of skull showing different parts of human brain

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 on 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 man weighs about 1.5 kg and consists of about 100,000,000,000 neurons.

Spinal Cord

Spinal cord is an extension of medulla oblongata (Figure 1.5). 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.

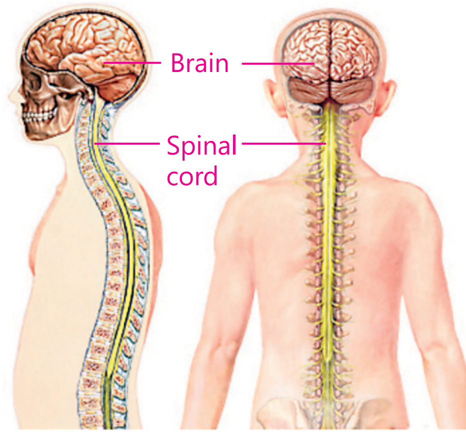


Figure 1.5: Spinal cord

1.1.2 Peripheral Nervous System

Peripheral nervous system (PNS) consists of a network of nerves which are spread in the body to connect all the body parts to the central nervous system (brain and spinal cord) (Figure 1.1). 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.

1.1.3 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. The working of the nervous system has been depicted in Figure 1.6.

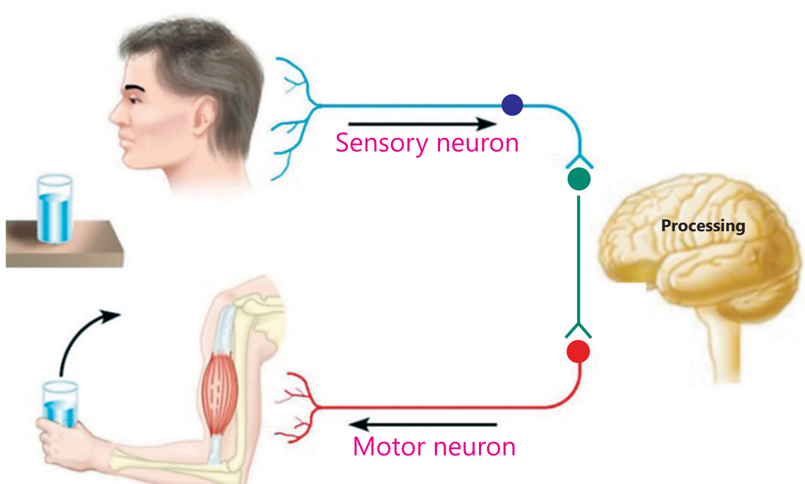


Figure 1.6: Function of nervous system

- 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 cells which detect stimuli are called **receptors**.
- 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.

Activity 1.2

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

1.1.4 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.

1.2 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 1.7, temperature of hot object is a stimulus which is received by the cells (receptors) 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 effectors.

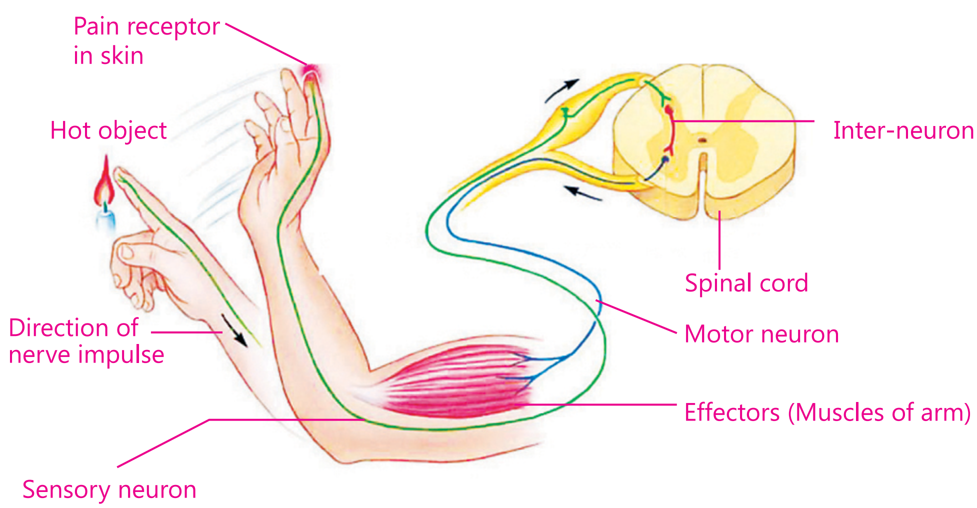


Figure 1.7: Reflex arc representing reflex action. Touching a hot object (flame in this example) results in immediate withdrawal of hand through contraction of muscles of arm.

1.3 Excretory System

As a result of breakdown of various food items and other chemical components of the body, nitrogenous waste matter is produced, which must be immediately removed from the body. Waste products in the body also include nitrogenous materials and other salts. Accumulation of waste materials in the body is dangerous and therefore must be removed from the body. The removal of nitrogenous waste materials from the body is called **excretion**.

Nitrogenous materials, extra water and salts are removed by the **excretory system**. Some extra salts are also removed through skin during perspiration. Human excretory system consists of one pair of kidneys and associated structures, i.e. two ureters, a urinary bladder and a urethra (Figure 1.8).

1.3.1 Kidneys and Associated Structures

Human body has two dark brown, bean-shaped kidneys in the abdominal region, one on either side of the vertebral column. The right kidney is a little lower than the left one. The outer surface of kidney is convex while the inner surface is concave. The following structures are attached with kidneys.

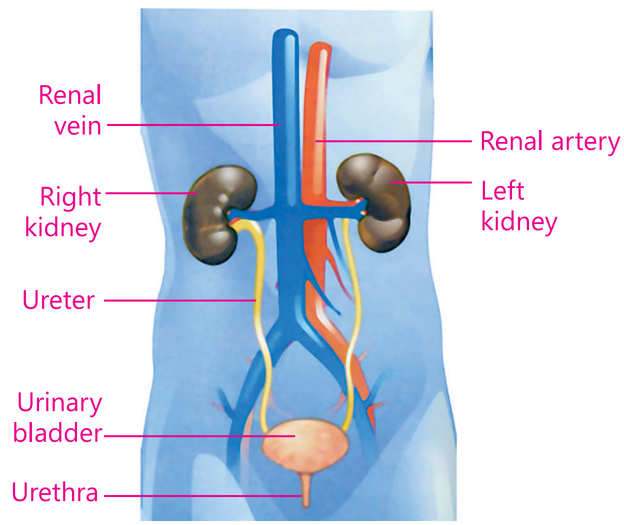


Figure 1.8: Human excretory system

A tube which arises from each kidney and enters the urinary bladder is called ureter. It transports urine from kidneys to urinary bladder. Urinary bladder is a muscular sac which collects urine from both ureters. A fine tube through which urine is released from urinary bladder to the outside is called Urethra.

Internal Structure of Kidney

Internally, each kidney is divided into three regions, i.e., renal cortex, renal medulla and renal pelvis (Figure 1.9). **Renal cortex** is the outermost region. **Renal medulla** is the middle region which is divided into conical masses called **renal pyramids**. **Renal pelvis** is the inner area where urine is drained. The urine from renal pelvis moves into ureter.

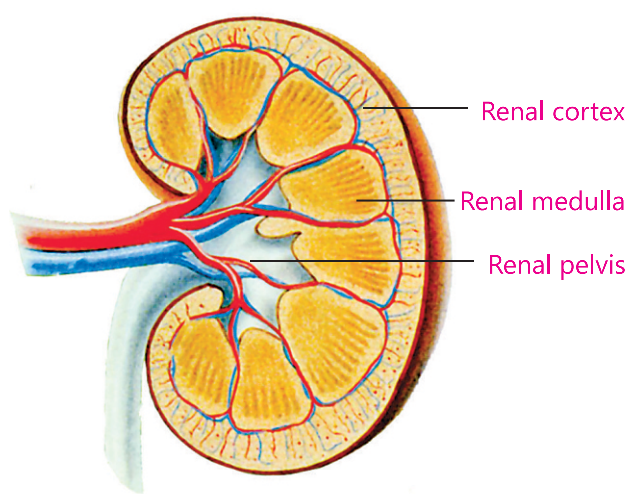


Figure 1.9: Internal structure of kidney

Nephron

Nephrons are the functional units of the kidney. They are the tubules where urine is formed. There are over one million nephrons in each kidney. Each nephron has two parts, i.e., renal corpuscle and renal tubule (Figure 1.10).

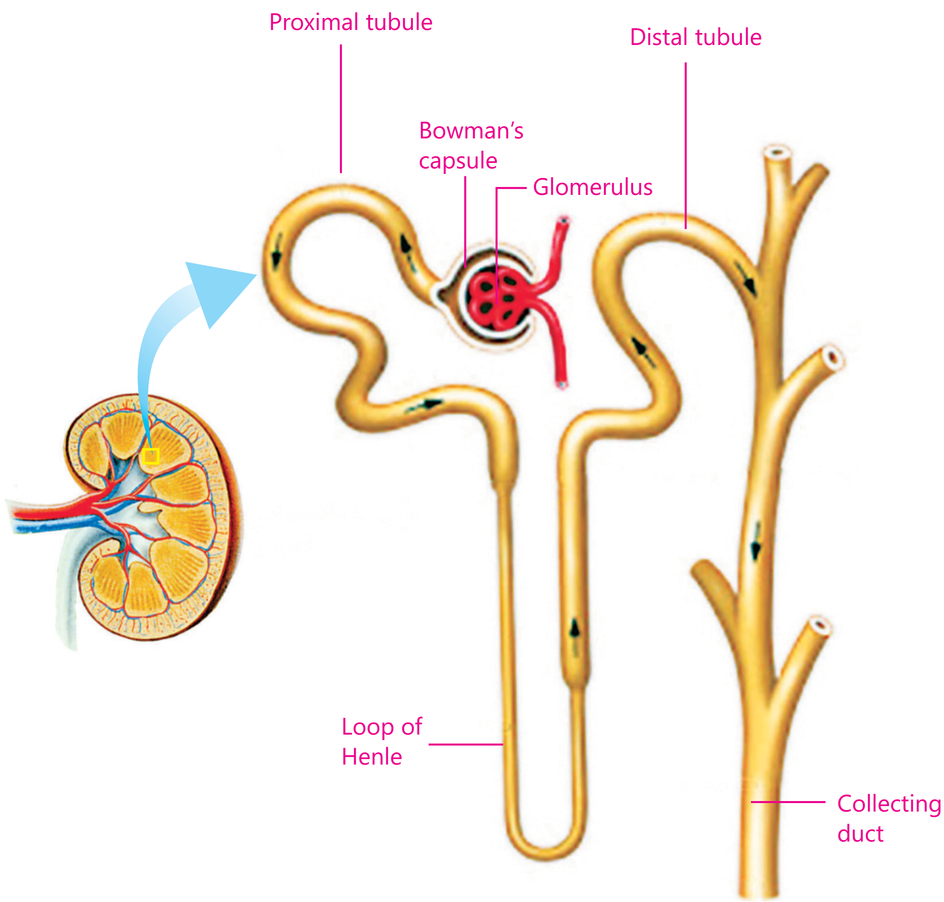


Figure 1.10: Structure of a nephron

Renal Corpuscle

It is the first part of nephron. It consists of two structures, i.e., glomerulus and Bowman's capsule (Figure 1.10). **Glomerulus** is a tuft of blood capillaries formed by the division and sub-division of small arteries and veins. **Bowman's capsule** is a cup-shaped structure enclosing glomerulus.

Renal Tubule

This part of nephron starts after Bowman's capsule. The first coiled part of renal tubule is called **proximal tubule**. The next part is U-shaped and is called **Loop of Henle**. The last part of the renal tubule is again coiled and is called **distal tubule**.

The distal tubules of many nephrons open in a **collecting duct** (Figure 1.10). Many collecting ducts join and drain into renal pelvis.

1.3.2 Function of Kidneys

Blood carries nitrogenous waste materials from the body to the kidneys. Inside the kidneys, blood containing nitrogenous waste reaches the glomerulus. Here, most of the water and waste materials are filtered from the blood into the Bowman's capsule (Figure 1.11). The blood after losing waste material is collected in arterioles, which ultimately form renal artery. The "clean" blood is brought back to the main circulatory system. This filtrate which moves into the renal tubule of nephron also contains some useful substances. During its passage towards the collecting duct, 99% of the filtrate (containing useful substances) is reabsorbed into the blood in capillaries around renal

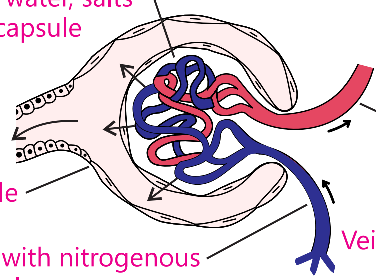


Figure 1.11: Structure of a Bowman's capsule

tubule. During this reabsorption, more waste materials are absorbed from blood capillaries into the renal tubule filtrate. Now, the filtrate in renal tubule is called **urine** which moves into the collecting ducts and then into the renal pelvis.

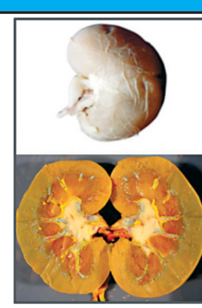
For your information

The average composition of normal human urine in grams per 100 cm^3 is approximately as follows:

Water	= 96.0 g
Urea	= 2.0 g
Mineral salts (mainly sodium chloride)	= 1.8 g
Other nitrogenous substances	= 0.2 g

Activity 1.3

- Get or purchase a kidney of a sheep or a goat from butcher's shop.
- Observe its outer structure and make its diagram on your workbook.
- Cut the kidney lengthwise into two halves.
- Observe the cut surfaces of two halves of the kidney with the help of a magnifying glass and draw the internal structure of the kidney on your workbook.



1.4 Malfunctioning of Kidneys

1.4.1 Formation of Stones in Kidneys

Sometimes kidneys cannot work efficiently, i.e. to remove nitrogenous waste or salts from the blood. In such situation, the salts accumulate in kidneys and form stones (Figure 1.12). Formation of stones disturbs the normal functioning of kidneys and causes severe pain. Kidney stones may travel to ureter or urinary bladder (Figure 1.12). The common causes of stones in kidneys are excessive calcium salts in the food and uric acid etc.

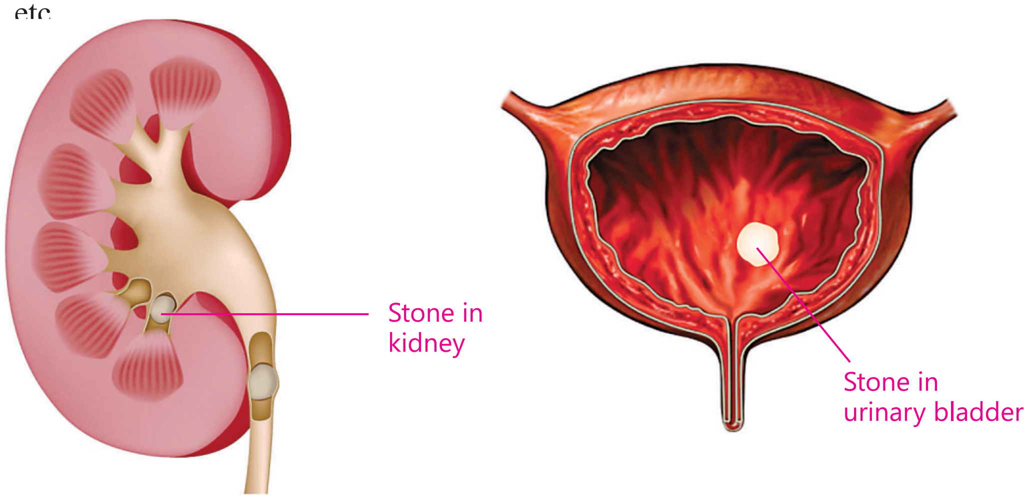


Figure 1.12: Stones in kidney and urinary bladder

Small sized stones can be removed through urinary system by drinking more water. Medium sized stones are removed by **lithotripsy**. Lithotripsy involves bombardment of shockwaves on the stones from outside. Shockwaves break the stones into small pieces which are passed out of the body through urine. Still larger stones need surgery for their removal.

1.4.2 Renal Failure

Renal failure is the complete or partial failure of kidneys to work. The main causes of renal failure are long-term **infections, diabetes mellitus** and **hypertension.** Diabetes mellitus is a disease in which sugar level increases in the blood. Hypertension is a state of high blood pressure in the body. Sudden blockage of blood supply to the kidneys may also result in renal failure. Dialysis and kidney transplant are the treatments of renal failure.

1.4.3 Treatment of Malfunctional Kidneys

1.4.3.1 Dialysis

Cleaning of blood by artificial methods is called dialysis. It is done by a machine called dialyzer. The blood of the patient is passed through the dialyzer which contains dialysis fluid. Blood flows through the tubes of the dialyzer and dialysis fluid flows around these tubes (Figure 1.13). The waste materials move from blood to the dialysis fluid. The cleansed blood is returned to the body.

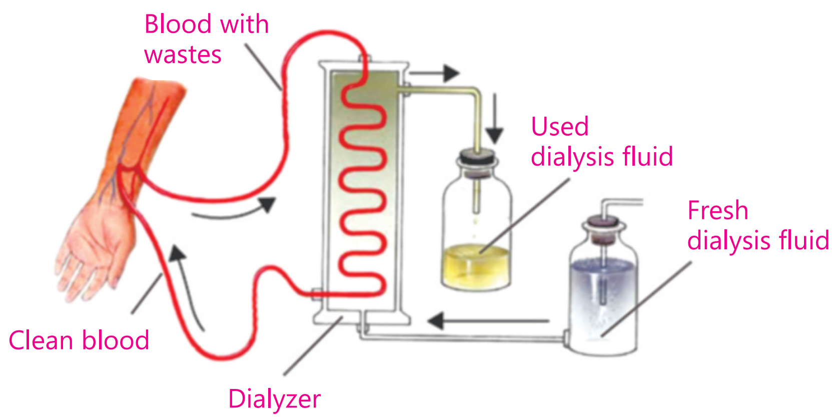


Figure 1.13: Dialysis

1.4.3.2 Kidney Transplant

This method is used at the last stage of kidney failure. In this method, a kidney donated by some healthy person is grafted in the body of the patient (Figure 1.14). The donor of kidney may be blood relative or any other close relative.

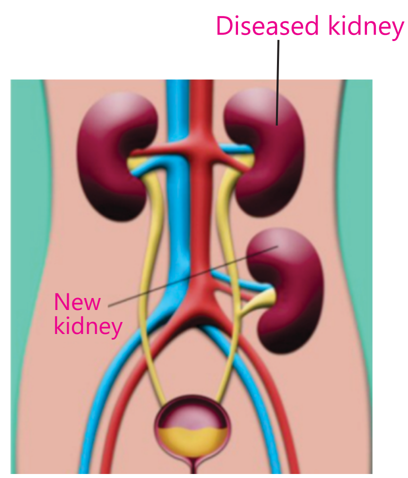


Figure 1.14: Kidney transplant

Science, Technology, Society and Environment

Lithotripsy and kidney transplant are the well-known technologies used in medical science to cure kidney problems.

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 connect 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.
- Human excretory system consists of a pair of kidneys, two ureters, a urinary bladder and a urethra.
- Nephrons are the functional units of kidneys. These are the tubules where urine is formed.
- Accumulation of salts in kidneys results into kidney stones.
- Kidney stones can be removed by using more water, by lithotripsy or by surgery.
- Dialysis and kidney transplant are the treatments of renal failure.

QUESTIONS

1.1 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 a, b, c

(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:

a. nerve cell b. nerve
c. dendrite d. spinal cord

(v) Sensory neurons carry messages towards:

a. muscles b. muscles and glands
c. sense organs d. brain and spinal cord

(vi) If body movements are NOT precise and accurate, the part of brain which may be affected:

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

(viii) The part of body which filters nitrogenous wastes from blood:

a. liver b. kidney
c. intestine d. stomach

(ix) The part of the nephron where reabsorption of useful materials occurs from filtrate to blood:

a. glomerulus b. renal tubule

c. collecting duct d. Bowman's capsule

(x) The function of nephron is to:

a. store urine

b. form urine

c. push out urine from urinary bladder

d. break stones in kidneys

1.2 Write names of the main parts of the following.

(i) Forebrain (ii) Hindbrain

(iii) Neuron (iv) Nephron

1.3 Write the functions of the following.

(i) Forebrain (ii) Hindbrain

(iii) Neuron (iv) Nephron

1.4 Give short answers.

(i) Give at least three examples of voluntary actions.

(ii) Give at least three examples of involuntary actions.

(iii) Define:

(a) sensory neurons (b) motor neuron

(c) inter-neuron

(iv) Skin is also considered as excretory organ. Why?

1.5 Differentiate between:

(i) Receptors and effectors

(ii) Neuron and nerve

(iii) Voluntary actions and involuntary actions

(iv) Kidneys and lungs

(v) Lithotripsy and dialysis

1.6 Explain the central nervous system.

1.7 Describe peripheral nervous system.

1.8 Describe the main parts of excretory system in humans.

1.9 Write a note on the internal structure of kidney.

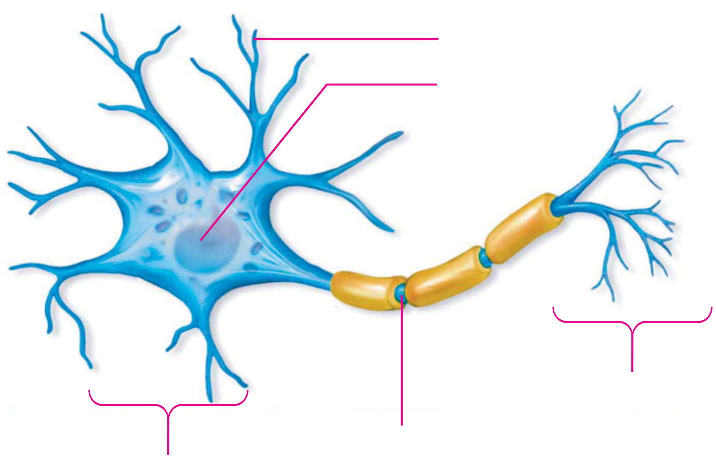
1.10 Describe structure of nephron.

1.11 Write notes on:

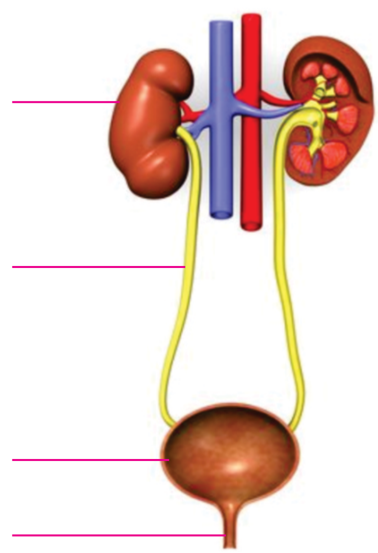
(a) Reflex action (b) Renal failure (c) Dialyzer

1.12 Identify and label the following diagrams.

(a) ---



(b) ---



Critical Thinking

1. Why a motor cyclist is advised to wear the helmet?
2. A person met an accident in a car. When he was brought to the hospital he did not know even his name. What would have happened to him? Relate your answer with reference to your nervous system.
3. 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	

Online Learning

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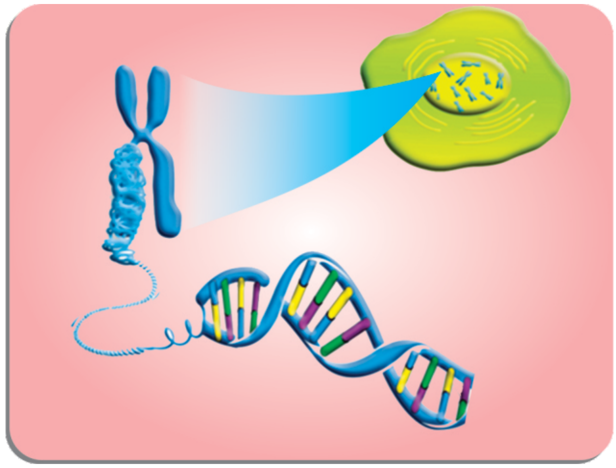
www.healthline.com/human-body-maps/nervous-system
www.kidsbiology.com/human_biology/excretory-system.php
www.biology4kids.com/files/systems_excretory.html

Chapter 2

CELL DIVISION



STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Differentiate between mitosis and meiosis.
- ☑ Identify DNA and chromosomes in the cell diagram.
- ☑ Define heredity and recognize its importance in transferring of characteristics from parents to offspring.
- ☑ Identify the characteristics that can be transferred from parents to offspring.
- ☑ Compare characteristics related to ear and eye colour.

It is our common observation that living things grow and increase 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. Where do new cells come from? The answer to the question is that the new cells arise by the divisions of pre-existing cells. In this chapter, we will discuss the process of cell division. Why do offspring resemble their parents? This is the heredity which produces resemblance in the offspring with their parents. Heredity and basis of heredity will also be discussed in this chapter.

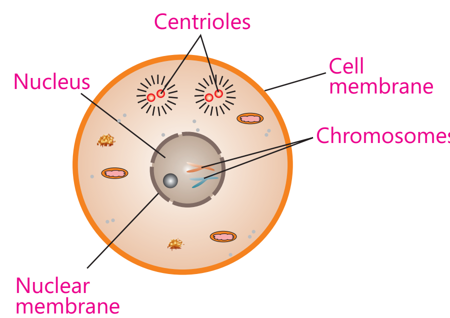
2.1 Cell Division

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**. During interphase, chromosomes in the nucleus are duplicated, i.e., copies of all the chromosomes are developed.

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.

? You need to know...

- Nucleus is part of the cell which controls the 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 an individual forms gametes (sperms or eggs in animals) or spores (in plants), the number of chromosomes is reduced to half in the gametes or spores.



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

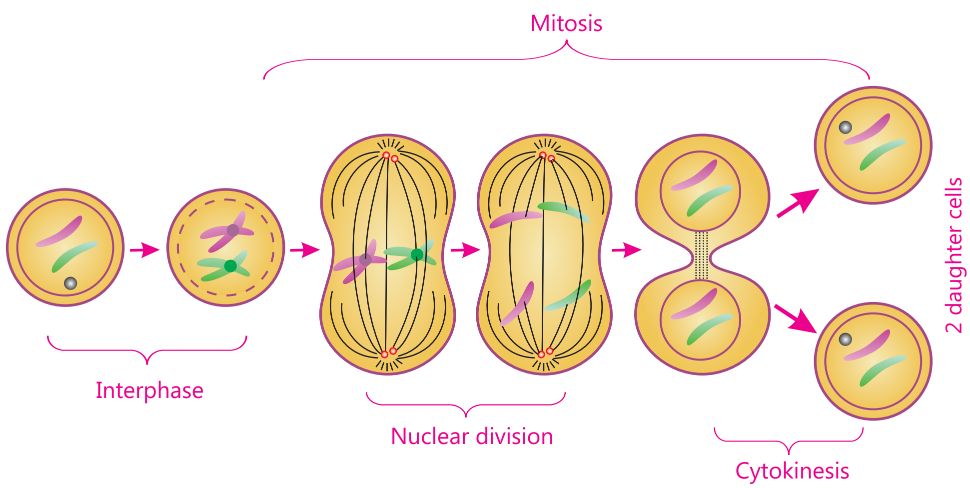


Figure 2.1 Mitosis

with same number of chromosomes as in the parent cell. The number of chromosomes is doubled during interphase. Two sets of chromosomes are formed. During mitosis when the nucleus of parent cell divides the two set of chromosomes are distributed equally in the two daughter nuclei (Figure 2.1).

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.

Meiosis

Meiosis is a process by which the nucleus of a 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, compared to the parent cell (Figure 2.2).

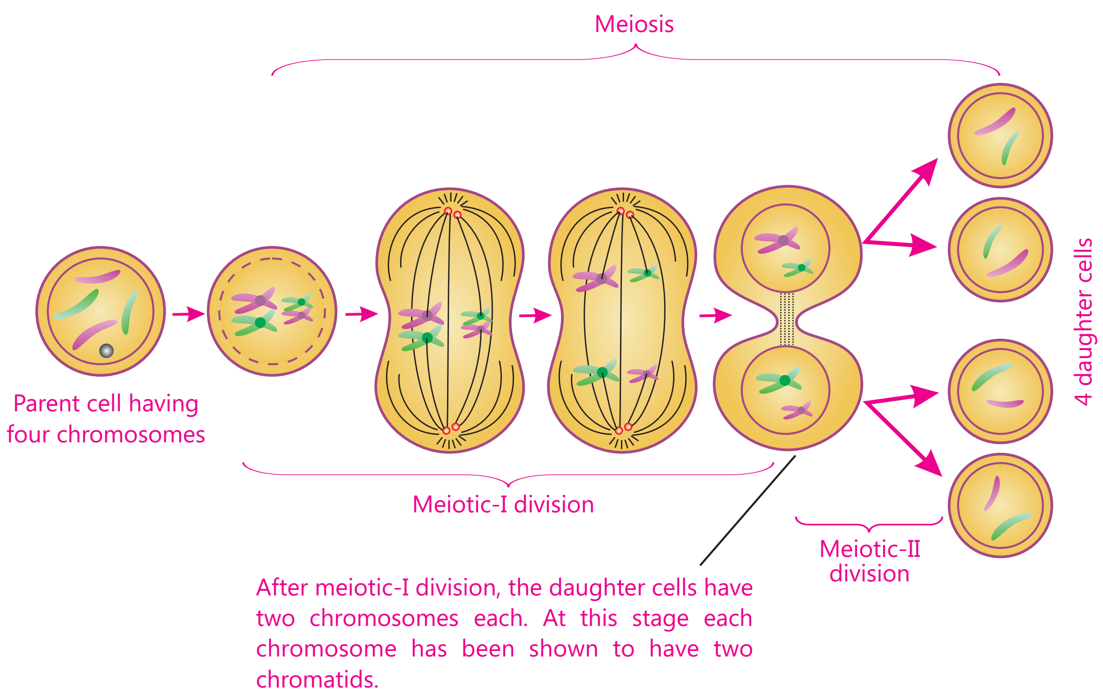


Figure 2.2: Meiosis

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 general body cells.	Meiosis occurs to produce gametes (sperms and eggs) in animals or spores in plants.

2.2 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 offspring and are called **hereditary** characteristics.

Activity 2.1 - 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:

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

Activity 2.1 - (Continued...)

- What feature or features are common to you and your brothers and sisters?
- Which of these features are also present in your parents or grandparents?
- What conclusions do you draw from the above observations?
- What are the characters, which are transferred from parents to offspring, called?
- Which of your body features are different from your brothers and sisters?
- What are the characteristics, which are different in members of a family or in members of a species, 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. Differences among members of a family or a species are called **variations**. Beneficial variations help organisms to adapt (live successfully) their environment, have greater chances of survival and continue their race.

2.3 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., tallness, dwarfness, eye colour, free earlobe, attached earlobe, 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** which are attached to the same part called **centromere.** The relationship between the cell nucleus, chromosomes, genes and DNA is shown in Figure 2.3.

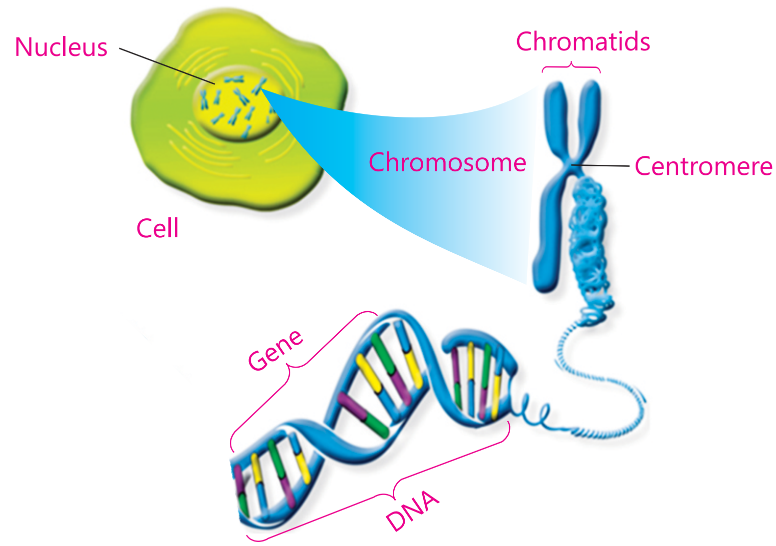


Figure 2.3: Chromosomes, genes and DNA

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.

For your information

Number of Chromosomes in different organisms

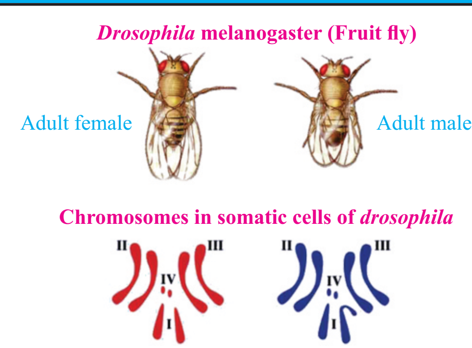
Man	46	Monkey	48	Cat	30
Maize	20	Onion	16	Pea	14

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*?



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, the DNA molecule consists of two strands formed of nucleotides. The two stands of DNA are linked to each other by cross bands like a ladder (Figure 2.4).

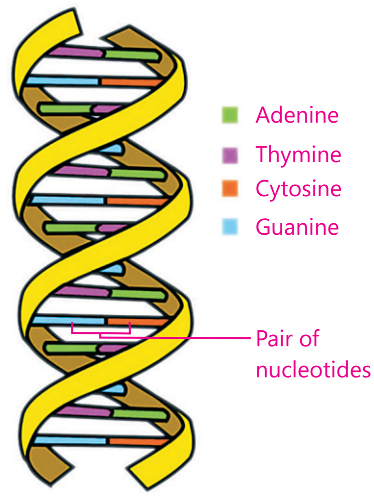


Figure 2.4: Watson and Crick Model

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.

Inheritable and Non-inheritable Characters

The characters such as eye colour, skin colour, hair colour, free or attached earlobes, height, intelligence, etc., are transmitted from parents to the offspring. Such characters that are transmitted from one generation (parents) to the next generation (offspring) are called **inheritable characters**. Inheritable characters are controlled by genes.

Many characters of parents are not transferred to their offspring because these are not developed by genes. Such characters are called **non-inheritable characters**. For example, if a body organ of a person is lost or weakened due to disease, this character is not transferred to his or her children.

Examples of Inheritable Characters

i. Eye colour

The colour of eyes in an organism is controlled by a pair of gene. Thus, it is an inheritable character. The genes control the production of brown pigment in the iris of the eyes. If the genes work and produce more pigment, the eyes are black. Production of very less pigment results in light brown eyes (Figure 2.5). Blue, green, and hazel eye colours are developed due to the production of brown pigment in different amounts.

Figure 2.5: Different eye colours

ii. Attached and Detached Earlobes

In some people the earlobes are attached with the sides of the face while others have free earlobes (Figure 2.6). This character is also controlled by genes. When the said genes work, the earlobes hang freely (detached earlobe). Some people do not have this gene. Their earlobes remain attached with the sides of the face.

Figure 2.6: Attached and detached Earlobes

Activity 2.2: Comparing characteristics related to eye colour

Observe the eye colour of your classmates and friends and record your observations in the table given below:

No.	Name of your friend	Eye colour (Black/ Blue/ Brown/ Grey)	Which of the parents or grandparents (both paternal and maternal) he/she has received this character from?
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

Activity 2.3: Comparing characteristics related to earlobe

Observe the ears of your classmates and friends and record your observations in the table given below:

No.	Name of your friend	Earlobe (Free/attached)	Which of the parents or grandparents (both paternal and maternal) he/she has received this character from?
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

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.

KEY POINTS

- 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 compared to that in the parent cell.
- The transmission of characters from parents to offspring is called heredity.
- The characters which are transmitted to next generation are called inheritable characters.
- Eye colour, skin colour, hair colour, free or attached earlobes, height, intelligence, etc., are inheritable characters.
- 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.
- 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.

QUESTIONS

2.1 Encircle the correct option.

(i) Cell makes copies of its chromosomes during:
a. interphase b. nuclear division of mitosis
c. nuclear division of meiosis d. cytokinesis

(ii) The section of DNA which has information for making a specific protein is called:
a. DNA strand b. nucleotide
c. chromosome d. gene

(iii) Chromosomes are made of:
a. DNA only b. proteins only
c. DNA, proteins and fats d. DNA and proteins

(iv) The characters which are passed from parents to offspring:
a. inheritable characters b. non-inheritable characters
c. environmental characters d. natural characters

(v) An event that occurs during interphase:
a. division of nucleus b. division of cytoplasm
c. duplication of chromosomes d. formation of cell wall

(vi) Reduction of chromosomes takes place during:
a. mitosis b. meiotic-I
c. meiotic-II d. both mitosis and meiotic-II

(vii) In humans, a sperm has 23 chromosomes. Egg cell has:
a. 23 chromosomes b. 46 chromosomes
c. no chromosomes d. 69 chromosomes

(viii) 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

(ix) In humans, the eye colour is developed due to the effects of:
a. diet b. environment
c. genes d. both 'a' and 'b'

(x) Which statement is correct?

a. DNA has instructions for making proteins

b. Protein has instructions for making DNA

c. Both of these

d. None of these

2.2 Match the words of column A with the relevant words in column B.

A	B
DNA	Haploid cell
Cytokinesis	Diploid cell
Free earlobe	Division of cytoplasm
Zygote	Gene
Egg	Hereditary character

2.3 Give short answers.

(i) Name two inheritable characters.

(ii) Name two non-inheritable characters.

(iii) What is a gene?

(iv) Define heredity.

(v) What are haploid cells?

2.4 Describe mitosis.

2.5 Describe meiosis.

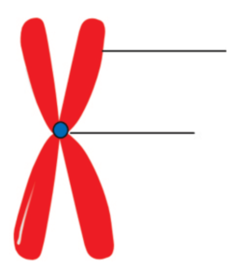
2.6 Define heredity and describe its importance in transferring of characteristics from parents to offspring.

2.7 Describe the characteristics that can be transferred from parents to offspring.

2.8 Write notes on:

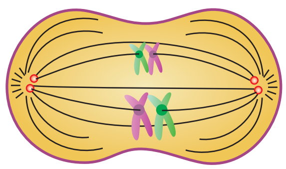
(a) DNA (b) Chromosomes (c) Genes

2.9 Identify and label the following diagram:

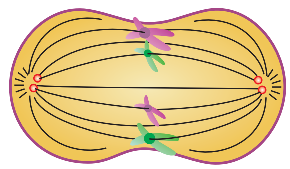


Critical Thinking

1. Gametes are haploid cells. What do you think would happen if the gametes forming a zygote are diploid?
2. 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?
3. Which of the following figures represent a phase of mitosis and the other a phase of meiosis?



(a)



(b)

Online Learning

www.pitb.gov.pk
www.uic.edu/classes/bios101/genes
www.human-nature.com/drawin/
www.en.mimi.hu/Biology/

Chapter 3

BIOTECHNOLOGY

STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Define biotechnology.
- ☑ Explain how DNA is replicated.
- ☑ Describe the relationship between DNA, genes and chromosomes.
- ☑ Define bacterium.
- ☑ Explain how genes are introduced into a bacterium.
- ☑ List some biotechnological products used in daily life.
- ☑ Explain that genetic modification in different foods can increase the amount of essential nutrients.
- ☑ List general applications of biotechnology in various fields.
- ☑ Explain how biotechnology allows meeting the nutritional needs of growing populations.

Application of knowledge in the areas like engineering and medicines, etc., is called technology. The technology in which living things are used in different ways to help and benefit human beings is called **biotechnology**. 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.

You need to know.

Relationship between chromosomes, DNA and genes

As we have learnt in the previous chapter, there is a close structural and functional relationship between, chromosomes, DNA and genes.

- Chromosomes are the thread-like structures found in the nucleus of a cell. They are made up of DNA and proteins.
- DNA is the hereditary material.
- Genes (the sections of DNA) are located on chromosomes and control the development of hereditary characters in an organism.
- In human cells, there are more than one thousand genes on a single chromosome.

Relationship between Chromosome, DNA and Gene

3.1 DNA Replication

DNA has a unique property to replicate itself. Replication of DNA is a process by which DNA makes its copy. The process of DNA replication takes place in the nucleus of the cell during interphase.

The first step in DNA replication is unwinding of its double helix structure and separation of two strands from each other like the separation of two strands of an open zipper (Figure 3.1).

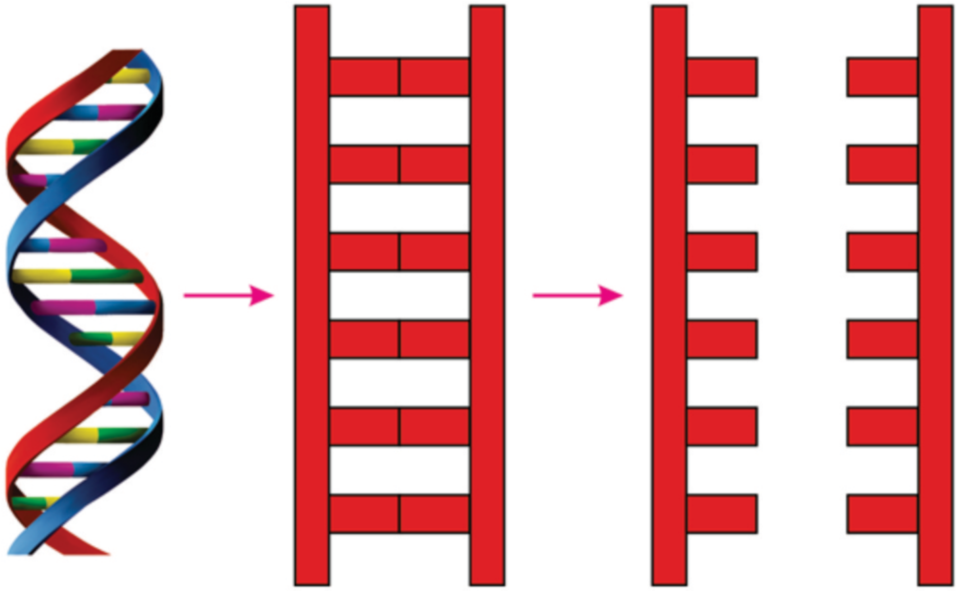


Figure 3.1: Unwinding of DNA and separation of two strands

In second step, each of these strands produces a new strand using new nucleotides. In this way, one double strand DNA molecule produces its identical copy and two daughter DNA molecules are formed. Each daughter DNA contains one new strand and one strand of the parent DNA (Figure 3.2).

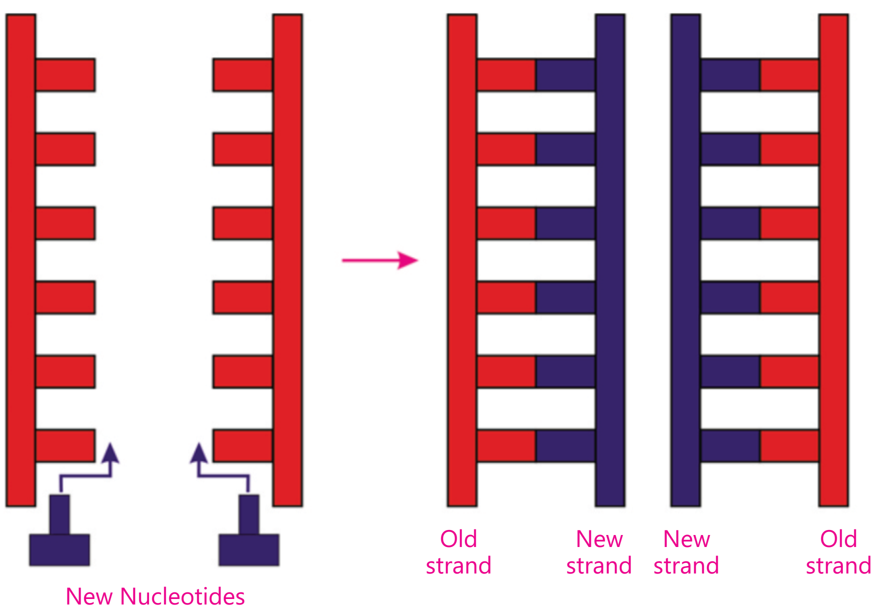


Figure 3.2: Replication of DNA

3.2 Introduction of Gene into Bacterium

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.

Why do Scientists use Bacteria in Genetic Engineering?

Bacterial cell 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 3.3).

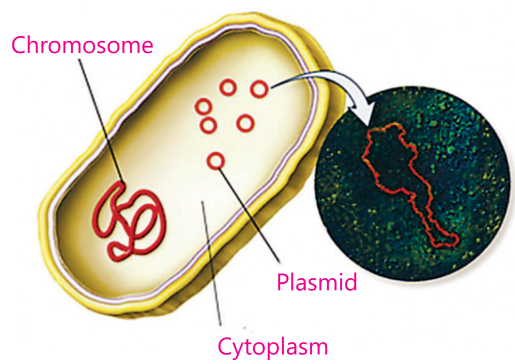


Figure 3.3: Bacterial Cell

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.

> **? Do you know?**
>
> A bacterial cell divides to form two daughter cells within 20 minutes.

How do Scientists Insert Gene in a Bacterium?

The first step 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 3.4). 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 3.4).

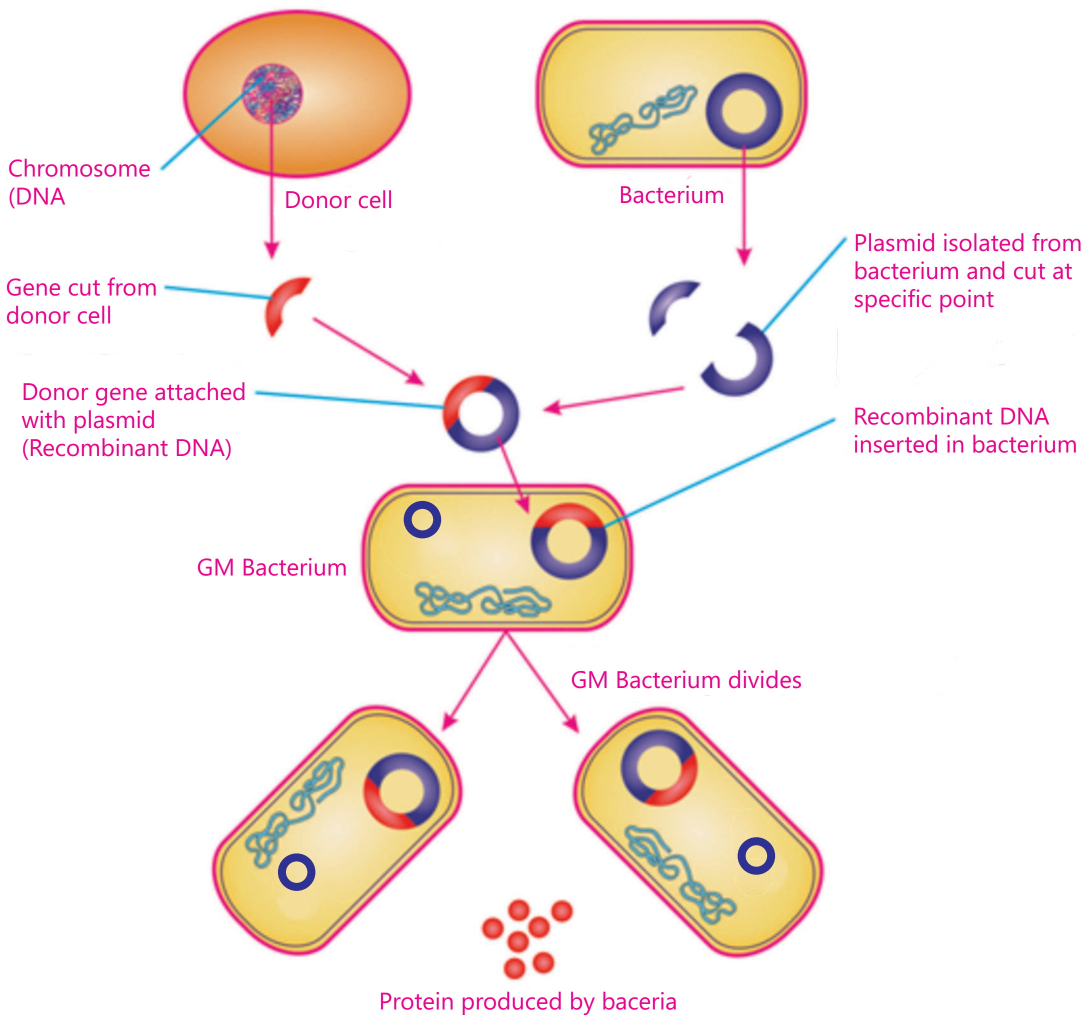


Figure 3.4: Introduction of gene into a bacterium

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.

3.3 Genetic Modifications and Biotechnology Products

The change in the genes of organisms using biotechnology techniques is called genetic modification. The change in the genes of an organism can be produced by removal, addition or modification of genes. 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 improvement in the nutritional quality of edible plants is also one of the advancements of genetic modification. The organism whose genes are modified is called Genetically Modified Organism (GMO). GMOs are also used to prepare useful and lifesaving products such as insulin and vaccines, etc. (see Figure 3.5).

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

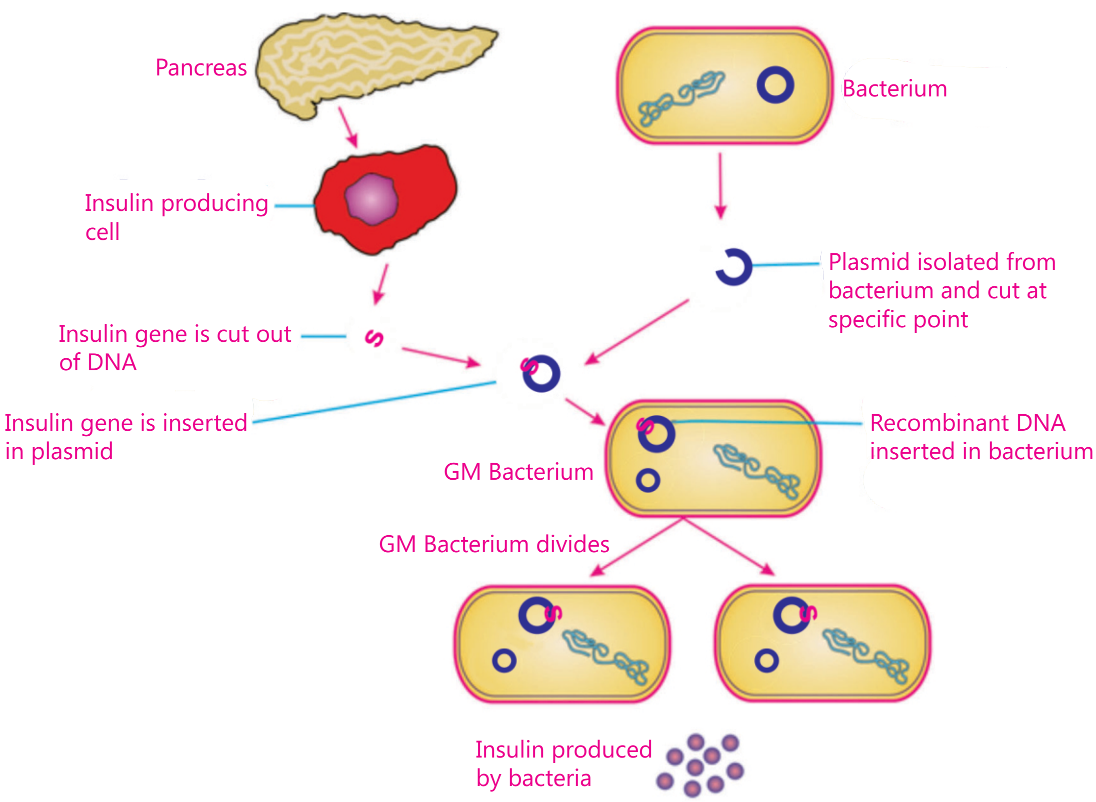


Figure 3.5: Production of insulin by genetically modified bacterium

patients need regular injections of insulin to control glucose level in the blood. In past, insulin was extracted from the pancreas of animals. Nowadays, it is produced using biotechnology techniques. Scientists insert the human insulin gene in bacteria to modify them genetically. These genetically modified bacteria (GM bacteria) prepare insulin. The insulin prepared in GM bacteria is extracted from bacterial colonies and used. The steps of biotechnology techniques for the production of insulin are shown in the Figure 3.5.

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 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, its 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 hepatitis-B, typhoid, measles, etc., have been developed using biotechnology (Figure 3.6). Vaccines for malaria and HIV are being developed.

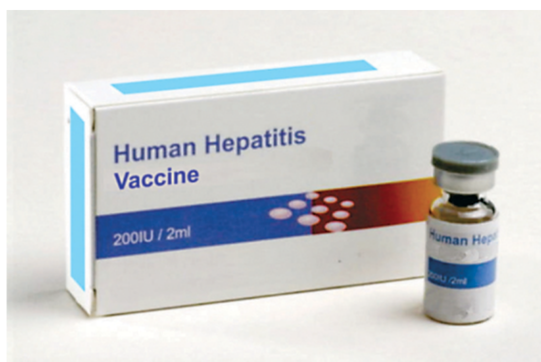


Figure 3.6: Vaccine for Hepatitis B

Other important lifesaving biotechnology products include blood clotting factors, growth hormones, etc.

3.4 Applications of Biotechnology

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

3.4.1 Agriculture

Biotechnology has played a revolutionary role in improving our agriculture and production of high yields of crops (Figure 3.7). 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. Cultivation of such genetically modified crops improves the quality 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.

Figure 3.7: High yield crop

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.

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

- Pakistani scientists in some Universities are trying to produce wheat having higher proportion of iron in the flour. This may help overcome iron deficiency in food.

! You need to know.

- Most of the high yield crops or fruit trees are susceptible to diseases. Introduction of disease resistance genes into such crops or fruit trees enable 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.

3.4.2 Food Production and Preservation

Use of better quality genes in the animals is producing high yields of milk and meat (Figure 3.8).

Milk producing animal

Meat producing animals

Goat meat

Figure 3.8: Genetically modified animals and animal product

Production of better quality fruits and vegetables and increasing their shelf lives are also due to using biotechnology techniques (Figure 3.9).

Better quality fruit

Vegetables

Figure 3.9: Genetically modified fruits and vegetables

! You need to know.

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

3.4.3 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 and curing and correction of genetic defects, etc., are the major roles of this technology in developing better health. Various biotechnology products which are used 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

Important biotechnology techniques

Gene Therapy

Gene therapy is an advanced biotechnological technique which is used to cure genetic and acquired diseases like cancer and AIDS. In this process, defective genes are supplemented or replaced by normal genes.

Genetic Testing

Genetic testing is one of the latest biotechnological techniques used for genetic diagnosis of inherited diseases. It involves the direct examination of DNA molecule. It is also used to determine a child's paternity or a person's ancestry.

Cloning

Cloning is also amongst the latest biotechnological techniques used in various types of genetic analyses. Animal cloning can be used for production of animal organs, and strong, well built livestock for quality production of milk and meat.

3.4.4 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.

Gene therapy, genetic testing, cloning, etc., are the examples of biotechnological methods used for treating various diseases.

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.
- The process by which DNA makes its copy is called DNA replication.
- The use of biotechnology techniques to change the genes of an organism is called genetic modifications. Genetic modification involves the removal, addition or modification of genes.
- Genetic engineering is a biotechnology 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 yields 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

3.1 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. fungi and algae

(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) Biotechnological method for the production of animal organs:

a. gene therapy b. genetic testing

c. cloning d. organ transplant

(ix) 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

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

a. tissue culture b. fermentation
c. biodegradation d. genetic engineering

3.2 Match the statements of column A with the relevant statements of column B.

A	B
Growth hormone	Viral infection
Beta-Endorphin	Diabetes
Vaccine	stimulating growth
Interferon	Immunity against diseases
Insulin	Pain killer

3.3 Give short answers.

(i) What is biotechnology?
(ii) What is genetic testing?
(iii) Name at least two life saving products of biotechnology.
(iv) Briefly describe gene therapy.

3.4 How do scientists insert the gene of a desirable protein into a bacterium?

3.5 Give diagrammatic explanation of biotechnological process for the preparation of insulin.

36. Describe the application of biotechnology in agriculture.

3.7 What is genetic modification? How is it helpful in increasing the amounts of different nutrients in food?

3.8 Describe the application of biotechnology in health and environment.

Online Learning

www.pitb.gov.pk
www.uic.edu/classes/bios101/genes
http://www.discoveryeducation.com
http://www.ucsusa.org/food_and_environment/biotechnology (The Union of Concerned Scientists Website)
www.sciencedaily.com/news/plants_animals/biotechnology/

Chapter 4

POLLUTANTS AND THEIR EFFECTS ON ENVIRONMENT

STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Explain the sources, properties and harmful effects of air pollutants.
- ☑ List problems in human organ systems caused by air pollutants.
- ☑ Plan and conduct a campaign that can help to reduce air pollution in their local environment.
- ☑ Explain the greenhouse effect.
- ☑ Describe the causes and effects of ozone depletion.
- ☑ Carry out a research to explain global warming and its likely effects on life on the Earth.
- ☑ Design a model to explain the greenhouse effect.
- ☑ Explain the formation of acid rain and identify its consequences on living and non-living things.
- ☑ Define deforestation.
- ☑ State the effects of deforestation on the environment.
- ☑ Identify human activities that have long-term adverse consequences on the environment.
- ☑ Explain the importance of local and global conservation of natural resources.
- ☑ Suggest ways in which individuals, organizations and government can help to make the Earth a better place to live.

The environment we live in is not as clean as it should be. Various natural and human activities contaminate it with harmful substances. Dust storms, rotting of vegetation, volcanic eruption, etc., are the natural phenomena which release dust particles and poisonous gases in the environment. On the other hand, burning of fuels in the vehicles and industry and many other human activities are releasing poisonous compounds in the environment. The poisonous and harmful substances which contaminate or pollute the air are called **air pollutants**. In this chapter, we will discuss the effects of air pollutants on human life and the environment. Awareness about environmental pollution and measures to reduce it will also be discussed.

4.1 Air Pollutants and Their Sources

Carbon monoxide (CO), sulphur dioxide (SO_2), oxides of nitrogen (NO and NO_2), chlorofluorocarbons (CFCs), etc., are the main air pollutants. Poisonous gases produced during the decay of dead organic matter and particulate matter like soot, dust particles, pollens, metallic compounds (e.g., compounds of lead), etc., also pollute the air.

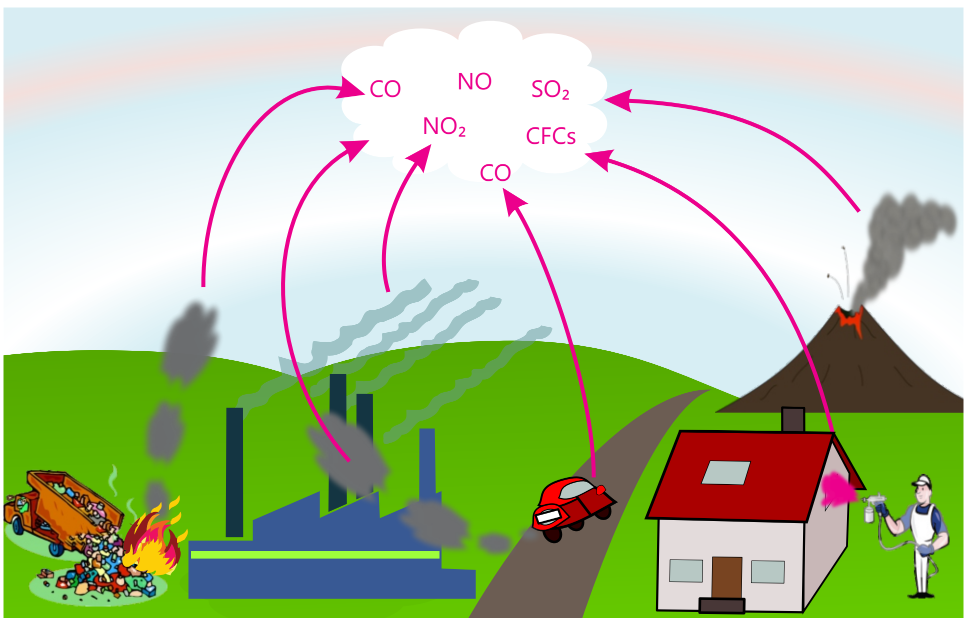


Figure 4.1: Air pollutants

Carbon monoxide is produced by the incomplete combustion of coal and other fossil fuels (natural gas, petrol, oil, etc.). Smoke released from motor vehicles and industries is the main source of carbon monoxide (Figure 4.1).

Sulphur dioxide is produced by burning of coal or oil in factories. Smoke released from thermal power stations usually contains sulphur dioxide. Oxides of nitrogen are produced by burning of coal and oil at high temperature in industries and vehicle engines. Chlorofluorocarbons (CFCs) are the compounds which contain chlorine, fluorine and carbon atoms. CFCs are used in aerosol sprays, refrigerators and air conditioning system.

On leakages from these appliances, CFCs enter the air. Fossil fuels (coal, natural gas, oil, petrol, etc.) and aerosols are the main **sources of air pollutants** (Figure 4.2).

Vehicles' smoke

Industrial smoke

Smoke emitted from thermal power station

CFCs in aerosol spray

Figure 4.2: Sources of air pollutants

Rotting vegetation and volcanic eruption are natural sources of air pollution (Figure 4.3).

Rotting vegetation

Volcanic eruption

Figure 4.3: Natural sources of air pollutants

4.1.1 Properties of Air Pollutants Their and Effects on Human Organ Systems

Carbon monoxide

Carbon monoxide is a colourless, odourless and poisonous gas. It affects the human organ systems badly and causes headache, brain damage and respiratory problems. When carbon monoxide reaches our blood, it binds with haemoglobin and reduces its oxygen-carrying capacity.

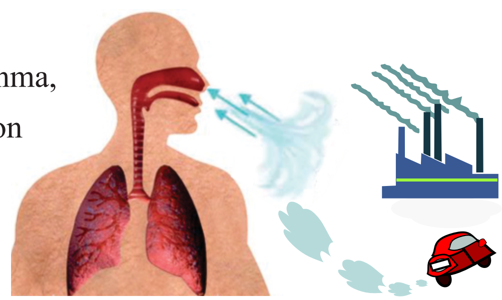
Sulphur dioxide

It is a colourless gas with irritating smell. It dissolves in rain water and causes acid rain. Exposure to sulphur dioxide causes breathing difficulties, pneumonia, lung cancer etc.

Interesting information

Sulphur dioxide causes:

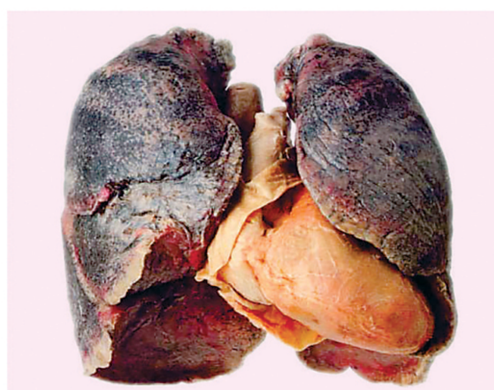
- Severe respiratory problems such as asthma, chronic bronchitis, degraded lung function
- Respiratory failure
- Cardiovascular diseases
- Cancer



Oxides of Nitrogen

Oxides of nitrogen are all toxic gases. They dissolve in rain water to cause acid rain. They have severe effects on lungs and damage them (Figure 4.4).

(a) Oxides of nitrogen released by burning of fuel at high temperature



(b) Effect of oxides of nitrogen on lungs

Figure 4.4

For your information

- Sulphur dioxide destroys chloroplast in plants. As a result, the photosynthesis and plant growth are affected.

4.2 Effects of Human Activities on Environment

Human activities such as burning of fuels, extensive use of vehicles, aerosols, fertilizers, insecticides, pesticides, etc., and deforestation are affecting the environment badly. We will discuss here a few examples of adverse effects of human activities on the environment.

4.2.1 Greenhouse Effect

When sunlight falls on the Earth, a small part of it is absorbed by the Earth and is converted to heat energy. A part of this heat energy is reflected by the Earth back to the atmosphere. Some gases present in the atmosphere, e.g., carbon dioxide, methane, oxides of nitrogen, water vapours, etc., trap a part of the heat reflected by the Earth causing increase in the atmospheric temperature (Figure 4.5). These gases are called **greenhouse gases** and the phenomenon is called **greenhouse effect**.

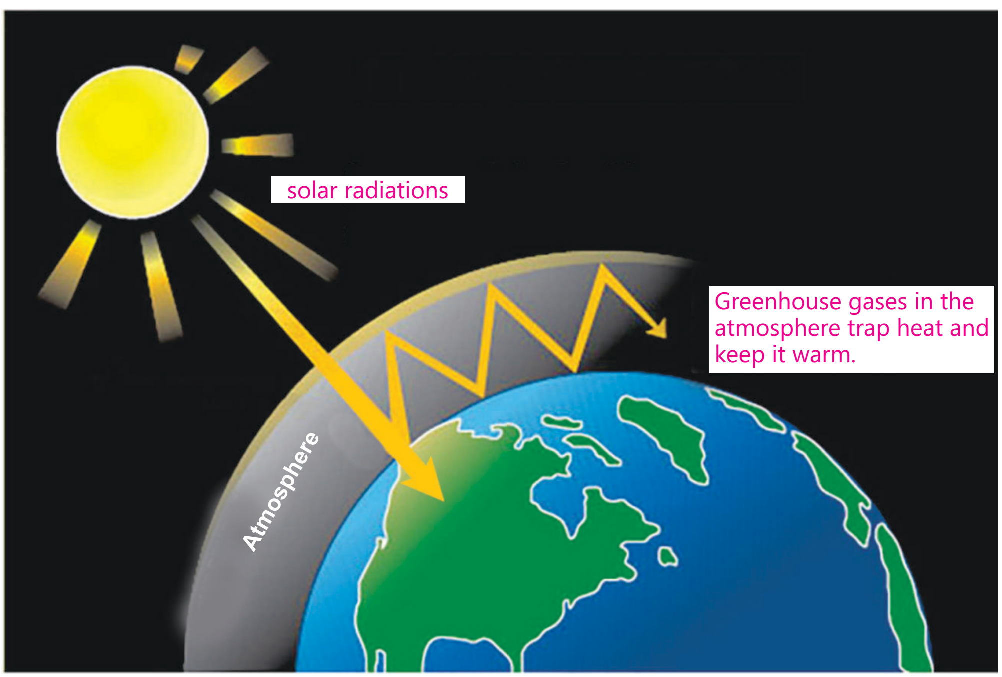


Figure 4.5: Greenhouse effect

Interesting information

Greenhouse is a big room made of glass panels or transparent plastic sheets. It provides warm environment to the plants and vegetation grown inside it so that they can grow well during winter. Glass or transparent plastic sheets used in greenhouses allow the Sun's heat to enter the greenhouse and trap the heat which is reflected back by the Earth. The heat trapped by the walls and roof of the greenhouse keeps the inside environment warm.

Activity 4.1

Material required:

Collect some easily available plastic sheets, wooden strips, nails, etc. and potted plants.

Procedure:

- Follow the Figure given in the boxed information above and design simple greenhouse.

4.2.2 Ozone Depletion

A layer of ozone (O_3) in the upper atmosphere of the Earth stops the ultraviolet rays coming from the Sun to the Earth. In this way, the living things on the Earth remain safe from harmful effects of the ultraviolet radiation coming from the Sun.

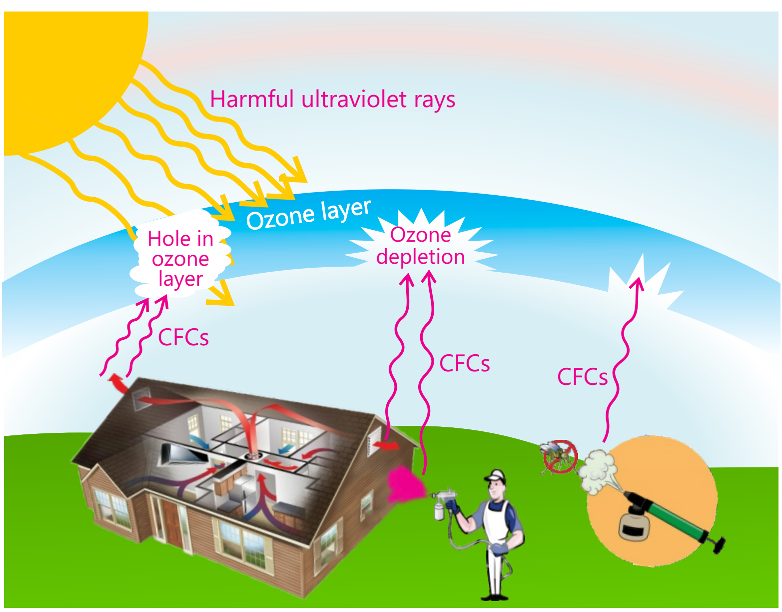


Figure 4.6: Ozone depletion

Chlorofluorocarbons (CFCs) which are used in air conditioners, refrigerators, spray cans, etc., enter the air on leakage from these appliances. On reaching the ozone layer, they react with ozone and cause thinning of this layer. Hence, the ozone layer is depleted (Figure 4.6). The phenomenon is called **ozone depletion**.

Through the thin ozone layer, ultraviolet rays of the Sun pass and reach the Earth where they affect the life by causing serious diseases like skin cancer and eye problems, etc. These ultraviolet rays also increase the temperature of the Earth.

4.2.3 Global Warming

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 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**.

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.

Figure 4.7: Effects of global warming

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 4.7).

Interesting information

Burning of fuels releases millions of tonnes of carbon dioxide into the environment each year.

Mini Exercise

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

4.2.4 Acid Rain

Sulphur dioxide and oxides of nitrogen are present in the atmosphere as air pollutants. They get dissolved in water vapours in clouds and turn into acids like sulphuric acid and nitric acid. These acids make the rain water acidic (Figure 4.8).

The effects of acid rain on animals, plants and buildings are shown in the Figure 4.9.

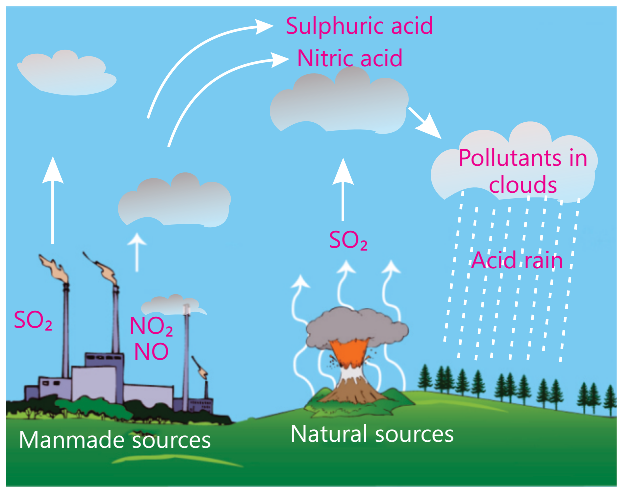


Figure 4.8: Acid rain

Fish killed by acid rain water

Effect of acid rain on trees

Stonework erosion caused by acid rain

Corrosion of metals caused by acid rain

Figure 4.9: Effects of acid rain

Acid rain kills the aquatic life in rivers, lakes and ponds etc. It destroys the leaves and barks of the trees. It corrodes the metals and the stones used in buildings. The acid rain water flowing into fields makes the soil acidic. The crops do not grow well in acidic soil. Microorganisms present in soil are also affected by acid rain.

4.2.5 Deforestation

Forests are our great wealth. They bring favourable changes in climate of an area. They stop storms and bring rains. They are source of many useful materials such as timber, firewood, resins, gums and medicines, etc. They prevent soil erosion. They provide habitat to a wide variety of wild life. Unfortunately, forests are cut to meet the demand for timber and to obtain land for housing and agriculture. As a result, the ecosystem is destroyed. Destruction of forests as a result of human activities is called **deforestation** (Figure 4.10).

Figure 4.10: Deforestation

Effects of Deforestation on the Environment

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.

Effects of Deforestation on Wildlife

All non-cultivated plants and non-domesticated animals of an area are collectively called wildlife. Deforestation destroys the habitats of wildlife (Figure 4.11). The extinction risk of wildlife is increased while the natural balance maintained by the wildlife is disturbed.

Figure 4.11: Effects of deforestation on wildlife

Information

- According to the experts, at least 25% of the total area of a country must be covered by forests but in Pakistan only 5% of its total area is covered by forests.

Do you know?

- Human activities have increased the proportion of carbon dioxide in the air from 0.03% to 0.04% in about 100 years. Scientists think that if this trend is continued, the amount of carbon dioxide in the air will be doubled by the middle of the next century.

4.2.6 Lack of Natural Resources

Resources are the materials in the environment that are ready for human use or may be used in future. Fossil fuels (coal, natural gas, oil, etc.), minerals, trees, animals, water, etc. are all natural resources. The resources on the Earth are limited. Many of them, e.g., minerals and fossil fuels are non-renewable. A resource that does not regenerate quickly is called **non-renewable resource**.

The limited and non-renewable resources (fossil fuels, etc.) are used to produce energy for running industry, transport and household appliances. They will get depleted and hence alternate sources of energy need to be developed. A lot of energy which could do useful work is wasted by man. For instance, household appliances are left running even when no one is using them. Similarly, instead of using public transport personal cars are used which consume a lot of fuel. The unwise use of non-renewable resources of energy may result into non-recoverable loss. To avoid such loss, the resources must be conserved for future use. We must also search for alternate sources of energy like solar energy, wind energy, hydropower and atomic energy, etc.

Do you know?

- Formation of fossil fuels is a very slow process. It takes millions of years.

4.3 Conservation of Resources

Fossil fuels are present on the Earth in limited quantities. Their unwise use must be stopped and they need to be conserved.

Three (3) R strategies, i.e., **Reduce-Reuse-Recycle** can be adopted for conservation of resources (Figure 4.12).

- The first strategy in this connection is **"Reduce"**, i.e., the use of non-biodegradable objects should be reduced and the resources which are used in their manufacture should be conserved.
- The second step in three (3) R strategies is **"Reuse"**, i.e., the non-biodegradable objects should be used again and again instead of throwing them after first use.

Figure 4.12: Three R Strategies

- The third strategy is **"Recycling"**, i.e., the waste objects made of non-biodegradable materials should be collected, cleaned, melted and remolded into new objects.

By adopting the above said (3R strategies) habits, we can conserve our resources.

4.4 Saving the Earth

The Earth is the only planet in our Solar System where life can survive. Pollutants are harmful to the life on Earth. We should keep the Earth's environment clean and healthy. Following measures can be taken for saving the Earth from the toxic effects of pollutants.

4.4.1 Solid Waste Management

Solid wastes include plastic and glass items, styrofoam, sewage sludge, agricultural wastes, and domestic trash, etc. These wastes pollute the Earth's environment when dumped on open places or burnt (Figure 4.13). Hence, we should not dump them on open places nor burn them. They should be managed properly. Landfill, incineration and recycling are the common methods of solid waste management.

Figure 4.13: Solid wastes

Landfill

In this method, solid wastes are buried in properly designed landfills which are well managed for maintaining hygienic conditions. It is relatively inexpensive method of disposing of waste materials.

Incineration

In this method, wastes are burned at extremely high temperatures.

Recycling

In this method, plastic items (like plastic bottles and polythene bags), glass pieces, aluminium and steel cans, copper wires, etc. are collected separately, cleaned, melted and moulded into new products. In this way, they are used again and again to reduce pollution.

4.4.2 Environmental campaigns

Environmental campaigns should be conducted frequently for creating awareness among common people about pollution and reducing its harmful effects. Such campaigns may include seminars, school talks / debates, celebrating the World Environment Day (5th of June every year), etc.

Activity 4.3

- Prepare banners and posters showing harmful effects of air pollution.
- Prepare some banners reflecting methods to reduce pollution.
- Conduct a walk in your locality to create awareness about air pollution and its harmful effects.

Activity 4.4

- Conduct a seminar on the importance of local and global conservation of natural resources.

4.3.3 Responsibility for All

All of us are responsible for keeping the environment clean. The individuals, the organizations and the Government must share their responsibility to check the activities which cause pollution. Following measures can be taken to reduce air pollution.

- Domestic trash and other solid wastes should not be dumped on open places.
- Instead of personal car, 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 urban areas.
- Acidic industrial exhaust gases must be neutralized before releasing into the air.
- Engines of the vehicles should be tuned properly.
- CFC-free products should be used.
- 3R strategies of Reduce-Reuse-Recycle for the conservation of resources should be adopted.
- Trees should be grown along the road sides.
- Deforestation should be avoided.

KEY POINTS

- The poisonous and harmful substances which contaminate or pollute the air are called air pollutants.
- The main air pollutants are carbon monoxide, sulphur dioxide, oxides of nitrogen and chlorofluorocarbons (CFCs).
- Fossil fuels (coal, natural gas, oil, petrol, etc.) and aerosols are the main sources of air pollutants.
- Air pollutants enter the human body through breathing and affect the human organ systems causing serious diseases.
- Chlorofluorocarbons cause the thinning of protective ozone layer in our atmosphere.
- Rotting of vegetation and volcanic eruption, etc., are the natural sources of air pollutants.
- Carbon dioxide, methane, oxides of nitrogen, water vapours, etc., are called greenhouse gases.
- Greenhouse gases trap the heat reflected by the Earth and produce a warming effect on the Earth. This is called greenhouse effect.
- Earth's globe is getting warmer as a result of the greenhouse effect and the ozone depletion. The phenomenon is called global warming.
- The air pollutants, e.g., sulphur dioxide and oxides of nitrogen get dissolved in rain water and produce acid rain.
- Deforestation produces changes in the weather and climate and disturbs the ecosystem.
- A resource that does not regenerate quickly is called non-renewable resource.
- Three (3) R strategies, i.e., "Reduce-Reuse-Recycle" is the best way to be adopted for conservation of natural resources.
- Landfill, incineration and recycling are the common methods of solid waste management.
- The individuals, the organizations and the Government must share their responsibility to check the activities which cause air pollution.

QUESTIONS

4.1. Encircle the correct option.

(i) Indicate an air pollutant among the following:

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

(ii) The gas which is responsible to stop ultraviolet radiation coming from the Sun:

a. carbon dioxide b. sulphur dioxide
c. ozone d. nitrogen

(iii) Which of the following is not a greenhouse gas?

a. Methane b. Carbon dioxide
c. Sulphur dioxide d. Water

(iv) The pollutants which are mainly responsible for ozone depletion are:

a. oxides of carbon b. oxides of sulphur
c. oxides of nitrogen d. chlorofluorocarbons

(v) Identify the chemicals which cause the rain to become acidic:

a. oxides of carbon and dust particles
b. oxides of sulphur and nitrogen
c. solid particles of carbon and lead
d. chlorofluorocarbons.

(vi) Reason for increase in the amount of carbon dioxide in air:

a. plantation b. deforestation
c. using CFC-free products d. recycling of materials

(vii) Which air pollutant when attaches itself with haemoglobin, reduces its oxygen carrying capacity?

a. Carbon dioxide b. Sulphur dioxide
c. Oxides of nitrogen d. Carbon monoxide

(viii) The phenomenon which does not lead to global warming:

a. greenhouse effect b. ozone depletion
c. deforestation d. photosynthesis

(ix) Glass and styrofoam are the examples of:

a. biodegradable materials b. non-biodegradable materials
c. harmful products d. air pollutants

(x) The amount of which greenhouse gas can you reasonably control?

a. Oxides of nitrogen
b. Water vapours
c. Methane
d. Carbon dioxide

4.2 Write short answers.

(i) What are the main air pollutants?
(ii) Name greenhouse gases.
(iii) Name the acids which are present in the acid rain?
(iv) Ozone layer is important. Why?
(v) 3R strategies stand for what?
(vi) Write down the names of three such products which can be recycled.
(vii) Name common methods which are used for solid waste management.
(viii) How does ozone depletion contribute towards global warming?
(ix) Sulphur dioxide is an important pollutant. From where does it enter the atmosphere?

4.3 Describe the adverse effects of carbon monoxide on human organ systems.

4.4 Explain the following phenomena and their effects on the environment.

(a) Greenhouse effect
(b) Global warming
(c) Acid rain
(d) Ozone depletion

4.5 Point out the sources of air pollutants you find in your locality and suggest ways to reduce the pollution produced from these sources.

4.6 Suggest what can following communities do to reduce air pollution.

(a) Students (b) Farmers (c) Factory owners (d) Scientists

4.7 What is deforestation? Explain its effects on wildlife.

4.8 What types of climatic changes can appear by deforestation?

4.9 Suggest ways for proper management of solid wastes.

4.10 Recycling is good practice to conserve natural resources. Explain.

4.11 What should we do to adopt 3R strategies for conservation of resources?

4.12 Controlling pollution is a responsibility for all. What would you suggest for the individuals, the organizations and the governments to share this responsibility?

Critical Thinking

1. What line of action will you adopt to reduce the amount of CO_2 in air?
2. Predict what will happen if the amounts of greenhouse gasses are drastically reduced in the atmosphere?

Chapter 5

CHEMICAL REACTIONS

STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Define chemical reactions and give examples.
- ☑ Explain the rearrangement of atoms in chemical reactions.
- ☑ Explain the balancing of a chemical equation.
- ☑ Define the law of conservation of mass.
- ☑ Identify the nature of chemical changes in various reactions.
- ☑ Describe changes in the states of matter in a chemical reaction.
- ☑ Explain the types of chemical reactions with examples.
- ☑ Explain the energy changes in chemical reactions.
- ☑ Describe the importance of exothermic reactions in daily life.

We have already learnt about elements and compounds which are the examples of pure matter. The substances such as hydrogen (H_2), oxygen (O_2) etc. are the elements while 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 (H_2O). 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.

5.1 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 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 5.1.

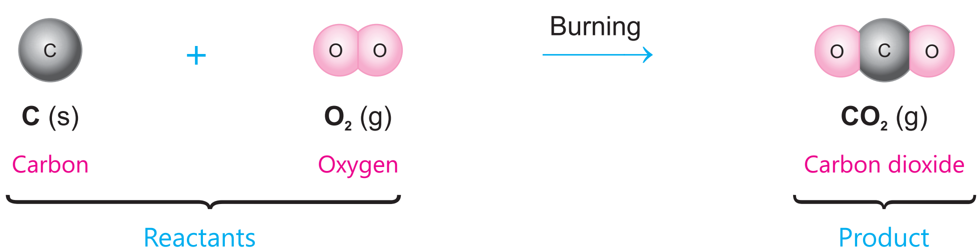


Figure 5.1: Rearrangement of atoms during chemical reaction of carbon with oxygen

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**.

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 5.2).

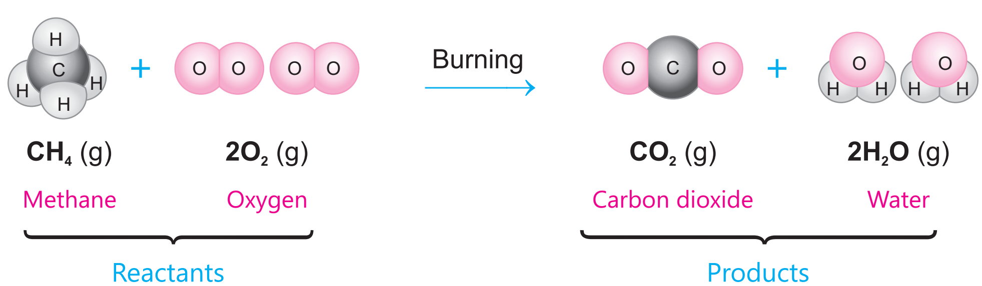


Figure 5.2: Rearrangement of atoms during chemical reaction of methane with oxygen

The rearrangement of atoms during the chemical reaction of hydrogen with oxygen to form liquid water is shown below in Figure 5.3.

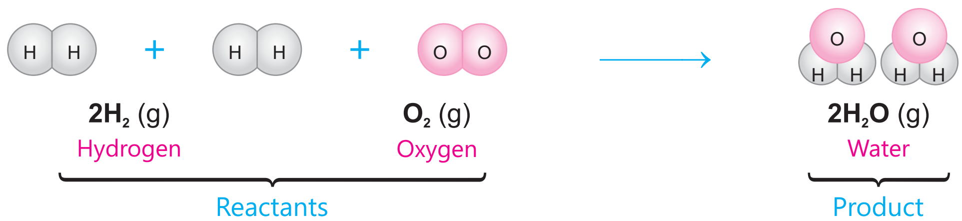


Figure 5.3: Rearrangement of atoms during chemical reaction of hydrogen with oxygen

5.1.1 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 its burning in 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.

$$\underset{\text{Carbon dioxide}}{6CO_{2\,(g)}} + \underset{\text{Water}}{6H_2O} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \underset{\text{Glucose}}{C_6H_{12}O_{6\,(aq)}} + \underset{\text{Oxygen}}{6O_{2\,(g)}}$$

During 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.

$$\underset{\text{Glucose}}{C_6H_{12}O_{6\,(s)}} + \underset{\text{Oxygen}}{6O_{2\,(g)}} \longrightarrow \underset{\text{Carbon dioxide}}{6CO_{2\,(g)}} + \underset{\text{Water}}{6H_2O} + \text{Energy}$$

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 5.1

Apparatus / Material required

China dish, burner, tripod stand, 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 contents in the china dish.
- Record your observation.

We will learn from the activity 5.1 that iron (Fe) reacts with sulphur (S) on heating. The result of this reaction is the formation of a black mass of iron sulphide.

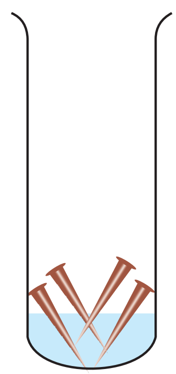
$$\underset{\text{Iron}}{Fe_{(s)}} + \underset{\text{Sulphur}}{S_{(s)}} \longrightarrow \underset{\text{Iron sulphide}}{FeS_{(s)}}$$

Activity 5.2

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 observation.

We will learn from the activity 5.2 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.

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

5.2 Chemical Equations and their Balancing

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 the reactants are written on the left hand side of the arrow whereas the products are written on the 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), (g) and (aq) which stand for solid, gas and aqueous states respectively. For example; the chemical equation representing the reaction of sulphur with oxygen to from 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. The signs (s) and (g) indicate the physical states of the reactants and the products.

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

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

5.2.1 Balancing the Chemical Equation

The chemical equation in which the number of atoms of each element 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.

$$Hcl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O$$

The chemical equation in which the number of atoms of each element 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 element 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 element on both sides of the arrow.

(ii) Work with one element 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 element is less and try to balance this element on both sides of the equation. Start multiplying with relatively small numbers.

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

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

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	4O 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.

Mini Exercise

Balance the following equations.

$$Fe_{(s)} + Cl_2(g) \longrightarrow FeCl_3(s)$$

$$Al_{(s)} + O_2(g) \longrightarrow Al_2O_3(s)$$

$$Na_2CO_3(aq) + HClO_3(aq) \longrightarrow NaClO_3(aq) + CO_2(g) + H_2O$$

$$CO_2(g) + H_2O \longrightarrow C_6H_{12}O_6(aq) \quad O_2(g)$$

5.3 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 5.3

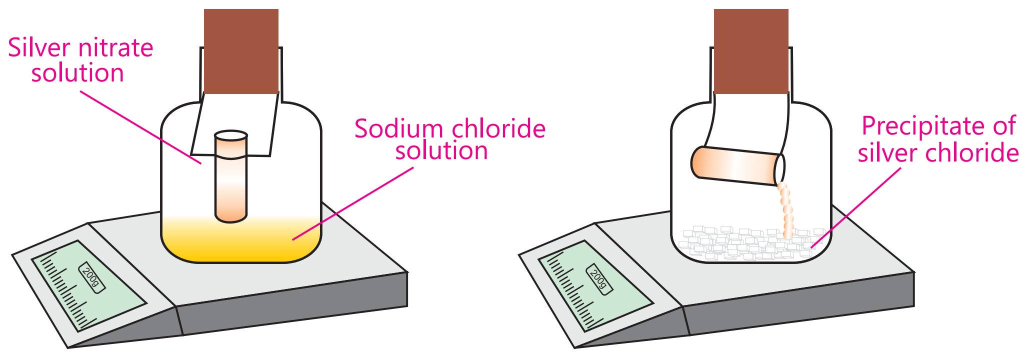
Apparatus / Material Required

Conical flask, weight balance, sodium chloride solution, silver nitrate solution

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 observation.
- Weigh the flask again and note whether both the weights are equal or not.



Through the activity 5.3 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.

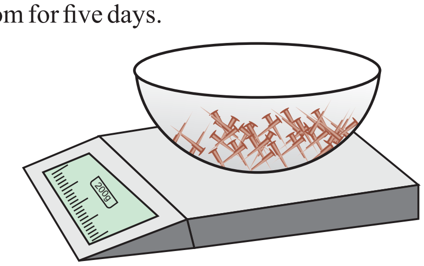
Activity 5.4 - Higher Order Thinking

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.

5.4 Types of Chemical Reactions

Thousands of chemical reactions are taking place all the time in the world. They are classified into different types. Here we will discuss only two types, i.e., addition reactions and decomposition reactions.

5.4.1 Addition Reactions

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

$$2H_2\,(g) + O_2\,(g) \longrightarrow 2H_2O\,(g)$$
Hydrogen + Oxygen → Water

$$H_2\,(g) + Cl_2\,(g) \longrightarrow 2HCl\,(g)$$
Hydrogen + Chlorine → Hydrogen chloride

$$N_2\,(g) + 3H_2\,(g) \longrightarrow 2NH_3\,(g)$$
Nitrogen + Hydrogen → Ammonia

$$2Mg\,(s) + O_2\,(g) \longrightarrow 2MgO\,(s)$$
Magnesium + Oxygen → Magnesium oxide

$$2Na\,(s) + Cl_2\,(g) \longrightarrow 2NaCl\,(s)$$
Sodium + Chlorine → Sodium chloride

$$CaO\,(s) + CO_2\,(g) \longrightarrow CaCO_3\,(s)$$
Calcium oxide + Carbon dioxide → Calcium carbonate

5.4.2 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.

$$2KClO_3\,(s) \xrightarrow{\text{Heat}} 2KCl\,(s) + 3O_2\,(g)$$
Potassium chlorate → Potassium chloride + Oxygen

$$CaCO_3\,(s) \xrightarrow{\text{Heat}} CaO\,(s) + CO_2\,(g)$$
Calcium carbonate → Calcium oxide + Carbon dioxide

$$2Pb(NO_3)_2\,(s) \xrightarrow{\text{Heat}} 2PbO\,(s) + 4NO_2\,(g) + O_2\,(g)$$

Lead nitrate → Lead oxide + Nitrogen dioxide + Oxygen

5.5 Energy Changes in Chemical Reactions

In order to know 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.

5.5.1 Exothermic Reactions

Exo means outside and therm means heat. Exothermic reactions are those reactions during which heat is given out. Burning is a common example of exothermic reaction. Fossil fuel (coal, natural gas, etc.) burns in the air to release heat.

$$C\,(s) + O_2\,(g) \longrightarrow CO_2\,(g) + \text{Heat}$$

$$CH_4\,(g) + 2O_2\,(g) \longrightarrow CO_2(g) + 2H_2O + \text{Heat}$$

$$Fe\,(s) + S\,(s) \longrightarrow FeS\,(s) + \text{Heat}$$

Fireworks are also the examples of exothermic reactions (Figure 5.4).

Figure 5.4: Fireworks

Activity 5.5 - 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 sides of the beaker.

What do you feel?

Why does it happen so?

During activity 5.5, sides of the beaker become warm. The heat which makes the mixture in the beaker and sides of the beaker warm is released by exothermic reaction between calcium oxide and water.

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

5.5.2 Endothermic Reactions

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

$$\underset{\text{Calcium carbonate}}{CaCO_{3\,(s)}} + \text{Heat} \longrightarrow \underset{\text{Calcium oxide}}{CaO_{(s)}} + \underset{\text{Carbon dioxide}}{CO_{2\,(g)}}$$

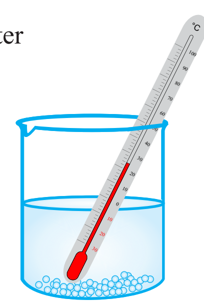
Activity 5.6 - Endothermic Reaction

Apparatus / Material Required

Beaker, sodium carbonate solution, calcium chloride solution, thermometer

Procedure

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



Why does it happen so?

During activity 5.6, you will feel that the sides of the beaker become cold. This is because an endothermic reaction takes place by absorbing heat from the surrounding walls of the beaker.

$$CaCl_2\,(aq) + Na_2CO_3\,(aq) + Heat \longrightarrow CaCO_3\,(s) + 2NaCl\,(aq)$$

Calcium chloride + Sodium carbonate → Calcium carbonate + Sodium chloride

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

$$N_2\,(g) + 2O_2\,(g) + Heat \longrightarrow 2NO_2\,(g)$$

Nitrogen + Oxygen → Nitric oxide

$$H_2\,(g) + I_2\,(g) + Heat \longrightarrow 2HI\,(g)$$

Hydrogen + Iodine → Hydrogen iodide

5.5.3 Importance of Exothermic Reactions in Daily Life

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.

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 exothermal reaction is used to cook food, drive vehicles and generate electricity.

QUESTIONS

5.1 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 water.

(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

5.2 Answer the following questions briefly.

(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.

5.3 Differentiate between the following.

(i) Addition reaction and decomposition reaction.

(ii) Balanced chemical equation and unbalanced chemical equation.

(iii) Exothermic reaction and endothermic reaction.

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

5.5 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) $Zn + HCl \longrightarrow ZnCl_2 + H_2$

5.6 When coal burns, it leaves ash behind. Ash so produced is lighter than the coal which has burnt. Justify the decrease in mass in the light of law of conservation of mass.

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

(i) Addition reaction (ii) Decomposition reaction

(iii) Exothermic reaction (iv) Endothermic reaction

5.8 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

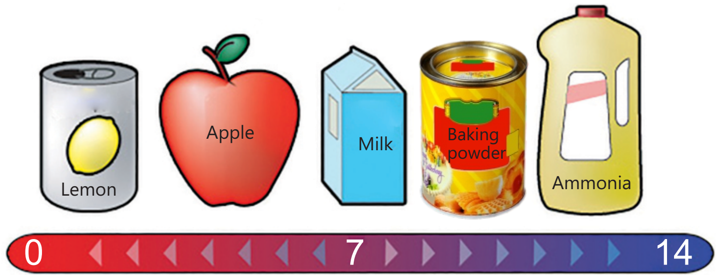
5.9 Describe the applications of chemical reactions.

5.10 Write down the rules for balancing chemical equations.

5.11 Describe the importance of exothermic reactions in everyday life.

5.12 Give two examples of chemical reactions from everyday life which are essential for life.

Chapter 6



ACIDS, BASES/ALKALIS AND SALTS

STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Define the terms acid, alkali and salt.
- ☑ Describe the properties of acids, alkalis and salts.
- ☑ Explain the uses of acids, alkalis and salts in daily life.
- ☑ Define indicators.
- ☑ Use indicators to identify acids, alkalis and neutral substances.
- ☑ Investigate the colour changes in the extracts of various flowers and vegetables by adding acids and alkalis.

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, you will learn about acids, bases and salts, their properties and uses. pH, its range in aqueous medium and indicators would also be discussed.

6.1 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 can be defined as the compounds which produce hydrogen ions (H^+) in their aqueous solutions. Citrus fruits (Figure 6.1) have

Figure 6.1: Citrus fruits

sour taste due to citric acid. Hydrochloric acid is an important mineral acid. It is also found in gastric juice of the stomach. It acts as an antiseptic and is helpful in digestion of proteins.

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 6.1.

Table 6.1: 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	Malic acid	Apples
Citric acid	Citrus fruit	Stearic acid	Fats

Some examples of the acids which are prepared from mineral elements are given in Table 6.2.

Table 6.2: 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 6.1

Apparatus / Material required:

Test tube, water, dilute acetic acid

Procedure:

- Take a clean test tube half full of water.
- Put 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?

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

Activity 6.2

Apparatus / Material required:

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

Procedure:

- Take a little 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 in the test tubes 1, 2 and 3 separately.

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

Activity 6.3

Apparatus / Material required:

Test tube, vinegar, 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 and observe the changes taking place in the solution.

What do you infer from this activity?

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

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

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

$$Mg_{(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$$

Magnesium + Hydrochloric acid → Magnesium chloride + Hydrogen

$$Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + H_{2(g)}$$

Zinc + Sulphuric acid → Zinc sulphate + Hydrogen

Hydrogen gas produced in the reaction burns with pop sound (Figure 6.2). This is a test for identification of hydrogen gas.

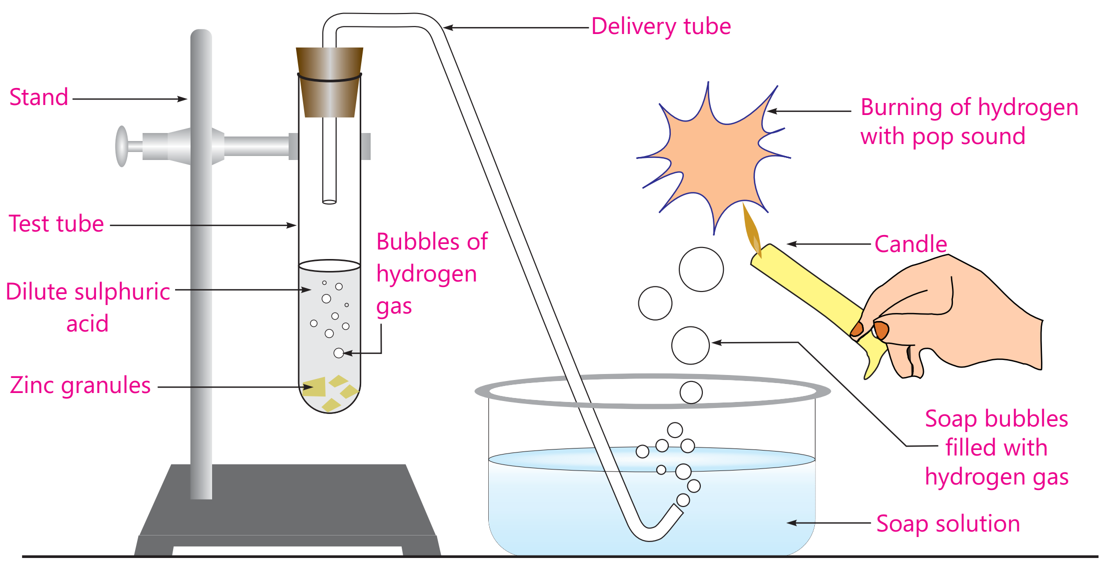


Figure 6.2: Reaction of zinc with dilute acid

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

$$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(\ell)} + CO_{2(g)}$$

Calcium carbonate + Hydrochloric acid → Calcium chloride + Water + Carbon dioxide

$$NaHCO_3\,(s) + CH_3COOH\,(aq) \longrightarrow CH_3COONa\,(aq) + H_2O + CO_2\,(g)$$

Sodium hydrogen carbonate + Acetic acid → Sodium acetate + Water + Carbon dioxide

Carbon dioxide produced in the reaction turns lime water milky (Figure 6.3). This is a test for identification of carbon dioxide gas.

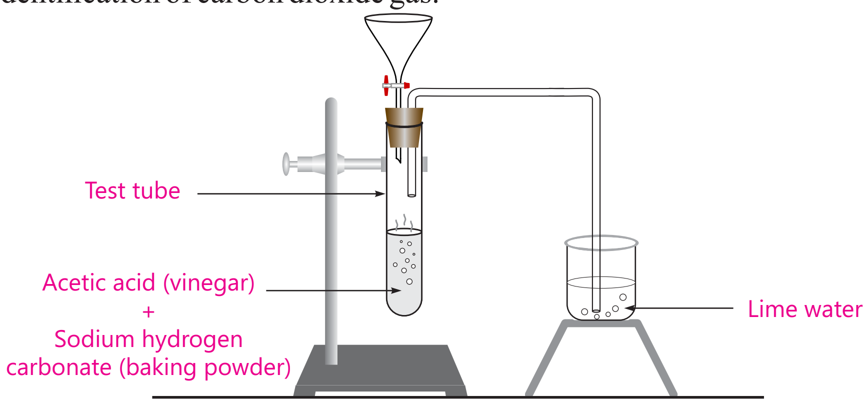


Figure 6.3: Reaction of acetic acid with sodium hydrogen carbonate

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

$$H_2SO_4\,(aq) + 2NaOH \longrightarrow Na_2SO_4\,(aq) + 2H_2O$$

Sulphuric acid + Sodium hydroxide → Sodium sulphate + Water

Uses of Acids

A very brief idea of the uses of mineral acids is 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.

(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.

Sulphuric Acid

Sulphuric acid is used:

(i) as a dehydrating agent.

(ii) in the manufacture of fertilizers like ammonium phosphate, 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 so large and so important that it is known as the king of chemicals (Figure 6.4).

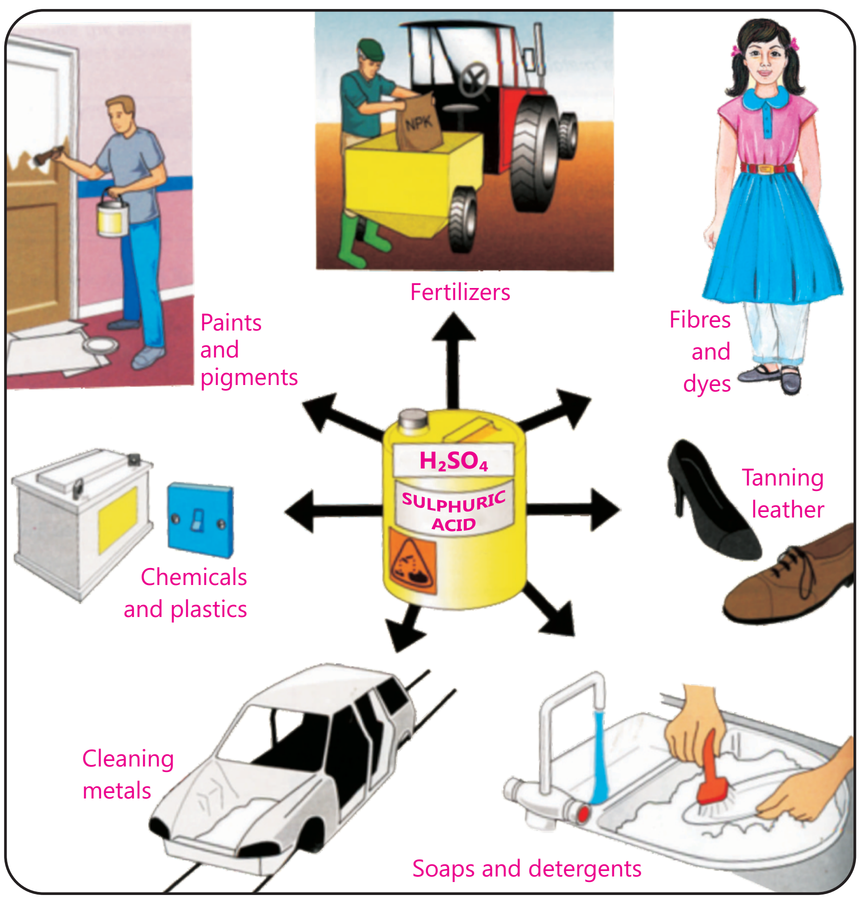


Figure 6.4: Uses of sulphuric acid

Acetic Acid

Acetic acid is used:

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

6.2 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 form 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 6.3.

Table 6.3: 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 6.5).

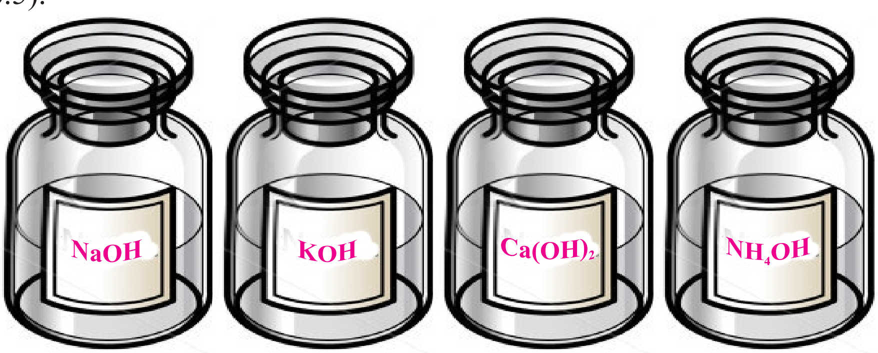


Figure 6.5: Common alkalis used in laboratory

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 6.4

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 solution of bases are good conductor of electricity.

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

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

NaOH (aq)	HCl (aq)	NaCl (aq)	H_2O (ℓ)
Sodium hydroxide	Hydrochloric acid	Sodium chloride	Water

Activity 6.5

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 6.6). We can identify ammonia gas by its pungent smell. Ammonia also turns moist red litmus paper blue.

$$Ca(OH)_2\,(aq) + 2NH_4Cl\,(aq) \xrightarrow{heat} CaCl_2\,(aq) + 2H_2O\,(\ell) + 2NH_3\,(g)$$

Calcium hydroxide + Ammonium chloride → Calcium chloride + Water + Ammonia

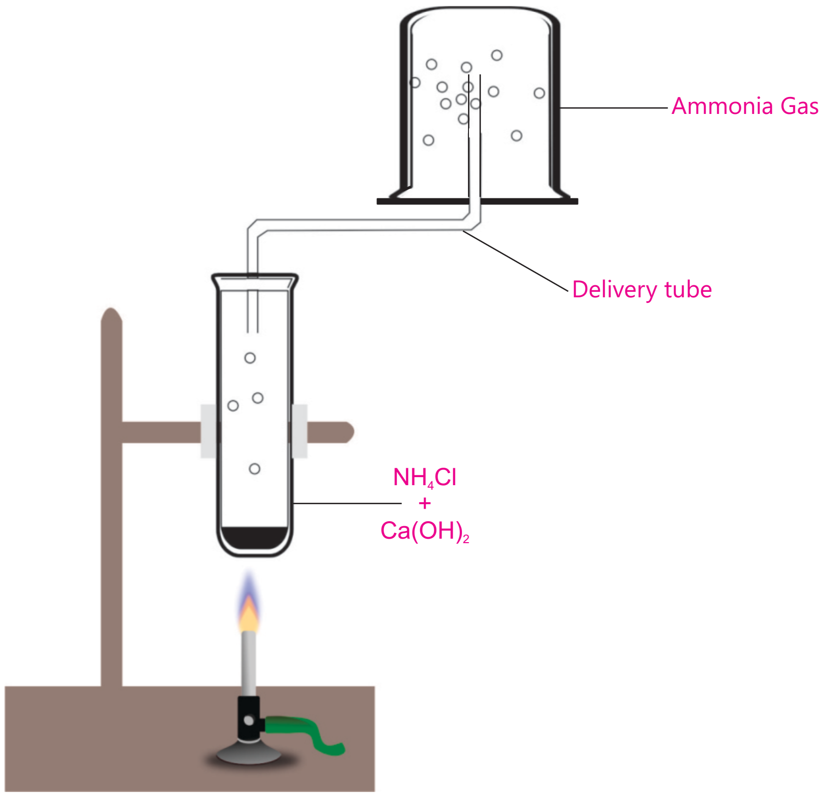


Figure 6.6: Reaction of calcium hydroxide with ammonium chloride

(vi) Alkalis react with fats to form soap.

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.

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.

6.3 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 6.4 and shown in figure 6.7.

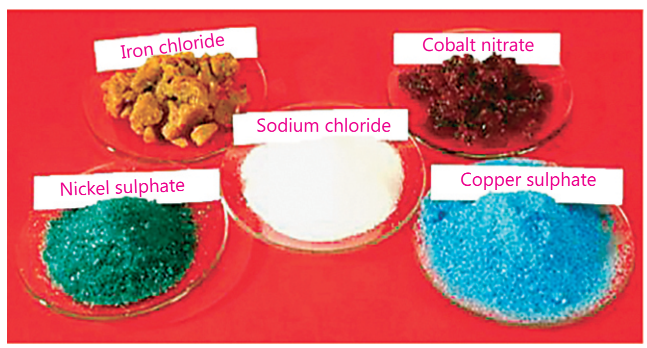


Figure 6.7: Some common salts

Table 6.4: 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 states. 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.

$$\underset{\text{Sodium carbonate}}{Na_2CO_3\,(s)} + \underset{\text{Hydrochloric acid}}{2HCl\,(aq)} \longrightarrow \underset{\text{Sodium chloride}}{2NaCl\,(aq)} + \underset{\text{Water}}{H_2O\,(\ell)} + \underset{\text{Carbon dioxide}}{CO_2\,(g)}$$

(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.

$$\underset{\text{Ferric chloride}}{FeCl_3\,(aq)} + \underset{\text{Sodium hydroxide}}{3NaOH\,(aq)} \longrightarrow \underset{\text{Ferric hydroxide}}{Fe(OH)_3\,(ppt)} + \underset{\text{Sodium chloride}}{3NaCl\,(aq)}$$

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

$$\underset{\text{Sodium carbonate}}{Na_2CO_3\,(s)} + \underset{\text{Water}}{2H_2O\,(\ell)} \longrightarrow \underset{\text{Sodium hydroxide}}{2NaOH\,(aq)} + \underset{\text{Carbonic acid}}{H_2CO_3\,(aq)}$$

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 6.8). They perform the following functions:

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

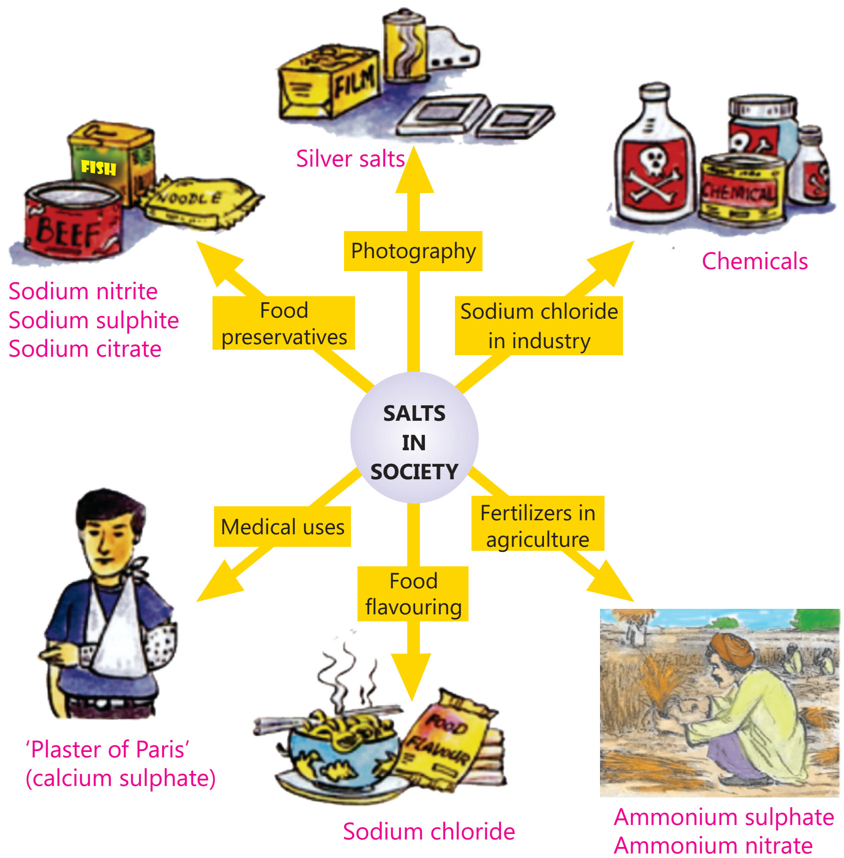


Figure 6.8: Uses of salts

(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 ($CaSO_4 \cdot \frac{1}{2}H_2O$) 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 (Figure 6.8).

(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.

6.4 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 found 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 6.6

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 strong alkalis is 12 to 14.

Activity 6.7

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 distilled water in different test tubes.
- Add 1.5 cm^3 of distilled water.
- Dip separate universal indicator papers 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		

6.4.1 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 ion. The greater the concentration of hydrogen ions (H^+) in a solution, the stronger the acid it is. The lesser the concentration of hydrogen ions as compared to hydroxide ions in a solution, the stronger the alkali it 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 6.9). The solutions having equal concentrations of hydrogen ions (H^+) and hydroxide ions (OH^-) are neutral solutions. They have pH = 7. pH = 7 is the midpoint 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.

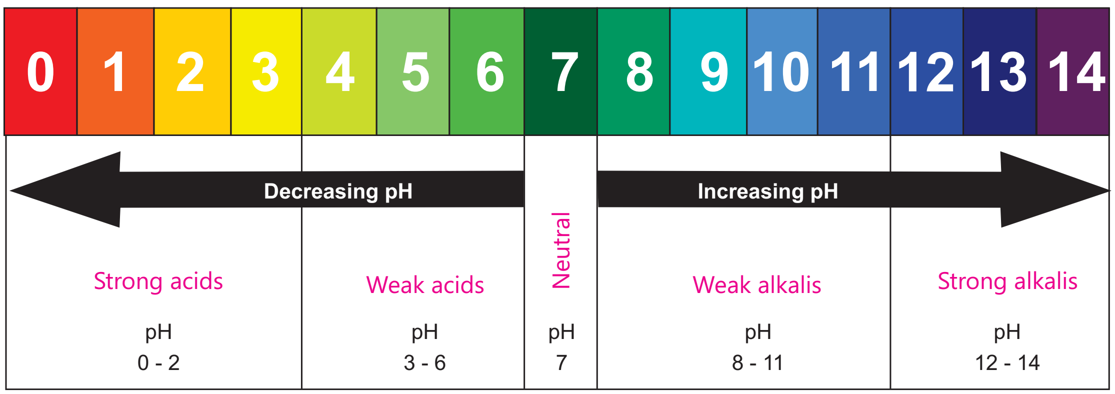


Figure 6.9: pH Scale

pH values of some common substances are given in Table 6.5.

Table 6.5: 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 6.10). 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 6.10: pH meter

6.5 Indicators

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

An indicator is a substance that shows different colours in acidic and basic solutions (Table 6.6). Some examples of indicators are phenolphthalein, methyl orange, litmus, turmeric, china rose and red cabbage.

Table 6.6: Indicators and their colours in acidic and basic solutions

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

Activity 6.8

Apparatus / Material required:

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

Procedure:

- Put these samples in clean test tubes.
- Add a few drops of red and blue litmus solution in each tube.
- 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.

Natural indicators

Red cabbage, turmeric, china rose and litmus.

Activity 6.9

Apparatus / Material required:

Turmeric powder, water, filter paper, different solutions

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 activity 6.8.

Turmeric (Haldi Powder)

You will observe that:

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

Red Cabbage

Activity 6.10

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 6.9 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 bases.
- Bases have bitter taste and turn red litmus blue, colourless phenolphthalein to pink.
- Bases neutralize acids to form salts and water.
- Bases have many uses in laboratories in homes and in industries.
- Many salts are commonly used in our daily life.

QUESTIONS

6.1 Fill in the blanks.

(i) Acids react with bases to form water and ________________.

(ii) Vinegar contains ________________ acid.

(iii) Tartaric acid is present in ________________.

(iv) Bases have ________________ taste.

(v) All alkalis are bases but all bases are not ________________.

(vi) Bases have ________________ touch.

(vii) Sodium hydroxide is also called ________________.

6.2 Put (✓) for correct and (✗) for incorrect statement.

(i) Acetic acid is found in grapes.

(ii) All carbonates react with mineral acids liberating CO_2 gas.

(iii) Acids turn red litmus blue.

(iv) All bases do not dissolve in water.

(v) Solution of a base has a soapy touch.

6.3 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 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. yoghurt

(v) Which is not the salt of phosphoric acid?

a. Na_3PO_4 a. NaH_2PO_4

c. Na_2HPO_3 d. Na_2HPO_4

(vi) Sodium carbonate is an important salt used for many purposes in industries. Sodium hydroxide is made to react with which acid to get it?

a. oxalic acid b. citric acid

c. carbonic acid d. acetic acid

6.4 Give 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?

6.5 What is the effect of dilute HCl on the colours of the following?

(i) Methyl orange (ii) Phenolphthalein (iii) Blue litmus

6.6 What is a base? Write down the names and formulae of four bases.

6.7 Mention the sources of the following.

(i) Citric acid (ii) Tartaric acid (iii) Acetic acid

6.8 What is the action of caustic soda on the colour of the following.

(i) Red litmus (ii) Phenolphthalein (iii) Methyl orange

6.9 Describe how are salts useful for the human body.

6.10 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?

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

6.12 How does the soil become acidic?

6.13 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 an acid as hydrochloric acid?

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

Calcium acetate, potassium hydrogen sulphate, magnesium nitrate, ammonium oxalate, sodium potassium tartarate, ferric chloride

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

Online Learning

www.krysstal.com/acidbase.html
www.science.uwaterloo.ca/~cchieh/cact/c123/salts.html
www.bbc.co.uk
cbse.myindialist.com
www.e-education.psu.edu
www.visualphotos.com

Chapter 7

FORCE AND PRESSURE

STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Define the term pressure.
- ☑ Identify the units of pressure.
- ☑ Explain hydraulics and hydraulic systems by giving examples.
- ☑ Explain how gases behave under pressure.
- ☑ Describe the causes of gas pressure in a container.
- ☑ Explain the working of aerosols.
- ☑ Identify the application of gas pressure.
- ☑ Describe the term atmospheric pressure.

We often use the word 'pressure' such as gas pressure, water pressure, blood pressure, atmospheric pressure, etc., in our daily life. In this chapter, we will learn about pressure, its relation with force and area and its applications.

7.1 Pressure, Force and Area

When water flows out of a tap with greater speed, we say that water is flowing with high pressure. If we put our hand palm under the tap water stream we feel a force (push) on our hand (Figure 7.1). This force acting normally on the surface of our hand palm is termed as **pressure**. Thus pressure can be defined as the force acting normally on unit area of a surface of an object. Mathematically, pressure can be defined as:

Figure 7.1

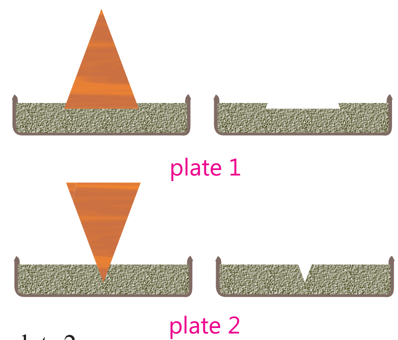
$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

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

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

From this relation it can be seen that when same force is applied on different areas, the smaller area will experience high pressure while the larger area will experience low pressure. Similarly, when different forces act on the same area, the larger force will exert high pressure while the smaller force will exert low pressure. Let us observe these effects in the following activities.

Activity 7.1 - Pressure exerted by the same force on different areas



Material required:

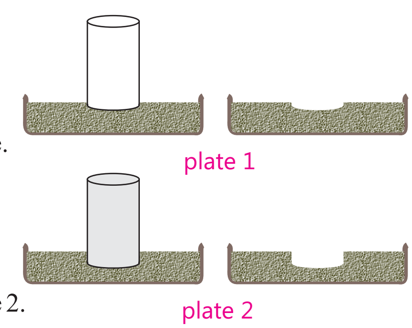
Wedge, two identical plates, wet sand.

Procedure:

- Fill the plates with wet sand and make the sand surface plane.
- Place the wedge with its broader edge downward on the sand in plate 1.
- Pick the wedge up and note depth of the mark/pit made on the sand surface.
- Now invert the wedge and place its narrow edge on the sand in plate 2.
- Pick the wedge up and note the depth of the mark/pit made on the sand surface.

What do you think about the pressure developed by the same force (weight of the wedge) on different areas of sand?

Activity 7.2 - Pressure exerted on the same area by different forces



Material required:

A glass jar, two identical plates, wet sand.

Procedure:

- Fill the plates with wet sand and make the sand surface plane.
- Place the empty jar on the wet sand in plate 1.
- Pick the jar up and note the depth of the mark/pit made on the sand surface.
- Now fill the jar with sand and place it on the wet sand in plate 2.
- Pick the jar up and note the depth of the mark/pit made on the sand surface.

What do you think about the pressure developed by different forces (weight of empty jar and weight of jar filled with sand) on the same area?

For your information.

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

7.1.1 Units of Pressure ($N\ m^{-2}$) or pascal (Pa)

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, the unit for its measurement is newton per square metre ($N\ m^{-2}$). It is the SI unit of pressure. It is also known as Pascal. Pascal is 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 ($1N\ m^{-2}$) or one pascal (1 Pa).
- 1Pa (one pascal) is a very small pressure. It is approximately equal to the pressure exerted by a ten rupee note lying flat on a table. For this reason, pressure is usually measured in kilopascals (kPa), a bigger unit of pressure.
- 1 kPa = 1000 Pa (pascal)

Activity 7.3

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:

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

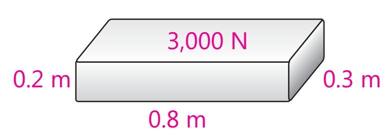
$$= \frac{500\ \text{N}}{0.025\ \text{m}^2} = 20{,}000\ \text{N m}^{-2}$$

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?



7.2 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 tank. 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 the following activities:

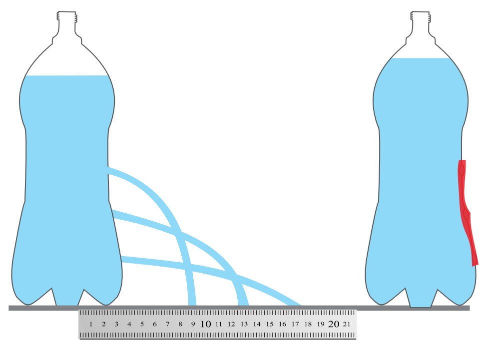
Activity 7.4

Material required:

1.5 litre plastic bottle, iron nail, insulation tape, metre rod, etc.

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 floor.
- Remove the tape and observe the ejection of water out of the three holes.
- Note the distances of the streams of water coming out of various holes 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.

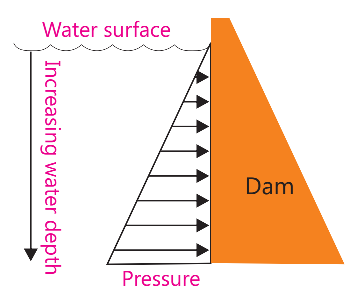
Does water flow out of all the holes with the same speed and pressure?

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 a liquid pressure which increases with the depth of the liquid in a container is called **hydrostatic pressure**.

Do you know?

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



We also see that water comes out of the holes in a direction perpendicular to the surface of the bottle. This shows that hydrostatic pressure always acts perpendicular to the surface.

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 the pressure of the water pushing down on you.

7.3 Liquid Pressure in Closed Containers

The liquids or fluids filled in closed containers exert pressure equally in all directions (Figure 7.2). This can be seen by the following activity.

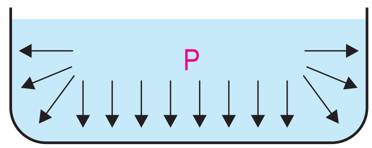
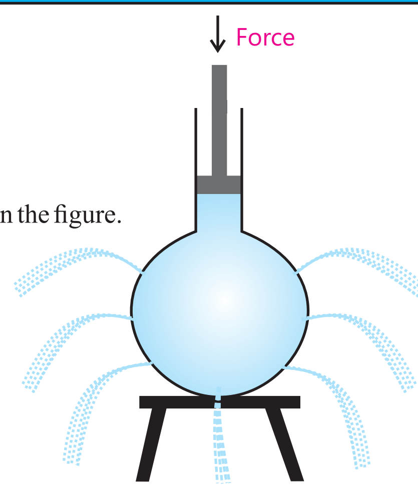


Figure 7.2

Activity 7.5



Material required:

Plastic bottle fitted with a piston at its mouth, water tub, etc.

Procedure:

- Take a plastic bottle fitted with a piston at its mouth.
- Make a few holes in the bottle at different places as shown in the figure.
- Dip the round part of the bottle in the water contained in a tub or vessel and pull the piston or plunger out to fill the bottle with water.
- Take the bottle out of the tub and push the piston or plunger in the bottle.
- Observe the water flowing out of the holes in the bottle.

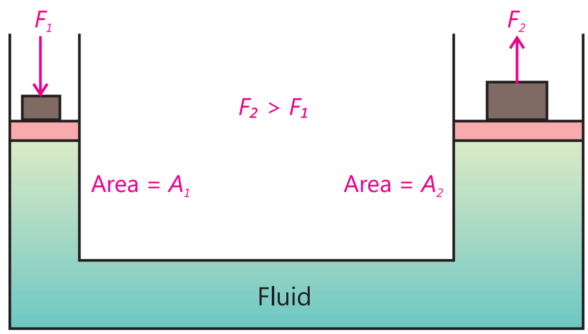
Does water flow out of all the holes with the same pressure?

We observe from this activity that pressure is exerted on fluid enclosed in a vessel is transmitted equally in all directions. This fact was first time discovered by Pascal and is called **Pascal's law**. Pascal's law is only applied to the fluid, filled in closed vessels.

The branch of science which deals with the transmission of fluid pressure through pipes as a source of mechanical force is called **hydraulics.** Such systems are often used to produce a large force with the help of a small force.

For your information.

A force applied on the fluid at smaller piston increases many times when it is transmitted to the fluid at the bigger piston. This is due to the large cross-sectional area of the bigger piston. All the Hydraulic systems work on this principle.



7.4 Applications of Pascal's Law - Hydraulic system

(i) Jack system

Figure 7.3 shows a hydraulic system called hydraulic jack. 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 pipe to a very large cylinder fitted with a piston. Since area of this piston is very large. So, a very large force is produced by pressure P at this bigger piston which may be used to lift something very heavy such as a car.

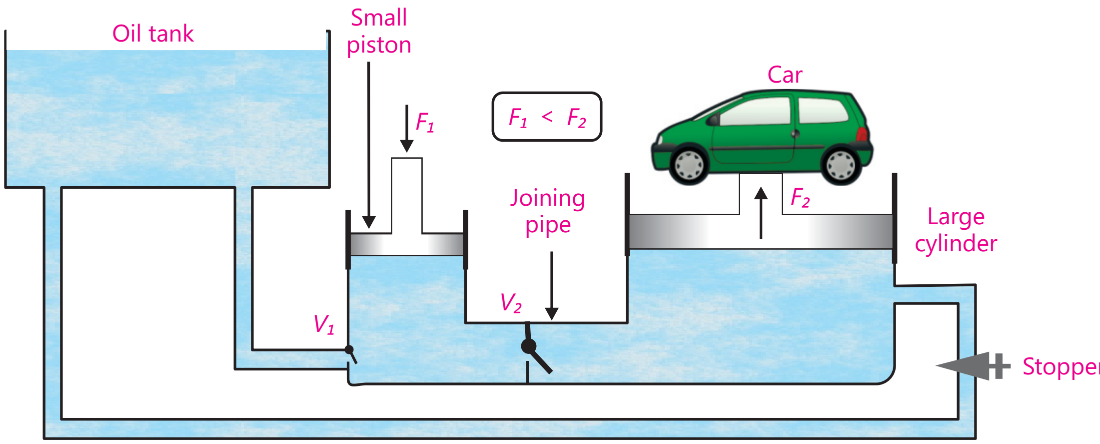


Figure 7.3

Valves V_1 and V_2 prevent 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 oil tank and the load is brought down.

(ii) Brake system

Brake system in the cars is another common example of a **hydraulic system** (Figure 7.4). This consists of a pipe and two cylinders. It is filled with special fluid called brake oil. At one end of the pipe there is a cylinder fitted with a small piston called master cylinder. The small piston is connected with brake pedal. At the other end of the pipe there is a second cylinder fitted with a large piston called slave cylinder. When small piston is pushed into master cylinder by applying a small force on brake pedal, the pressure thus produced is transmitted without loss to the slave cylinder. The large piston in the slave cylinder is pushed out with a large force. It then pushes the brake pad out to make it rub against the moving wheel disc. In this way a large frictional force is produced which stops the running wheel.

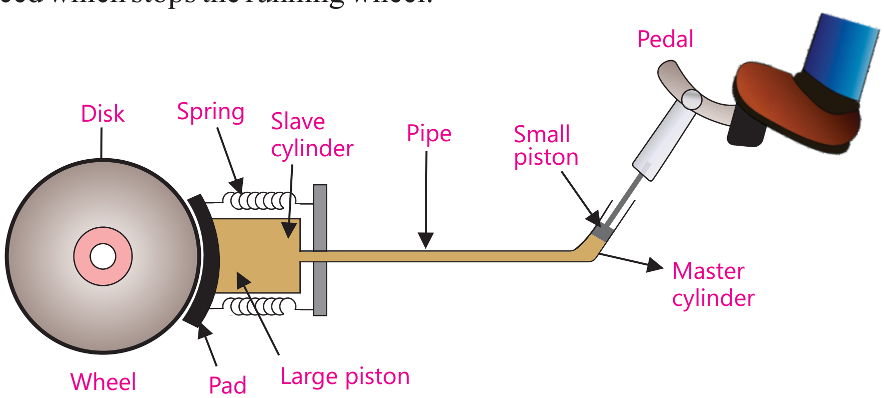


Figure 7.4: Hydraulic brake system

7.5 Gas Pressure in a Container

Molecules of a gas in a container are in a continuous state of random motion in all directions. During their motion, they collide with each other and with the walls of the container. Gas molecules colliding with the walls of the container exert force on the walls of the container and thus produce pressure (Figure 7.5).

If the volume of the container is decreased for the same quantity of gas the distances between the particles also decreases and there are more collisions of the particles with the walls of the container. As a result the gas pressure increases.

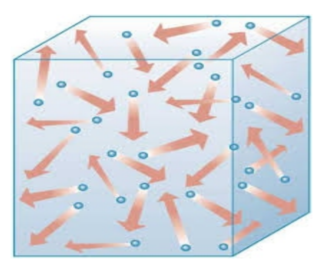


Figure 7.5: Gas pressure in a container

The gas pressure can also be increased by adding more gas in the container. Addition of more gas molecules means more collisions with the walls of the container and hence more pressure.

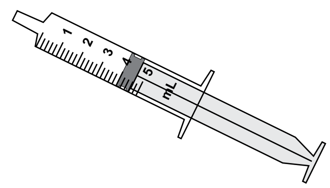
7.5.1 Pneumatics

Compressed air has the ability to do some mechanical work. The branch of science which deals with the study and applications of pressurized gas to produce mechanical motion is called **pneumatics**.

Activity 7.6

Material required:

Plastic syringe



Procedure:

- Take a new plastic syringe and carefully remove its needle.
- Pull out the plunger to fill the air in the syringe.
- Block the opening of the syringe with your finger and press the plunger in.
- You will notice that air inside the syringe is compressed and the plunger is moved back to some extent on releasing.

What do you infer from this activity?

Applications of compressed air

Compressed air is widely used in various daily life activities and in industries. Some common applications of compressed air are mentioned below:

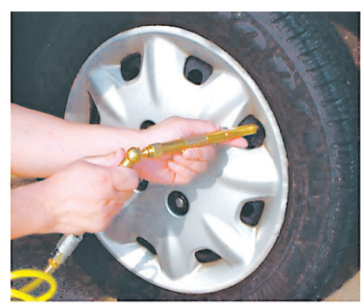


Figure 7.6: Air filling in automobile tyre

1. Automobile tyres are inflated with compressed air for smooth running of vehicles (Figure 7.6).

2. Spray guns use compressed air for spraying paint (Figure 7.7).

Figure 7.7: Spray gun

3. Air powered motors (Figure 7.8) use compressed air to work. Such motors are used at the places where electric motors are not suitable for safety reasons.

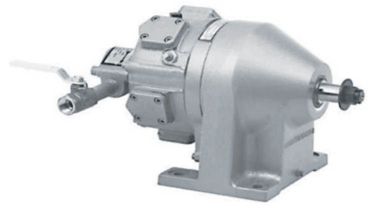


Figure 7.8: Air-powered motor

4. Compressed air is used to operate air-powered (pneumatic) tools like hammers, drills, etc. (Figure 7.9)

5. The compressed air is also used in air brake system in heavy vehicles. When a brake pedal is pressed, the compressed air is released from the storage tank. This air pushes the brake pad against the moving wheel to stop its motion (Figure 7.10).

Figure 7.9: Pneumatic hammer

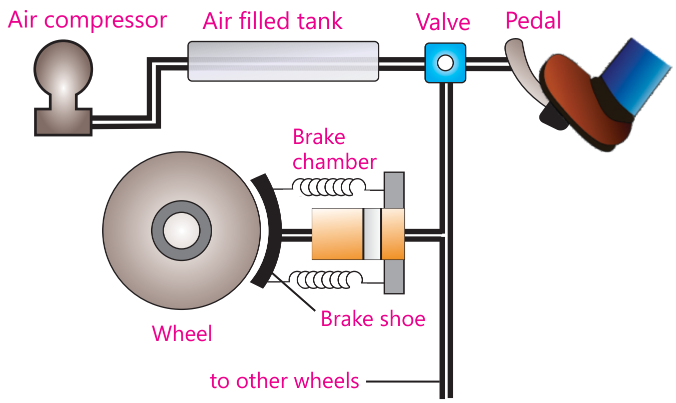


Figure 7.10: Air brake

6. Most of the dentistry tools use compressed air for their working (Figure 7.11). It is safer for the patient.

Figure 7.11: Most of the dentistry tools use compressed air

7.6 Aerosols

The products using 'sol' systems are called aerosols. “Sol” is a mixture of suspended solid or liquid particles in a gas or air. Different types of aerosols are used for various purposes (Figure 7.12). They are used as air fresheners, insect repellents, hair sprays, cleaning agents, spray paints, medicinal sprays (like inhalers.) etc.

Figure 7.12: Aerosol

How do aerosols work?

An aerosol contains a mixture of two fluids. One that boils below room temperature called the propellant and the other one is the product. The product is the substance which is actually used as air freshner, hair spray or insect repellent, etc. The propellant is the means of pushing the product out of the can. Both fluids are stored in a sealed metal can (Figure 7.13). At room temperature, a part of the propellant fluid vaporizes and increases pressure over the product liquid. A long plastic tube runs from the bottom of the can up to a valve system at the top of the can. When valve is opened by pressing the button, a passage from inside of the can to the outside opens. The high-pressure propellant vapour or gas pushes the liquid product up in the plastic tube and then out through the nozzle. The narrow nozzle breaks the flowing liquid into tiny drops which come out as a fine spray.

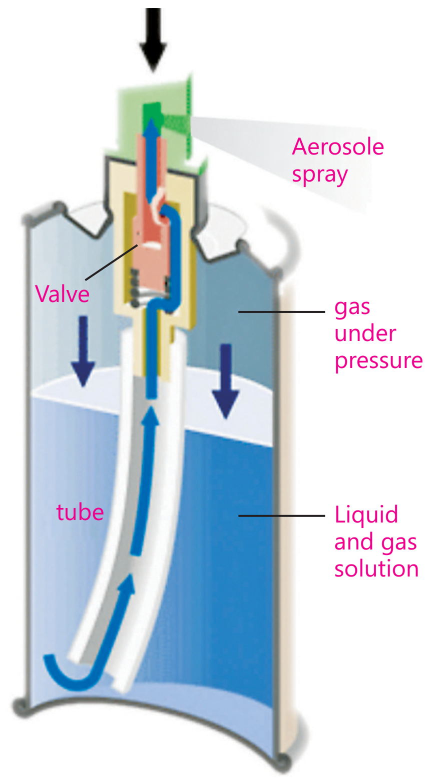


Figure 7.13: Aerosol

7.7 Atmospheric Pressure

Our Earth has a blanket of air around it. The Earth's gravity pulls the air column down. Hence, the air has weight. The weight of the air column (force) per unit area on the Earth is pressure which is termed as atmospheric pressure.

$$\text{Atmospheric pressure} = \frac{\text{Weight of the air}}{\text{Area}}$$

The instrument used to measure the atmospheric pressure is called **barometer**. The unit for measuring atmospheric pressure is the standard atmosphere. The standard atmosphere is abbreviated as **atm**. One atmosphere (1 atm.) is equal to 101,300 Pa or 101.3 kPa at sea level.

? Do you know?

The atmospheric pressure around us at ground level is about 100,000 Pa (100 kPa).

Activity 7.7

Material required:

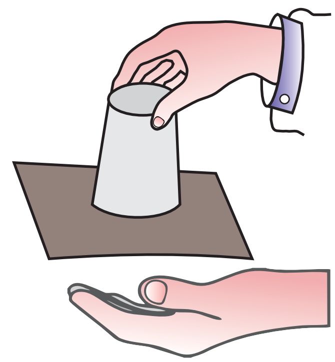
Glass, thick paper, water

Procedure:

- Take a glass and fill it with water up to brim.
- Put the paper on the glass.
- Hold and simply press the paper on the glass by keeping hand over the paper.
- Keep on hand over the paper, hold the glass from its lower part by your other hand and invert it.
- Remove the hand from the paper.

Does water fall down?

If not what prevents it from falling?



Atmospheric pressure varies with altitude

The Earth's surface where we live is the bottom of the sea of air. There is more weight of the air and hence more atmospheric pressure at the Earth's surface. As we go up in the air, atmospheric pressure decreases. This is because weight of air decreases as we go up in the air. Thus the people who climb up the hills experience less air pressure than those living at sea level. At sea level the atmospheric pressure is 101300 Pa (101.3 kPa) whereas, at a height of about 5km it falls to about 55000 Pa (55 kPa).

Altitude above the sea level can be determined on the basis of the measurement of atmospheric pressure. The lower the atmospheric pressure the greater is the altitude. When a barometer is calibrated to indicate altitude, the instrument is called **pressure altimeter** (Figure 7.14). Pressure altimeter is used in air crafts. Wrist-mounted altimeter is used by sky divers, hikers and mountain climbers.

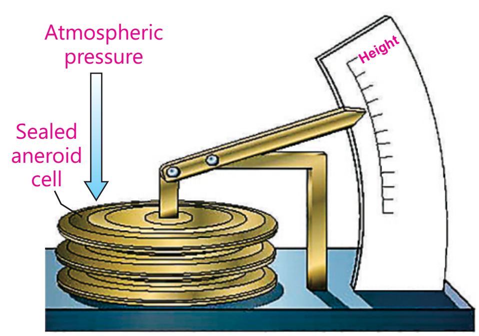


Figure 7.14: Pressure altimeter

Do you know?

- Atmospheric pressure is used for weather forecast.
- The weather is fine when the atmospheric pressure is high as 105000 Pa. when it falls to low, about 92000 Pa, there is a probability of a storm.

KEY POINTS

- The force per unit area acting normally on the surface of an object is called pressure.
- The SI unit of pressure ($N\,m^{-2}$) 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.
- Pascal's law states that fluids enclosed in a vessel exert pressure which is transmitted equally in all directions.
- 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 all the time collide with each other and with the walls of the container. The force of these collisions produces pressure on the walls of container.
- The branch of science which deals with the study and applications of pressurized gas to produce mechanical motion is called pneumatics.
- The products using 'sol' systems are called aerosols. “Sol” is a mixture of suspended solid or liquid particles in a gas or air.
- Different types of aerosols are used as air freshners, insect repellents, hair sprays, cleaning agents, spray paints, medicinal sprays (like inhalers.) etc.
- 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

7.1 Encircle the correct option.

(i) The SI unit of pressure is:

a. watt b. joule
c. pascal d. newton

(ii) 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.

(iii) A pressure of $10Nm^{-2}$ is equal to:

a. 10Pa b. 100Pa
c. 1000Pa d. 10,000Pa

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

a. 3 kPa b. 30 kPa
c. 300 kPa d. 3000 kPa

(v) Hydrostatic pressure of the liquids depends on:

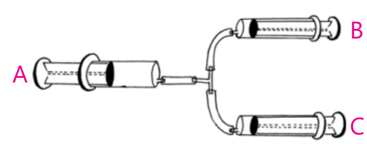
a. shape of the vessel
b. size of the vessel
c. volume of the vessel
d. depth of the liquid

(vi) 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

(vii) When the plunger A shown in the figure is pushed:

a. plunge B will move out more than C
b. plunger C will move out more than B
c. both B and C will move out equally
d. neither B nor C will move out



(viii) A gas in a container develops pressure due to:

a. collision of molecules with each other
b. collision of molecules with walls of the container
c. weight of the gas
d. composition of the gas

(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 1km

(x) What instrument is used to measure height?

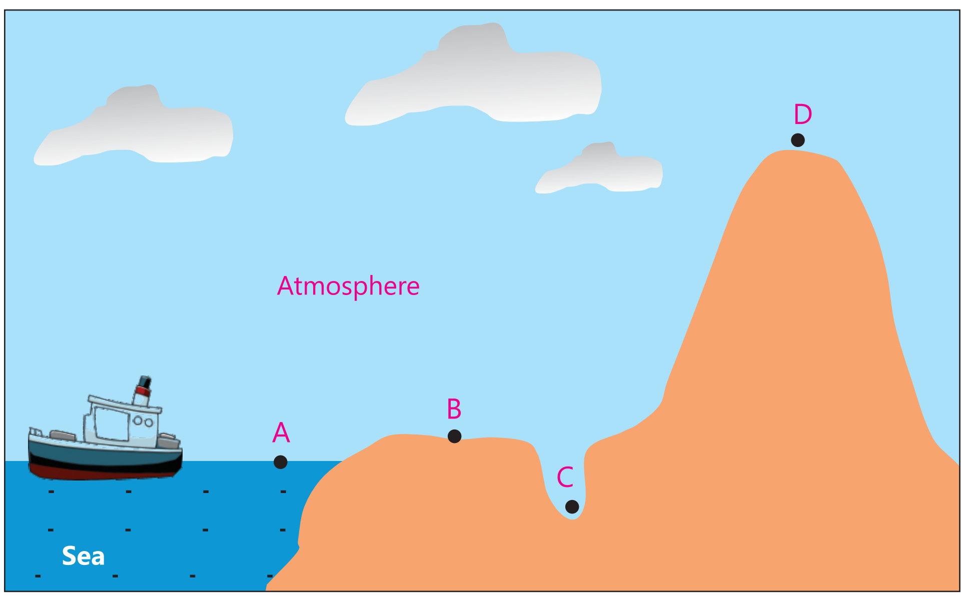
a. Hydrometer b. Hygrometer
c. Altimeter d. Sphygmomanometer

7.2 Define the following.

(i) Force
(ii) Area
(iii) Pressure
(iv) Hydraulics
(v) Pneumatics

7.3 Give brief answers.

(i) Give the commonly used units of force.
(ii) Give the commonly used units of area.
(iii) Give the commonly used units of pressure.
(iv) State Pascal's law.
(v) Differentiate between hydrostatic pressure and atmospheric pressure.
(vi) In the figure shown below indicate the location where atmospheric pressure is expected to be lowest.



7.4 Explain the following.

(a) Water pressure (b) Atmospheric pressure (c) Aerosols

7.5 Describe an application of Pascal's law.

7.6 Describe the use of a pneumatic system in daily life.

Chapter 8

MEASUREMENT OF PHYSICAL QUANTITIES

STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Define a physical quantity with examples.
- ☑ Apply the prefixes milli, kilo, centi, and interpret the units.
- ☑ Interconvert smaller units and bigger units.
- ☑ Select and use measuring instruments.
- ☑ Interpret SI units in daily life.
- ☑ Investigate why it is desirable for a scientist to use the SI units in their work.
- ☑ Measure the volume of liquid by reading correct meniscus.

How far is your school from your home? How much is the table heavier than the chair? How much more water can be filled in a jug than that in a glass? How long is the duration of a day? Such questions can be answered only when you are able to measure the physical quantities like length, mass, time, volume, etc. In this chapter, we will learn about these physical quantities and their measurements. Measuring instruments and units of measurements will also be discussed.

8.1 Physical Quantities

The quantities which can be measured are called physical quantities. Length, mass, time, volume, etc., are the examples of physical quantities. Physical quantities have at least two things in common. One is the size or magnitude and the other is the unit in which the quantity is measured. For example, to describe a brick, its length, width, height and mass are measured. These are called physical quantities.

8.2 International System of Units

In our daily life, we often need to measure various physical quantities. To measure a physical quantity, we compare it with some standard quantity. For example, if we purchase some sugar, we must know how much quantity of sugar we are talking about. Thus, there is a need of some standard quantity for measuring unknown quantity. This standard quantity is called unit.

Various standard units have been in use at different times in different parts of the world. With the passage of time, these units were made more precise and acceptable. People especially business communities and scientists of different countries faced problems of converting the units into one another. This problem was solved in a conference of the scientists from all over the world held in Paris.

In 1960, the eleventh general conference of International Committee on Weights and Measures recommended that all countries of the world should adopt a system of same kind of standard units. This conference recommended the use of International System of units. It is abbreviated as SI. According to this system, the units of length, mass, time and volume are given in the following table.

For your information

The standard kilogram kept in Paris

Physical Quantity	Symbol	Unit	Symbol
Length	l	metre	m
Mass	m	kilogram	kg
Time	t	second	s
Volume	V	cubic metre	m^3

A practical unit of volume is litre (L). Mostly the litre is used for measuring volume of liquids such as milk, petrol, cooking oil, etc. It is 1/1000th part of a cubic metre (m^3).

Therefore $1\ m^3 = 1000\ L$

Also $1\ L = 1000$ millilitre $= 1000$ cubic centimetre (cc)

Prefixes

The main advantage of SI units is that their multiples and sub-multiples can be conveniently expressed using prefixes. Prefixes are based on multiplying and dividing the units by powers of 10. The words or letters added before SI units such as milli (m), centi (c) and kilo (k) are known as prefixes.

- Milli means 1000^{th} part. For example, millimetre (mm) is 1000^{th} part of a metre, i.e., 1/1000 m. It means, 1 m = 1000 mm.
- Centi means 100^{th} part. For example, centimetre (cm) is 100^{th} part of a metre, i.e., 1 cm = 1/100 m. It means 1 m = 100 cm.
- Kilo means 1000 times. For example, kilometre (km) is 1000 times of a metre, i.e., 1 km =1000 m.

Thus, diameter of a thin wire can be written in smaller units of centimetre (cm) or millimetre (mm) instead of metre. Similarly, the longer distance between two cities may be expressed better in a bigger unit of distance, i.e., kilometre (km).

Examples

1. Convert 5 m into mm.

$$5\text{ m} = 5 \times 1{,}000\text{ mm}$$
$$= 5{,}000\text{ mm} = 5 \times 10^3\text{ mm}$$

2. Convert 50 m into cm.

$$50\text{ m} = 50 \times 100\text{ cm}$$
$$= 5{,}000\text{ cm} = 5 \times 10^3\text{ cm}$$

3. Convert 20,000 g into kg.

$$20{,}000\text{ g} = 20{,}000 \div 1{,}000\text{ kg}$$
$$= 20\text{ kg}$$

Multiples and sub-multiples of length

1 m	100 cm
1 cm	10 mm
1 km	1000 m
1 mm	10^{-3} m
1 cm	10^{-2} m
1 m	10^{-3} km

Multiples and Sub-multiples of mass

1 kg	1000 g
1 g	1000 mg
1 mg	10^{-3} g
1 g	10^{-3} kg

Sub-multiples of time

1 ms	10^{-3} s
1 µs	10^{-6} s

Mini Exercise

1. Complete the following:

1 km = ________ m , 1 cm = ________ m

1 mm = ________ m , 1 cm = ________ mm

2. The height of a student is 150 cm. What is his height in metres?

Mini Exercise

1. Complete the following:
   (i) 1 kg = ____________ g = ____________ mg
   (ii) 1 mg = ____________ g = ____________ kg
2. The mass of a bag of flour is 10 kg. What is the mass in grams?
3. Convert the following in grams:
   (a) 75.5×10^{3} mg
   (b) 1.58×10^{-2} kg
   (c) 440 mg

8.3 Measuring Instruments

Measuring instruments are used to measure various physical quantities such as length, mass, time and volume etc. We shall now describe some measuring instruments used in the laboratory.

8.3.1 Metre Rule

A metre rule is one metre long graduated stick. It is usually used to measure length of an object or distance between two points. A metre rule is divided into 100 equal parts, each part is equal to one centimetre (Figure 8.1). Each centimetre is further divided into 10 millimetres. Thus, a metre rule can measure the length of an object correct upto one millimetre.

For your information

It is better to measure from 1cm mark of the metre rule or measuring tape and then subtract 1 cm from the final reading. This is because of the wears and tears of zero edge of the scale.

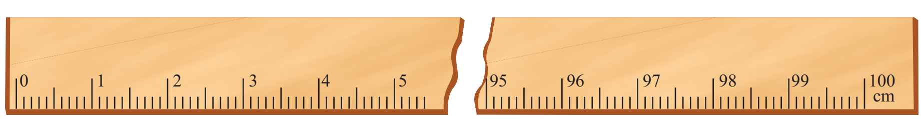
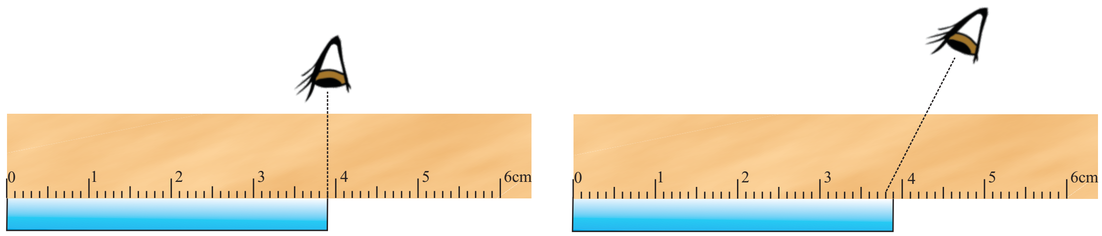


Figure 8.1: Metre rule

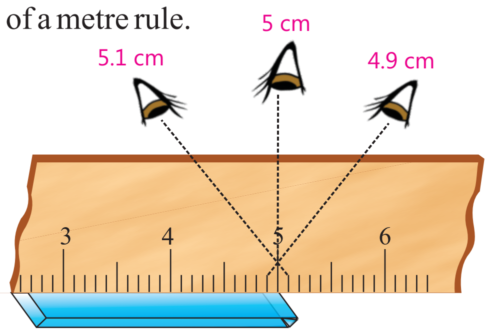
While measuring length or distance between two points, eye must be kept vertically above the reading point as shown in Figure 8.2(a). If the eye is positioned either left or right to the measuring point (Figure 8.2-b), the reading will become doubtful.



(a) Correct reading **(b)** Incorrect reading

Figure 8.2

Activity 8.1



- Measure the length of a plate with the help of a metre rule.
- Position your eye vertically above the reading mark on the scale. In this way you would get accurate measurement.
- Now measure the same length from wrong positions of the eye as shown in the figure.
- Wrong position of the eye will give you an incorrect reading.
- Such an error (due to wrong position of eye) is called parallax error.

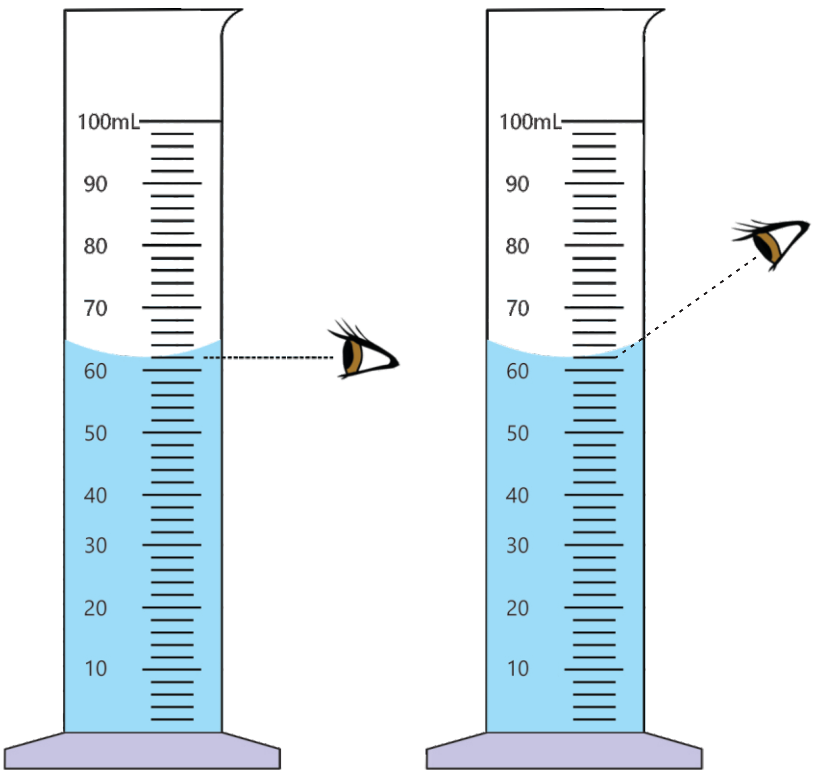
Mini Exercise

Measure the following lengths with the help of a measuring tape and convert them into larger or smaller units:

1. The length of your science textbook
   = ________ cm = ________ m
2. The height of the boundary wall of your school
   = ________ m = ________ cm = ______ mm
3. The distance of your classroom from the Principal office
   = ________ cm = ________ m = ________ km
4. Length of your classroom
   = ________ cm = ________ m
5. Height of your friend
   = ________ cm = ________ mm

8.3.2 Measuring Cylinder

A measuring cylinder is used to measure the volume of a liquid. It is made of glass or transparent plastic. It has a scale in millilitre (mL) or cubic centimetre (cm^3) along its length. That is why, it is also called graduated cylinder. Measuring cylinders of different capacities (from 5 mL to 500 mL) are available in the school laboratory. To measure the correct volume of a liquid, cylinder must be placed on horizontal surface and the eye should be kept on the level with the bottom of the meniscus (curved surface) as shown in Figure 8.3 (a).



(a) Correct reading **(b)** Incorrect reading

Figure 8.3: Measuring cylinder

Do you know?

Meniscus of all liquids is curved downward whereas meniscus of mercury is curved upward when they are put in a cylindrical container.

Interesting information

1 dm^3	=	1 L	=	1000 mL
1000 mL	=	1000 cm^3		
1 mL	=	1 cm^3		

Mini Exercise

Convert the following into dm^3.

(i) 5 m^3

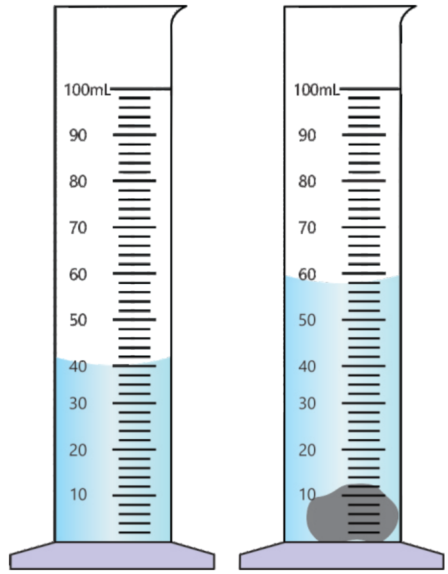
(ii) 1000 cm^3

Activity 8.2 - Measurement of volume of an irregular shaped object

- Fill 1/3rd of a graduated cylinder with water and note the volume of water V_1.
- Take a small irregular shaped object and drop it gently in the measuring cylinder by rolling down along the inner wall of the cylinder.
- The level of water in the cylinder will rise up.
- Note the new volume V_2 as shown by the cylinder.
- Increase in volume is in fact the volume (V) of the small irregular shaped object dropped in the cylinder.

Calculate the volume V of an irregular shaped object as follows:

$$V = V_2 - V_1$$



Measuring volume of a small irregular shaped object

8.3.3 Flasks

Flasks are laboratory vessels (containers). They are made of glass or plastic. Flasks are available in many shapes and sizes (Figure 8.4). Their sizes are specified by the volume they can hold. In school laboratory, these are usually available in the sizes of 50 mL, 100 mL, 250 mL, 500 mL and 1000 mL. These are graduated in the units of cubic centimetre (cc) or millilitres (mL). Flasks are used for making solutions.

Figure 8.4: Measuring flasks

8.3.4 Pipette

Pipettes are commonly used in chemistry and biology laboratory to measure the volume of a liquid in a smaller quantity. Pipettes have several shapes and sizes (Figure 8.5). These are graduated to a specific mark. These are commonly available in the sizes of 10 mL to 25 mL. Pipettes are made of glass or plastic.

Figure 8.5: Pipettes

KEY POINTS

- The quantity that can be measured is called a physical quantity. Length, mass, time, volume, etc. are the examples of physical quantities.
- The system of units recommended by the scientists in an international conference held in 1960 near Paris is known as System International units, abbreviated as SI.
- SI units of length, mass, time and volume are metre (m), kilogram (kg), second (s) and cubic metre (m^3) respectively.
- Metre rule, measuring tape, etc. are the instruments which are used for the measurement of length.
- Measuring cylinder, measuring flask and pipette etc. are the instruments used for the measurement of volume.
- The liquid in a measuring cylinder has its surface curved. This curved surface of the liquid level is called meniscus.
- The meniscus of the most of the liquids curves downwards whereas meniscus of mercury curves upwards.
- The correct way to read meniscus is to position the eye at the same level as the meniscus.

QUESTIONS

8.1 Encircle the correct option.

(i) An electronic balance is used to measure:

a. electric current b. length
c. mass d. volume

(ii) SI unit of mass is:

a. kilogram b. kilometre
c. pound d. ounce

(iii) Which of the following liquids makes the meniscus opposite to the others?

a. Mercury b. Water
c. Alcohol d. Petrol

(iv) Which of the following is SI unit of volume?

a. m b. m^2
c. m^3 d. kg

(v) A mass of 2 kg is equal to:

a. 1,000 g b. 2,000 g
c. 2,500 g d. 3,000 g

(vi) Which of the following relation is correct relation?

a. 1 min = 60 h b. 1m = 1,000 cm
c. 1mL = 1 cm^3 d. 1min = 30 s

(vii) A length of 50 mm is equal to:

a. 0.5 m b. 0.05 m
c. 0.005 m d. 0.0005 m

(viii) 25 cm^3 is equal to:

a. 25 mL b. 2.5 mL
c. 0.25 mL d. 250 mL

(ix) One kilometre is equal to:

a. 100 m b. 500 m
c. 1,000 m d. 10,000 m

(x) Pipettes are commonly used for:

a. making solutions

b. measuring the volume

c. transferring a measured volume

d. measuring mass

8.2 Match the Words of column A with those of column B.

A	B
Mass	Metre rule
Length	Flask
Volume	Digital watch
Time	Standard quantity
Unit	Balance

8.3 Short answer questions.

(i) Define a physical quantity.

(ii) Define the term prefix.

(iii) What is a metre rule?

(iv) How many millilitres are there in one dm^3?

(v) How many seconds are there in one solar day?

8.4 Descriptive questions.

(i) What are SI units? Explain.

(ii) Describe the importance of SI units.

(iii) The length of a wooden rod is 25.5 cm. What is this length in:

(a) millimetres? (b) metres?

(iv) The mass of an iron plate is 1,950 g. What is this mass in kilograms?

(v) Convert in minutes.

(a) 3,600 s (b) 2 h

(vi) Describe the use of measuring cylinder.

(vii) Write short notes on measuring flask and pipette.

Chapter

9

SOURCES AND EFFECTS OF HEAT ENERGY

STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Describe the sources and effects of heat.
- ☑ Explain thermal expansion of solids, liquids and gases.
- ☑ Explore the effects and applications of expansion and contraction of solids.
- ☑ Describe the uses of expansion and contraction of liquids.
- ☑ Explain the peculiar behaviour of water during contraction and expansion.
- ☑ Investigate the processes making use of thermal expansion of substances.
- ☑ Identify the damages caused by expansion and contraction in their surroundings and suggest ways to reduce these damages.
- ☑ Investigate the means used by scientists and engineers to overcome the problems of expansion and contraction in everyday life.
- ☑ Describe the working of a thermometer.

Heat is an essential requirement for life. In addition to keeping our bodies warm, we need heat for ripening crops and fruits, keeping the Earth's environment warm, melting of ice on the mountains and in the preparation of a large number of industrial products. In this chapter, we will learn about the sources, effects and uses of heat in different processes.

9.1 Sources of Heat

(I) Sun is the biggest source of heat. Sun's heat reaches the Earth in the form of radiations. Solar radiations keep the Earth environment warm at a suitable temperature for the survival of life (Figures 9.1and 9.2).

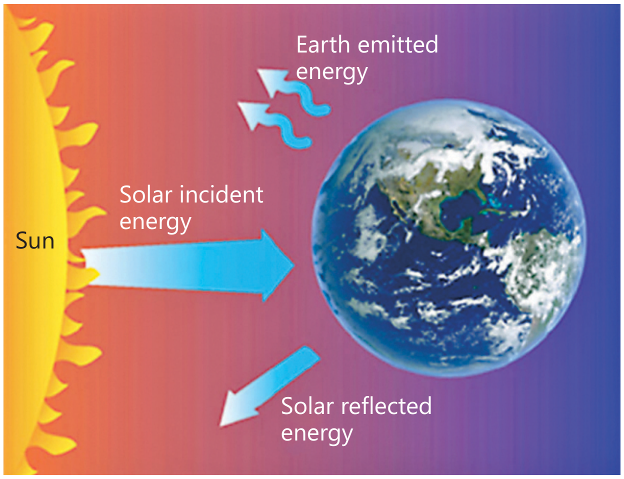


Figure 9.1: Solar radiations keep the Earth warm

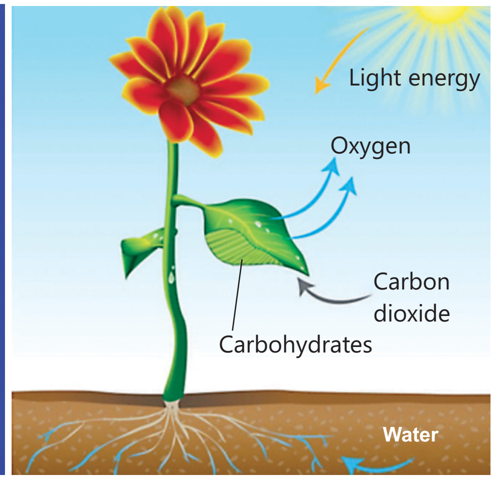


Figure 9.2: Solar radiations used by plants

(ii) We keep our bodies warm and alive by the heat produced from the food during its metabolism in the body cells.

(iii) Heat is also produced by burning of wood, coal, oil and gas, etc. We cook food (Figure 9.3) and warm our rooms by the heat produced by burning of wood and natural gas, etc. Heat produced by the burning coal and oil etc. is used to produce electricity in thermal power stations (Figure 9.4).

Figure 9.3: Heat cooks food

Figure 9.4: Thermal power plant

(iv) Electricity is also used to produce heat (Figure 9.5).

Figure 9.5: Electric heater

9.2 Effects of Heat

All kinds of material objects are made up of tiny particles such as atoms and molecules. When an object is heated, the object expands. This expansion of material objects on heating is called **thermal expansion**. On the other hand, when an object is cooled, the object contracts. This contraction of material objects is called **thermal contraction**.

9.2.1 Thermal Expansion and Contraction of Solids

We know that material objects are made up of tiny particle; atoms and molecules. In solid objects these particles are strongly packed with each other. The motion of particles in solids is vibratory only, i.e., they move to and fro about their fixed positions. When solids are heated, the vibratory motion of their particles (atoms and molecules) becomes fast and they begin to push each other farther apart (Figure 9.6). This results into expansion of solids. Similarly, when solids are cooled, particles slow down and solids contract (Figure 9.7).

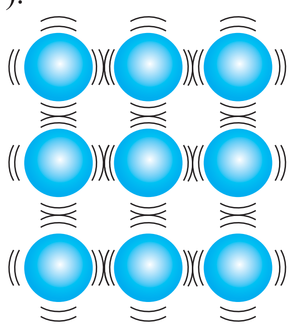


Figure 9.6: Motion of molecules when heated

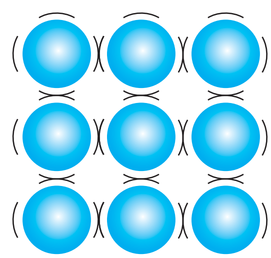


Figure 9.7: Motion of molecules when cooled

Activity 9.1

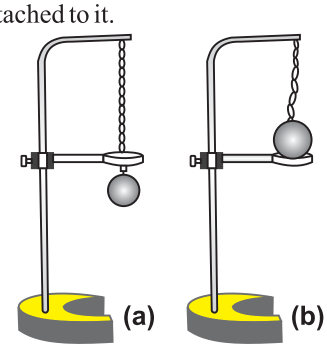
Material Required

Metal bob and ring apparatus (metallic sphere, ring, chain), stand, burner or spirit lamp

Procedure

- Take a metallic sphere which can pass easily through a ring as shown in figure (a).
- Remove the sphere out of the ring with the help of the chain attached to it.
- Heat the sphere to a high temperature and put it on the ring in order to pass it through the ring as shown in figure (b).
- Does it pass through the ring after heating?
- If not, why does it happen so?
- Let the sphere cool at room temperature and observe whether it passes through the ring or not.

If yes, why does it happen so?



In this activity, we see that solids expand on heating and contract on cooling.

The degree of expansion and contraction in solids depends on the nature of substances. Some solids expand or contract very little and we may not notice their expansion or contraction on heating or cooling. Different metals expand or contract at different rates. For example; one metre long brass rod increases 1 mm in length when its temperature increases by 100 °C but iron rod of the same length expands only 0.6 mm for the same increase in temperature.

Activity 9.2

Material Required

Bimetallic strip, burner or spirit lamp

(bimetallic strip consists of two different metals such as iron and brass which are joined together)

Procedure

- Take a bimetallic strip and notice that it is straight at room temperature.
- Heat the bimetallic strip over a gas burner.

What happens to the bimetallic strip on heating?

Why does it happen so?

- Let the bimetallic strip cool down to room temperature and observe what happens to it on cooling?

Why does it happen so?

Bimetallic strip before heating

Bimetallic strip after heating

For your information

In fire, the thermal expansion of steel beams, concrete and glass can cause considerable damage.

9.2.2 Thermal Expansion and Contraction of Liquids

Activity 9.3

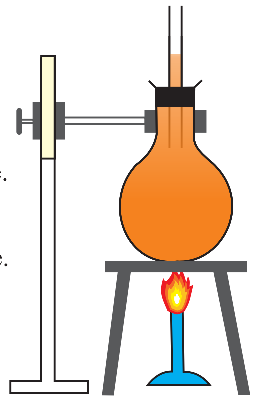
Material Required

Round bottom glass flask, cork or rubber plug which can be fitted at the mouth of flask, narrow glass tube, coloured water

Procedure

- Take a round bottom glass flask and fill it fully with coloured water.

- Pass a glass tube which is open at its both ends through a cork or rubber plug and fit the rubber plug into the mouth of the flask tightly as shown in the figure.
- Water will rise up in the glass tube to a small height.
- Note the level of the coloured water in the glass tube.
- Now heat the flask over a burner or spirit lamp.
- Observe what happens to the level of the coloured water in the glass tube.
- Record what do you observe?
- Now switch off the burner and let the hot water cool at room temperature.
- Note the level of the water again.
- What conclusion do you draw from this activity?



As you start heating the water, you will notice that the level of water in the tube first falls and then begins to rise up.

Why does it happen so?

9.2.3 Thermal Expansion and Contraction of Gases

Like solids and liquids, gases also expand on heating and contract on cooling. Let us perform the following activity to demonstrate it.

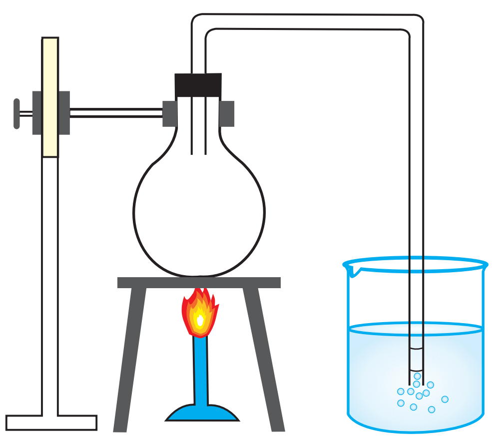
Activity 9.4

Material Required

Empty flask, thin U-shaped glass tube, cork or rubber plug with bore, stand, burner or spirit lamp, beaker, water

Procedure

- Take an empty flask and fit a cork or rubber plug into the mouth of the flask. Pass short limb of the U-shaped glass tube through the cork.
- Clamp the flask in a stand as shown in the figure.
- Dip the long limb of U-shaped glass tube in the water contained in the beaker as shown in the figure.
- Note and mark a line at the level of water in the glass tube.
- Heat the flask.



What do you observe in the water?

- Stop heating and let the system cool down to room temperature.

Observe and note the level of water in the glass tube again.

Is there any change in the level of water in the glass tube?

If yes, why does that happen?

This activity would make you learn that air in the flask expands on heating and leaves the flask producing bubbles in water. On cooling, the air inside the flask contracts, as a result, a suction is created in the flask which pulls the water level in the glass tube up.

? Do you know?

If air is filled into the car tyres to the fullest in the evening. The tyres may burst in the hot afternoon next day. This is because of expansion of air on getting heat from the surrounding.

9.3 Applications of Expansion and Contraction of Solids

Thermal expansion and contraction are used for different purposes. A few examples are:

1. Riveting

A rivet is a small, cylindrical and smooth shaft whose one end is swollen (called head) while the other end is flat (called buck-tail) (Figure 9.8). Hot rivets are used to join the metal plates. The process in which two metal plates are joined together by means of rivets is called riveting. For joining the two steel plates, they are placed one above the other and holes are drilled through them. The rivet is heated to make it red hot and is inserted in the holes of the plates (Figure 9.9-a). The ends of the rivet are then hammered into a round shape (Figure 9.9-b). When the rivet cools and contracts, it firmly grips the plates together (Figure 9.9-c).

Figure 9.8: Metal rivets

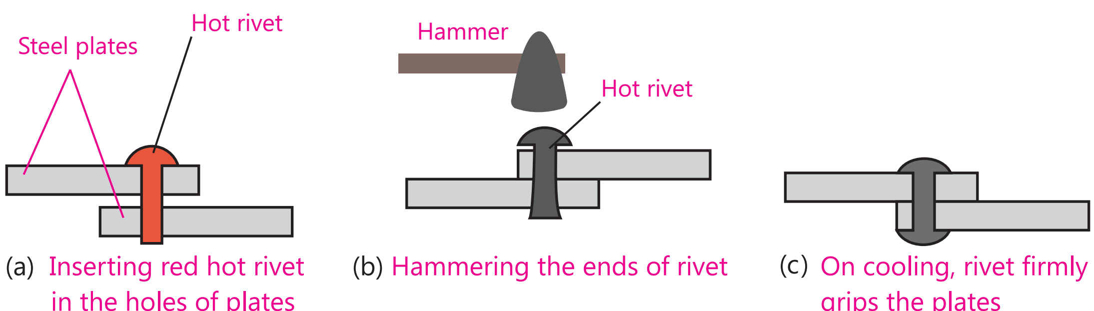


Figure 9.9: Riveting

2. Fixing a Metal Tyre Over the Wheel

The metal tyres which are fixed over the wooden wheels of the carts are slightly smaller than the wheels when they are cold. On heating, the metal tyre expands and its diameter increases. Then hot tyre can easily be fitted onto the wheel. On cooling, the metal tyre contracts and fits over the wheel tightly (Figure 9.10).

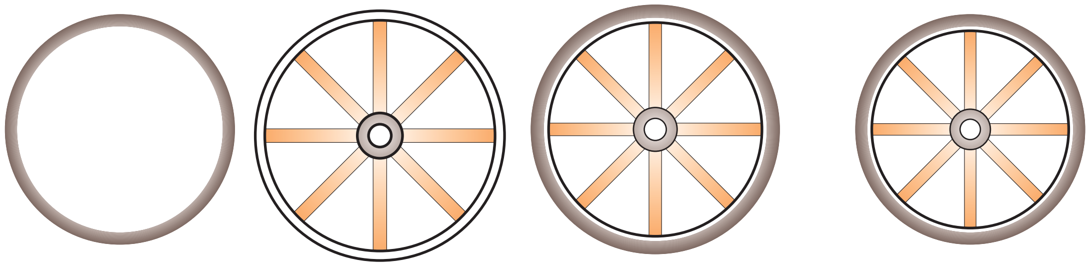


Figure 9.10: Fixing a metal tyre over the wheel

3. Fixing Axle into a Wheel

This method is mostly used to fit in the axle of train wheels. In this method, contraction is used instead of thermal expansion. The diameter of the axle is slightly larger than the hub of the metal wheel. The axle is placed in liquid nitrogen which is below -196 °C temperature. The axle cools and contracts. It is then inserted into the hub of the wheel and is allowed to come at room temperature. At room temperature, axle expands and fits into the wheel tightly (Figure 9.11).

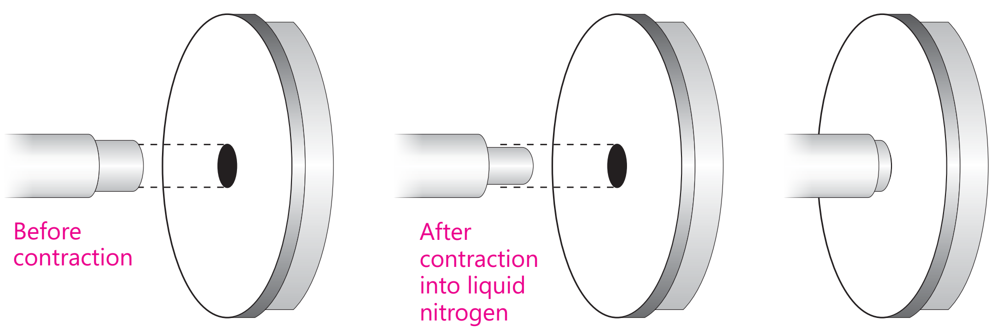


Figure 9.11: Fixing axle into the wheel

Applications of Bimetallic Strips

Bimetallic strips are used in thermostats. A thermostat is a device that is used to control temperature in electrical appliances such as electric irons, heaters, refrigerators, air conditioners, ovens, and stoves etc. It is also used in fire alarms.

1. Electric Iron

In an electric iron (Figure 9.12), when electric current flows through its heating element, it becomes hot. The bimetallic strip connected with the heating element through a spring also begins to heat up. On getting hot, bimetallic strip bends and is disconnected from the heating element. This makes the circuit open and switches OFF the electric iron. On cooling, the bimetallic strip straightens. The circuit is again closed and the iron is switched ON.

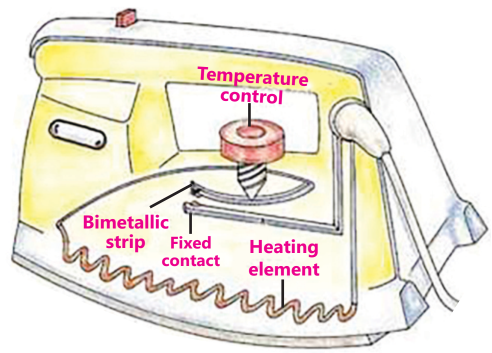


Figure 9.12: Electric iron

2. Fire Alarm

In case the fire breaks out, the bimetallic strip used in the fire alarm gets hot and bends to touch with the contact point of the battery. In this way the circuit is completed, and the bell connected in the fire alarm circuit begins to ring to warn of the fire (Figure 9.13).

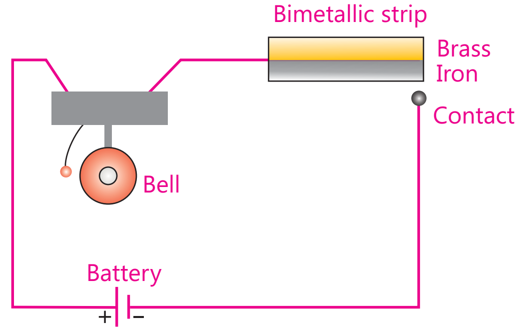


Figure 9.13: Fire alarm circuit diagram

9.3.1 Effects of Expansion and Contraction of Solids in Everyday Life

In our daily life, we pay special attention to deal with thermal expansion and contraction of solids in various construction projects. In order to avoid the harmful effects of thermal expansion and contraction of solids, the techniques used in different projects are as follows:

1. Expansion Gaps in Concrete Roads

In hot summer, the concrete used to build roads expands. If no space is provided for its

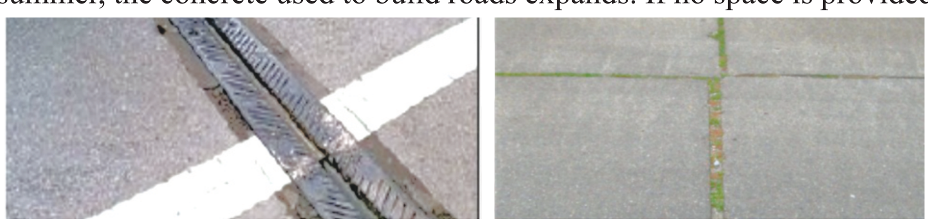


Figure 9.14: Gaps in roads and footpaths

expansion, the road surface cracks. To avoid such damage, small gaps are left after every few metres in the construction of concrete roads or footpaths (Figure 9.14).

2. Railway Tracks

Two sections of a railway track are not welded together. Instead they are laid with gaps between them (Figure 9.15). This allows expansion and contraction of rails during summer and winter seasons. If there are no gaps in the sections of railway tracks, they may de-shape due to expansion in summer.

Expansion gap in railway track

De-shaped railway track

Figure 9.15: Railway tracks

3. Expansion of Bridges

Iron girders are used in the construction of bridges. One end of each girder is fixed while the other end rests on the rollers. A gap is also left at this end (Figure 9.16). In this way, the girder can move forward or backward during expansion or contraction. If there is no expansion gap, bridges may get damaged.

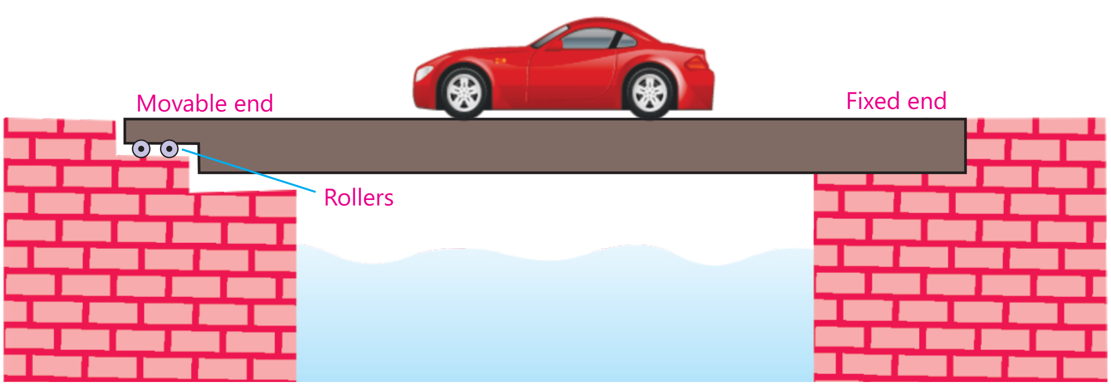


Figure 9.16: Rollers in bridges

4. Overhead Power Lines and Telephone Wires

Overhead telephone and electricity wires installed on poles expand during hot weather and contract in cold weather. The wires between two poles are given a certain amount of sag so that they may contract in winter without snapping (Figure 9.17).

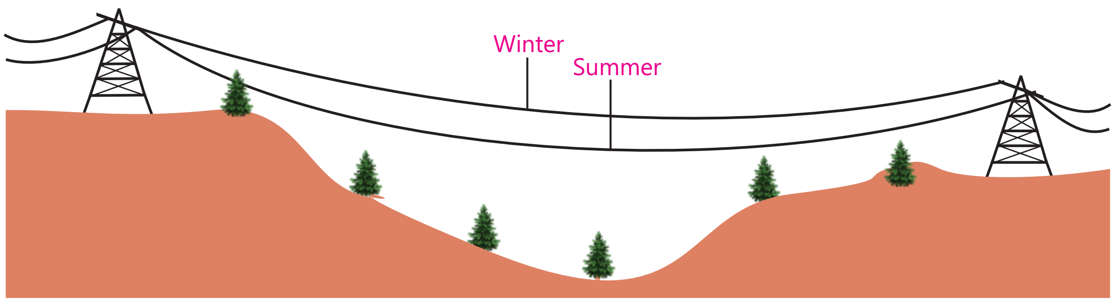


Figure 9.17: Overhead power lines

5. Large Bends in Pipes

The pipes through which hot or cold liquid or gas flows are often given bends so that they may expand or contract without cracking (Figure 9.18).

Figure 9.18: Pipes carrying hot or cold liquids

9.4 Uses of Expansion and Contraction of Liquids

Thermometer

The expansion and contraction property of liquids is widely used in different techniques. For example; liquids like mercury and alcohol are used in thermometers. A thermometer is a device that is used for measuring temperature (Figure 9.19). When the bulb of the thermometer is touched with some hot object, the liquid inside the narrow tube of the thermometer expands and rises up and the temperature of the hot object can be read on the scale.

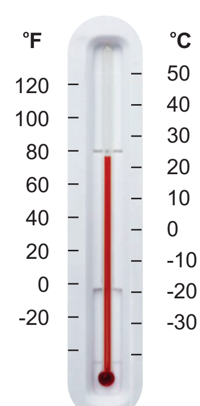


Figure 9.19: A thermometer

For your information

- The air filled in vehicle tyres, volleyballs and basketballs etc. expands in hot weather. As a result, the tyres and balls can burst in hot weather.
- While filling up the bottles with soda water, some space is left above the liquid surface for allowing the expansion of liquids in hot weather.

9.5 Peculiar Behaviour of Water

The behaviour of water with rise or fall in temperature is different from other liquids. When temperature of water is increased from 0 °C to 4 °C, it contracts, its volume decreases and its density increases. On cooling from 4 °C to 0 °C, water begins to expand, its volume increases and its density decreases. At 0 °C water freezes.

Figure 9.20: Peculiar behaviour of water

Due to this peculiar behaviour, when water freezes, it expands and density of ice becomes less than water. That is why ice floats on water surface (Figure 9.20). In this way, aquatic life (fish, etc.) survives underneath frozen lakes and ponds (Figure 9.21).

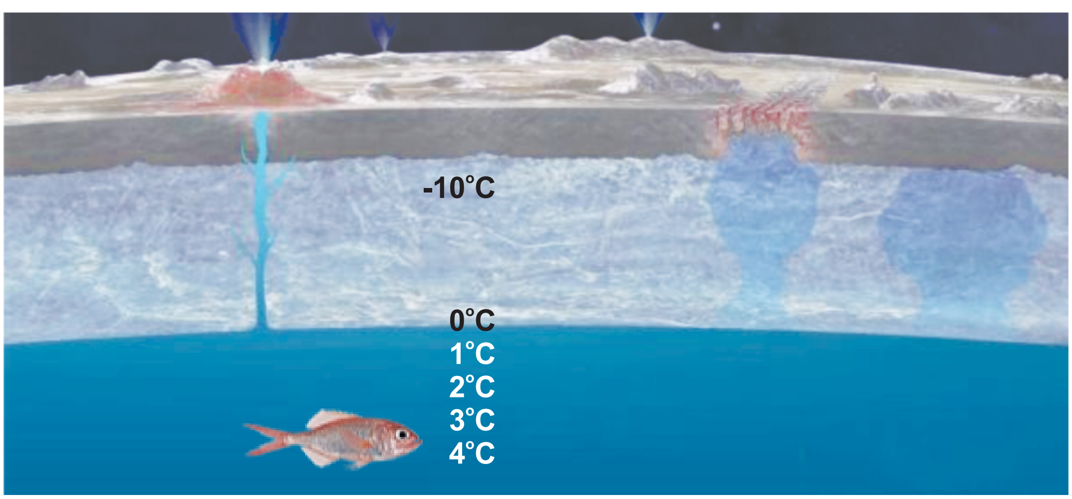


Figure 9.21: Fish living under frozen water

Activity 9.5

Material Required

Glass or beaker, ice cubes, water

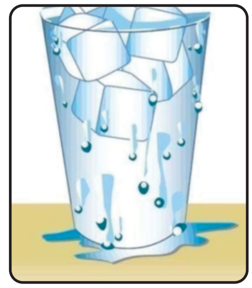
Procedure

- Take some ice cubes in a glass.
- Add water in the glass and fill it up to the brim.
- Wipe up the overflowed water from the outer sides of the glass.
- Wait for complete melting of ice cubes.

Observe what happens to the water level in the glass.

Why does it happen so?

What do you conclude from this activity?



KEY POINTS

- The Sun, fire and electricity are the main sources of heat.
- All material objects expand on heating and contract on cooling.
- Some solids expand or contract very little and we may not notice their expansion or contraction. However, some solids expand or contract significantly on heating or cooling.
- Expansion of solids during a hot day can cause damages.
- Hot riveting is a common method for joining two metal plates firmly.
- Bimetallic strips are used in thermostats. A bimetallic strip is made up of two different metals (iron and brass). It bends when heated or cooled due to uneven expansion or contraction of metals.
- Thermostat keeps the temperature constant. It is used in electrical appliances such as electric iron, heaters, refrigerators, airconditioners, ovens, stoves, etc.
- When a liquid is heated, its particles begin to move fast, inter particle distances increase. This makes the liquid expand. The reverse happens when the liquid is cooled down.
- Water behaves differently at the temperature range between 0 °C to 4 °C. In this temperature range, water expands on cooling and contracts on heating.
- When a gas is heated, its particles move fast, and inter particle spaces increase. As a result, the gas expands and its volume increases. The reverse happens when the gas is cooled down.

QUESTIONS

9.1 Encircle the correct option.

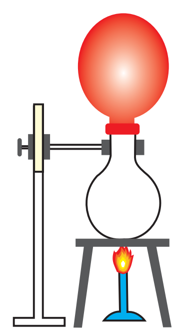
(i) Which of the following is the biggest source of heat energy?
a. Burning of fuels b. Electricity
c. The Sun d. Food

(ii) When an object is heated, the movement of its particles:
a. stops b. is not disturbed
c. decreases d. increases

(iii) Thermal expansion is not involved in:
a. automatic fire alarm b. thermostat
c. fixing metal tyres over the wheels d. wooden stick

(iv) Activity of metallic ball and ring shows:
a. solid objects expand on heating b. solid objects contract on heating
c. solids change their nature on heating d. there is no effect of heat on solids

(v) What will happen to the inflated balloon as shown in the figure, if the burner is removed?
a. Its volume will decrease
b. Its volume will increase
c. It will burst
d. Nothing will happen to it



(vi) The rise of liquid in the thermometer is due to:
a. evaporation b. contraction
c. expansion d. condensation

(vii) The contraction of the objects on cooling is due to the:
a. reduction in size of the particles b. increase in size of the particles
c. increase in inter particle distances d. decrease in inter particle distances

(viii) When ice melts and water reaches at 4 °C, its density:
a. increases b. decreases
c. decreases 4 times d. remains the same

(ix) An empty steel container is sealed and heated, which of the following properties of the gas present in this container increases?

a. Mass b. Pressure
c. Volume d. Density

(x) The instrument which uses the property of expansion and contraction of liquids is:

a. barometer b. thermometer
c. manometer d. speedometer

9.2 Give short answers.

(i) Write down the effects of heating and cooling on solids.
(ii) Write down the effects of heating and cooling on gases.
(iii) Why is water not used instead of mercury in thermometers?
(iv) Why one end of the iron girders is placed on rollers in construction of bridges?
(v) Why gaps are left between two sections of a railway track?
(vi) Why do hot air balloons rise up?
(vii) Why do gases expand faster than liquids and solids?
(viii) When a vessel containing a liquid is heated, the level of liquid initially falls and then rises up. Why does it happen so?

9.3 Descriptive questions.

(i) What is meant by thermal expansion? Explain expansion of solids with the help of an experiment.
(ii) Demonstrate how a bimetallic strip works in a thermostat.
(iii) Explain the peculiar behaviour of water during contraction and expansion.
(iv) Explain the damages which are caused by expansion or contraction by giving two examples.
(v) Describe the effects of expansion and contraction of solids.
(vi) Explain the expansion of liquids with the help of an experiment.
(vii) Describe a simple experiment to study the thermal expansion of gases.

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Chapter 10

LENSES

STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Define lenses.
- ☑ Differentiate between different types of lenses.
- ☑ Describe the image formation using a lens by ray diagram.
- ☑ Compare and contrast the working of human eye with the lens camera.
- ☑ Explain how eye focuses by altering the thickness of the eye lens.
- ☑ Investigate how eyes get used to darkness after sometime.
- ☑ Explain how lenses are used to correct short sightedness and long sightedness.
- ☑ Identify the types of lenses used for various purposes in daily life.

You have already studied the refraction of light in the previous class. Light, when enters from a lighter medium (e.g., air) to a denser medium (e.g., glass), it bends towards the normal. Conversely, when light enters from a denser medium (e.g., glass) to a lighter medium (e.g., air), it bends away from the normal. The main application of refraction is the image formation through lenses. In this chapter, we will learn about the types of lenses, image formation by lenses and uses of lenses.

10.1 Lenses

Lenses are widely used in our life. Many eyesight defects are corrected by the use of lenses. Lenses are commonly used in spectacles, cameras, microscopes, telescopes, binoculars, projectors and many other instruments for different purposes. Contact lenses are also becoming very popular these days. These can be placed in eyes and removed easily when needed.

A lens is a piece of any transparent material (like glass) with two faces, of which at least one is curved. Each surface of a lens is a part of a sphere. The centre of such a sphere is called **centre of curvature** (C). The centre of the lens is called **optical centre** (O). The line passing through the optical centre and centre of curvature of the faces of the lens is called **principal axis** or **optical axis** (Figure 10.1).

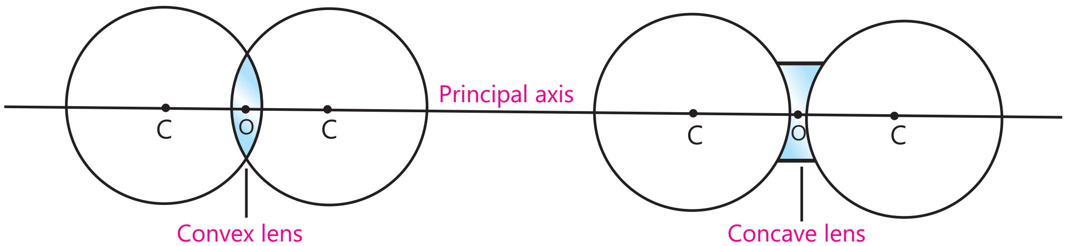


Figure 10.1: Centre of curvature and principal axis of the lenses

10.2 Types of Lenses

There are two types of lenses; **convex lens** or converging lens and **concave lens** or diverging lens (Figure 10.2). A convex lens is thicker in the middle and thinner at the edges. A concave lens is thinner in the middle and thicker at the edges.

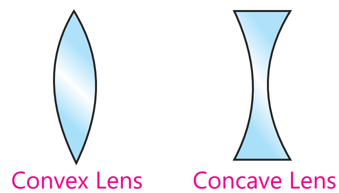
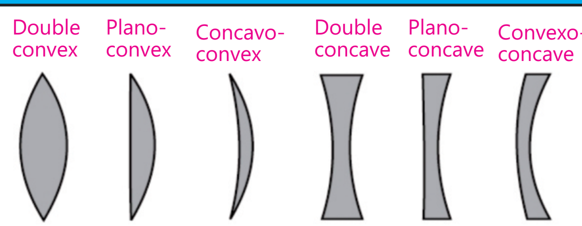


Figure 10.2: Convex and concave lenses

i For your information

There are different types of converging and diverging lenses such as double convex lens, plano-convex lens, concavo convex, double concave lens, plano-concave lens, convexo-concave.



Principal Focus (F) and Focal Length (*f*) of the Lenses

In case of convex lens the light rays parallel to the principal axis after refraction through the lens meet at a point. This point is called **principal focus** (F) or focus point of convex lens (Figure 10.3). As the light rays actually meet at the focus point after refraction through the convex lens, so the focus point is 'real'. The distance between the optical centre (O) and focus point (F) of the lens is called **focal length** (*f*). Focal length of a convex lens is taken as positive. Since a convex lens actually converges light at principal focus (F), that is why, it is also known as converging lens. Because of this property, convex lens makes real image

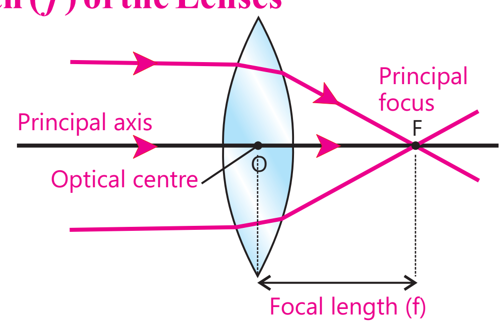


Fig. 10.3: Light rays passing through a convex lens

on the screen placed on the other side of the lens.

In case of concave lens, light rays parallel to the principal axis after passing through the lens bend in such a way that they do not meet at one point. They diverge out and appear to be coming from one point which is called principal focus. The principal focus of a concave lens is 'virtual'. The focal length of a concave lens is taken as negative. The image is not formed on the screen by a concave lens (Figure 10.4).

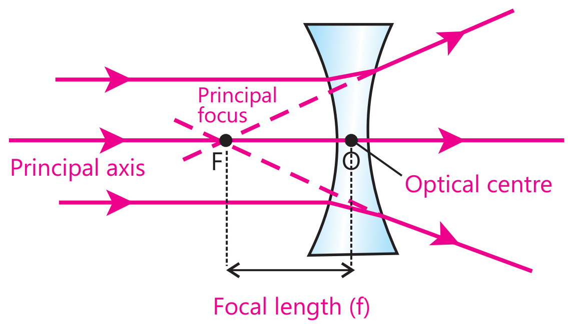
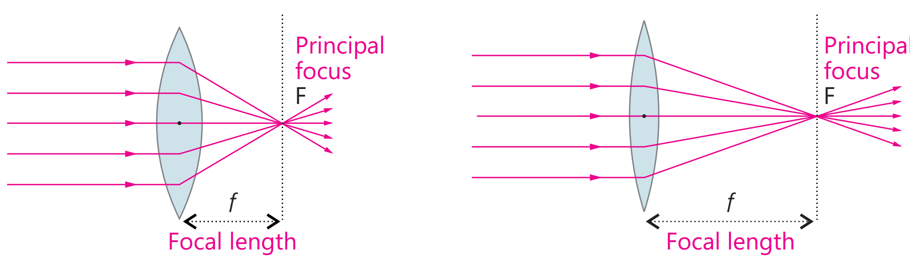


Fig. 10.4: Light rays passing through a concave lens

For your information

The focal length of a thick convex lens is shorter than that of a thin convex lens.



Thick convex lens **Thin convex lens**

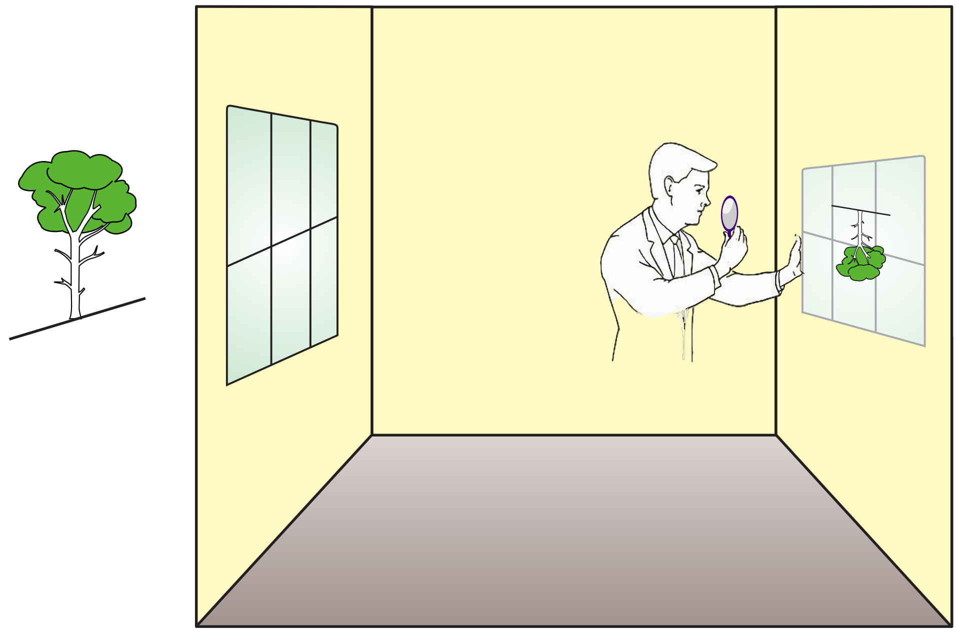
How to Find out Focal Length (*f*) of a Lens?

We use lenses of different focal lengths for different purposes. For the correct use of a lens, its focal length should be known. Let us perform a simple activity to find the focal length of convex lens.

Activity

- Take a convex lens and position yourself near the wall opposite to the window.
- Direct the lens towards the window in such a way that an image of a distant object such as a tree is formed on the wall.
- Move the lens slowly towards or away from the wall so that the image on the wall becomes sharp.
- At this position, note the distance between the lens and the wall. This distance is called focal length of lens.
- Measure this length and note it.
- Now take a concave lens and try to obtain the image of the same object on the wall.

- You will come to know that no image is formed on the wall by the concave lens.



10.3 Image Formation by the Lenses

Where and how an image is formed by a lens, it can be known by drawing a ray diagram. A ray diagram is a drawing showing the path of light rays. Therefore, the location and nature of image formed by a lens can be found very easily through a ray diagram. In this method, two or three light rays emerging from an object and passing through a lens are used. The image of the object is formed at the point where all the refracted rays meet after passing through the lens. In a ray diagram, light rays are represented by straight lines with arrow heads. The arrow heads show the direction of light ray. The following properties are used in drawing the ray diagrams:

1. A ray parallel to the principal axis after refraction from a convex lens passes through its principal focus (F). In case of concave lens, the refracted ray appears to come from the principal focus (F) (Figure 10.5).

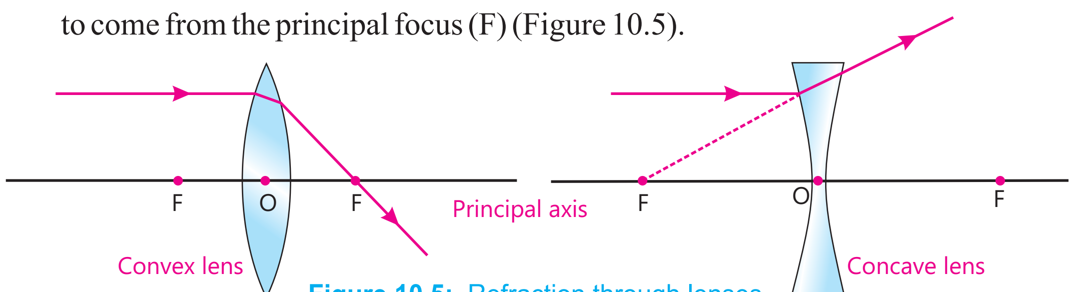


Figure 10.5: Refraction through lenses

2. A ray incident on the convex lens after passing through its principal focus (F) becomes parallel to the principal axis after refraction. In case of a concave lens, the ray pointing towards the principal focus appears to come from the principal focus after refraction (Figure 10.6).

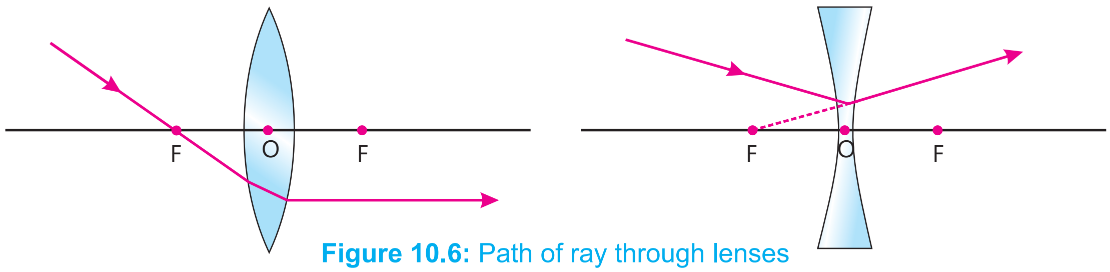


Figure 10.6: Path of ray through lenses

3. A ray passing through the optical centre of the lens goes straight without changing its direction (Figure 10.7).

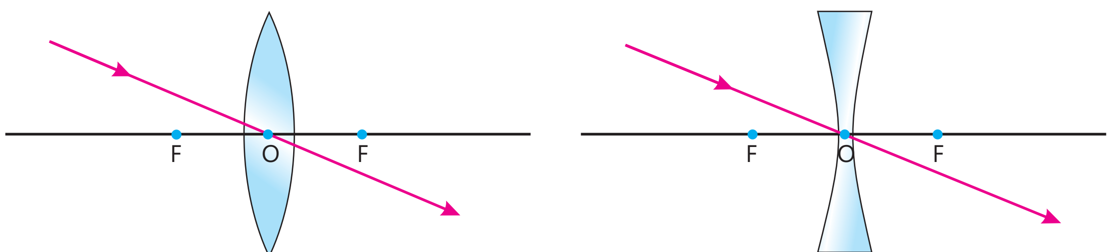


Figure 10.7: Path of ray through lenses

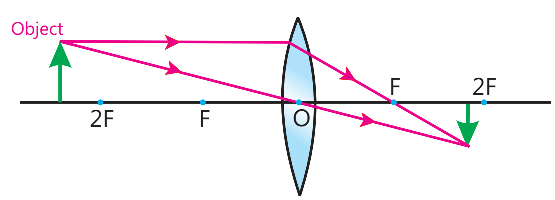
Image Formation Using a Lens by Ray Diagram

To find the position and nature of the image of an object by ray diagram method, follow the following steps:

1. Draw the positions of the object, lens and focal points on the principal axis.
2. Draw any two rays out of the three from the top of the object. In case of a convex lens, the point at which these rays cross each other after refraction is the top of the image.

Let us draw the ray diagrams to locate the image of an object placed at different positions in front of the convex lens (Figure 10.8).

a. When the object is placed beyond 2F, the image is formed on the other side of the lens between F and 2F. The image is real, inverted and smaller in size than the object.



b. When the object is at 2F, the image is also formed at 2F on the other side of the lens. The image is real, inverted and equal in size to the object.

c. When the object is between F and 2F, the image of the object is formed beyond 2F on the other side of the lens. The image is real, inverted and larger in size than the object.

d. When the object is at F, the image of the object is formed at infinity. It cannot be shown in the diagram because rays become parallel after refraction.

e. When the object is between O and F, rays after refraction diverge out and do not actually meet on the other side of the lens. A virtual image will be formed at a point where the rays meet when extended backward. These rays will appear to come from the image. The image will be magnified and erect.

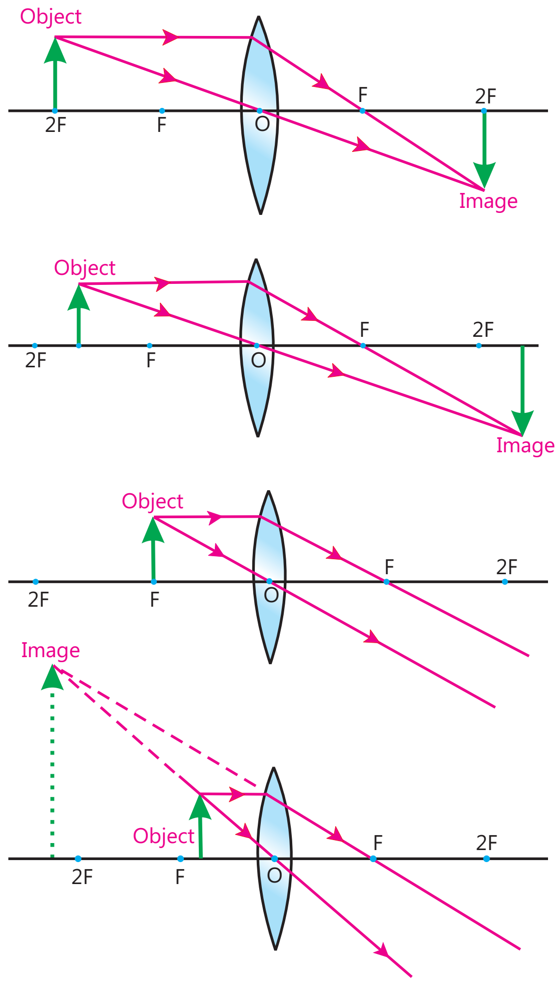


Figure 10.8: Position, nature and size of images formed through convex lens

- In case of concave lens, draw ray diagram by placing the object at different positions. Is real image formed on the other side of the lens? You will come to know that rays diverge out and do not meet on the other side of the lens after refraction. Therefore, real image is not formed on the other side. In fact, a virtual image is formed on extending the rays backward. This image is always virtual, erect and smaller in size (Figure 10.9).

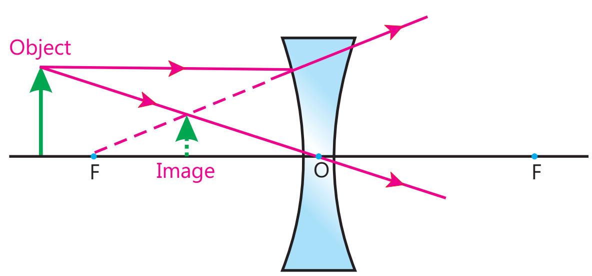


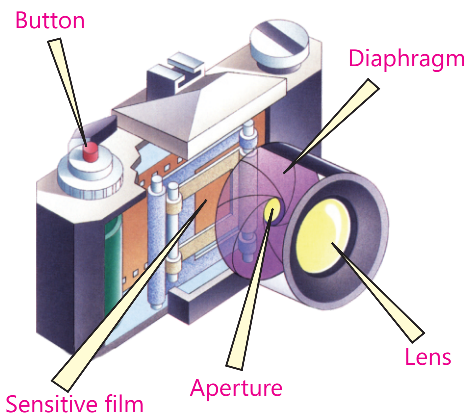
Figure 10.9: Position, nature and size of image formed through concave lens

10.4 Image Formation in Simple Camera and Human Eye

We know that if an object is lying at a distance more than the focal length of a convex lens, its real and inverted image is formed on the other side of the lens. The image through the eye and camera is formed in the same way. Let us compare the structure and function of both of them.

Camera

Camera is a kind of box to which a convex lens is mounted on the front side (Figure 10.10). The lens forms a real and inverted image of an object on the sensitive film placed behind it. A system is provided in the camera to move the lens back and forth so that sharp image is obtained on the film. There is shutter behind the lens that remains close normally. When the button is pressed, the shutter opens for a while. Light coming from the object enters the camera during this interval and image is formed on the film. The amount of light entering into the camera depends upon the size of aperture. Aperture is an opening in the diaphragm behind the lens. This can be made smaller or larger as required. The picture is obtained by developing the image on the film.



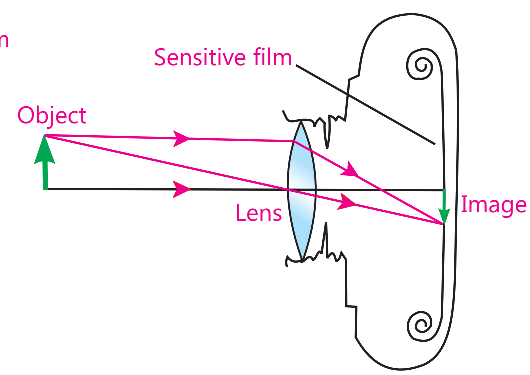


Figure 10.10: Image formation in camera

Human Eye

The human eye also works like a camera. Different parts of eye are shown in Figure10.11.

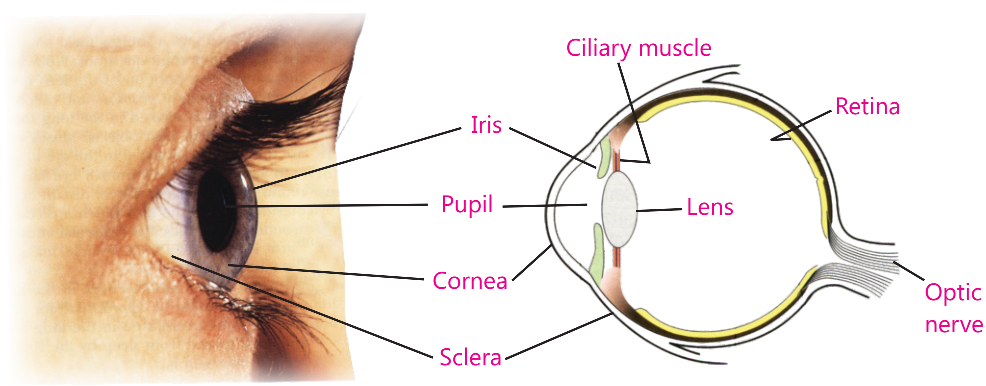


Figure 10.11: Human eye

The eye is almost a sphere of diameter about 2.5 cm. Its outer boundary called the sclera is thick and hard. At the front of the eye, there is a transparent hard skin known as cornea. Behind the cornea there is iris and after that there is convex lens. The inner layer of the back wall of eye is called retina. The retina of eye and the film of camera serve the same purpose. Like camera, the eye lens forms a real and inverted image of the object on retina. The optic nerve carries it in the form of signals to the brain. Although the image formed on the retina is inverted, but our brain interprets this correctly i.e. the right way up.

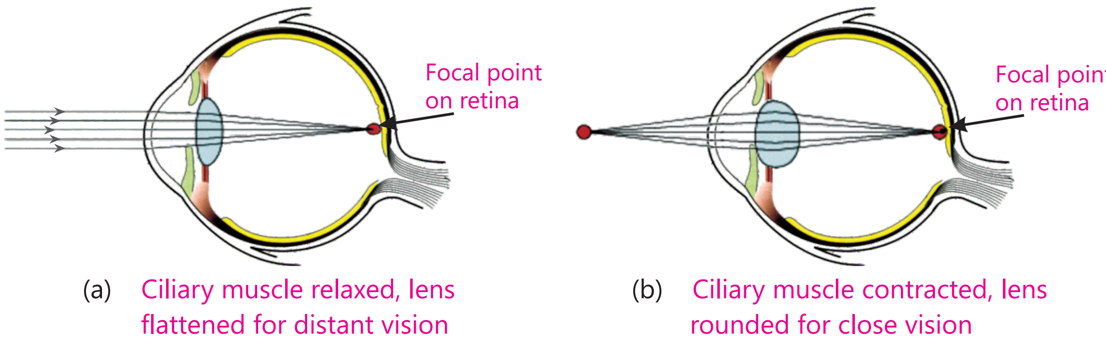


Figure 10.12: Ciliary muscles relax during distant vision (a), and contract during close vision (b).

The iris acts like the diaphragm of camera. The opening at the centre of iris is called pupil which is just like aperture of a camera. When light outside is dim, the iris contracts to make the pupil larger so that more light can enter the eye. In bright light, the iris makes the pupil smaller.

In a camera, lens is moved back and forth to focus the image on the film, but the eye lens does not move. Instead, the ciliary muscles make the lens thick or thin due to which its focal length changes (Figure 10.12). When you are looking at distant object, the ciliary muscles are in relaxed position and the image is formed on the retina. To look at something closer to the eye, these muscles make the lens thicker. This makes its focal length shorter and the image is again formed on the retina instead of forming at a point beyond it.

10.5 How Eyes Get Used to Darkness After Sometime?

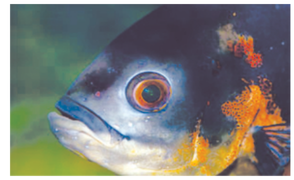
When we enter into a dimly lit room from bright sunshine, at first, we cannot see things clearly. But after sometime our eyes adjust to see in darkness. This is because, the retina of eye contains two types of vision cells. Near the centre of retina there are cone type cells.

These cells are active in bright light only and can perceive colours vision also. On the outside of retina are rod type cells which are active in dim light and only perceive object in black and white.

When suddenly we move from bright light to dark area, cone cells become de-activated but rods do not immediately become activate so that we feel difficulty in seeing for sometime. Then the rod cells become active after sometime and we are able to see in darkness though cannot perceive colours.

For your information

Some animals such as fish focus images onto the retina of their eye by moving their lens backward and forward.

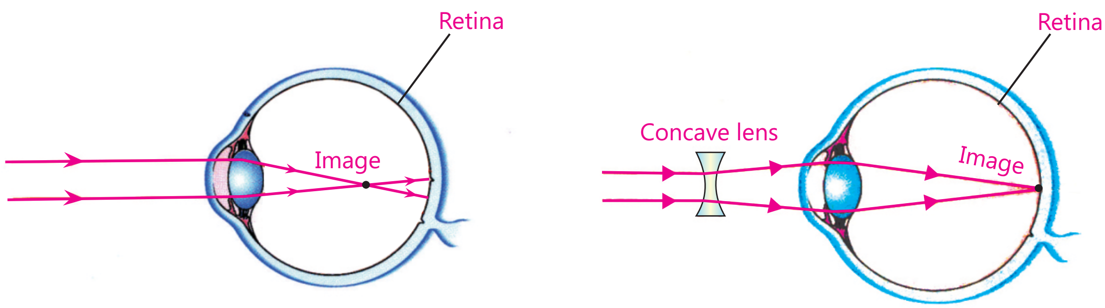


10.6 Defects of Human Eye

Short-sightedness and long-sightedness are the common defects of the eye.

Short-Sightedness

A person with this defect can see near objects clearly but distant objects appear blurred. This defect is caused when the eye lens becomes much thicker or eyeball becomes too long. The image of distant object is formed in front of the retina and not at the retina itself. This defect is also known as myopia and is corrected by using concave lens of suitable focal length. The concave lens diverges the light rays before they enter the eye and hence, the rays are refracted by the eye lens again to meet at the retina (Figure 10.13).



(a) Defected eye (b) Removal of defect

Figure 10.13: Correction of short-sightedness

Long-Sightedness

A person having this defect can see distant objects clearly but near objects appear blurred. This defect is caused when the eye lens becomes thin or the eyeball becomes too short. Due to this effect the image of the near object is formed beyond the retina. That is why the near object appears blurred in long-sightedness. This defect is known as hyperopia and is corrected by using suitable convex lens. The convex lens converges light rays before they enter the eye. After entering the eye, they are further bent by the eye lens to meet at the retina (Figure 10.14).

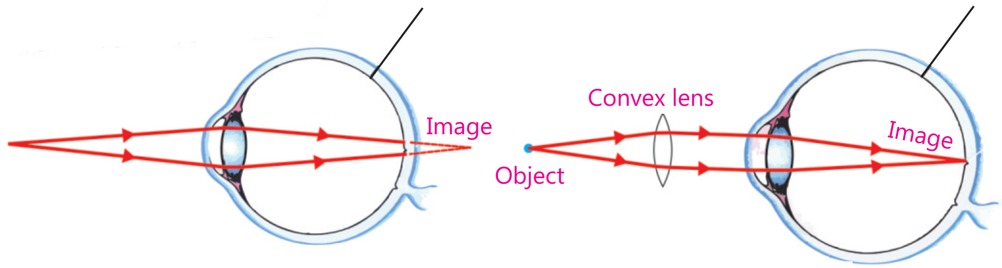


Figure 10.14: Correction of long-sightedness

10.7 Uses of Lenses

Lenses are used for various purposes in daily life. The following are their major uses:

Figure 10.15: Glass lenses in spectacles

1. Lenses are commonly used in spectacles (Figure 10.15).
2. Convex lenses are more widely used than concave lenses. Convex lenses are used to magnify images. They are used as magnifying glasses (Figure 10.16).

Figure 10.16: Magnifying glass

3. Contact lenses are becoming popular these days. These are very light and flexible. Contact lenses of different colours are used in eyes (Figure 10.17).

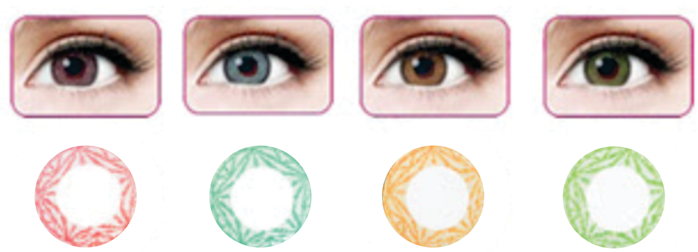


Figure 10.17: Contact lenses used in eyes

4. Special lenses are also used in high quality cameras, telescopes, and binoculars to improve the quality of images they provide (Figures 10.18, 10.19).

Figure 10.18: Lens **in camera**

Figure 10.19: Lens in binoculars

KEY POINTS

- A lens is a piece of any transparent material (like glass) with two faces, of which at least one is curved.
- A lens which is thick at the middle and thinner at the edges is called convex lens and the lens which is thin at the middle and thicker at the edges is called concave lens.
- The centre of the sphere of which any surface of the lens is a part , is known as its centre of curvature.
- Parallel rays after refraction through a convex lens converge at a point F which is called the principal focus of the lens.
- Parallel rays of light after refraction through a concave lens diverge out. They appear to come from a point F, which is called the principal focus of the lens.
- The distance between the optical centre and the principal focus is known as focal length of the lens.
- The image that can be obtained on the screen is known as real image.
- A convex lens forms real image on the screen while a concave lens always forms a virtual image.
- In short-sightedness, a person can see near objects clearly but distant objects appear blurred. This defect is corrected by using suitable concave lens.
- In long-sightedness, a person can see distant object clearly but near objects appear blurred. This defect is corrected by using convex lens of suitable focal length.

QUESTIONS

10.1 Encircle the correct option.

(i) A ray parallel to principal axis, after refraction from convex lens:

a. does not bend
b. passes through F
c. passes through C
d. passes through the middle of F and C

(ii) The centre of a lens is called:

a. optical centre
b. centre of curvature
c. principal focus
d. principal axis

(iii) The location of image of an object lying beyond 2F in front of a convex lens is:
a. between F and 2F b. beyond 2F
c. at F d. at 2F

(iv) The image of an object placed at C in front of a convex lens is formed:
a. at F b. between F and C
c. at C d. beyond C

(v) The image formed by a concave lens is:
a. virtual b. real c. inverted d. larger

(vi) The point through which a ray of light passes without changing its path is the:
a. centre of curvature b. optical centre
c. middle point of F and C d. principal focus

(vii) Pupil is made smaller or larger by:
a. ciliary muscles b. cornea
c. iris d. retina

(viii) In human eye, image is formed on:
a. cornea b. pupil c. iris d. retina

(ix) To obtain sharp image in a camera:
a. lens is moved back and forth b. film is moved back and forth
c. both the lens and the film are moved d. neither lens nor film is moved

10.2 Give short answers.
(i) Describe the paths of three rays which form image after passing through a convex lens.
(ii) Write the names of three instruments in which convex lens is used.
(iii) Define focal length.
(iv) Can image be obtained on the screen by a concave lens? Explain your answer briefly.
(v) How is the focal length affected when the lens of eye becomes thicker?
(vi) Upon what factor does the amount of light entering in a camera depend?
(vii) How long our eye takes to acquire dark adaption at its maximum?
(viii) Define short-sightedness and long-sightedness.

10.3 What is a lens? Explain the difference between convex and concave lenses.

10.4 Explain through ray diagram where the images would be formed by convex lens for different distances of object. Also discuss the nature of images.

10.5 What is a real and virtual image? Why is real image not formed by concave lens? Explain your answer by ray diagram.

10.6 Explain how eyes get used to darkness after sometime.

10.7 How do camera and human eye resemble with each other? What is the difference in their actions?

Chapter 11

ELECTRICITY

STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Design an experiment to generate electricity.
- ☑ Explain the working of a model generator.
- ☑ Identify the simple devices that generate electricity in daily life.
- ☑ Design and demonstrate the working of a power station.
- ☑ List types of energy being used in power stations.
- ☑ Relate problems involved in generating electricity.
- ☑ Describe basic components of an electronic system.
- ☑ List components that would be needed to turn A.C to D.C.
- ☑ State how output component in various devices could be used in their schools and surroundings.

Although electricity and magnetism were well known for centuries but Hans Christian Oersted a Danish Scientist in 1820 discovered a connection between them. He observed that current flowing through a coil of wire produces a magnetic field around it (Figure 11.1). In this way, he proved that a magnetic field can be produced by an electric current. In 1831, a British Scientist Michael Faraday discovered that the reverse of this phenomenon is also possible. He observed that when a loop of wire was moved quickly between the two opposite poles of a magnet, an electric current was produced

The physicist and philosopher Hans Christian Oersted (1772-1851)

in it. This fascinating discovery changed this world into a magic world. Today, it is hard to imagine our lives without electricity.
This chapter discusses the ways to generate electricity from traditional fuels and some other sources of energy, the working of a power station and the problems involved in generating electricity.

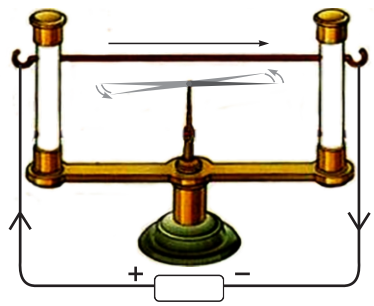


Figure 11.1: Compass needle near a wire, showing the effect discovered by Oersted

11.1 How Electricity is produced?

No fans, computers, refrigerators and other electrical appliances in our homes can be run without electricity. Electricity can be generated from many different sources by different methods. For example, dry cells and batteries produce electricity by chemical reactions of compounds.

Activity 11.1

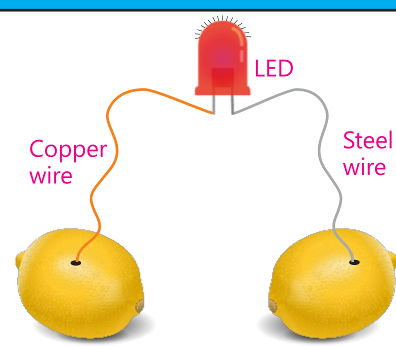
Material required

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.

Electricity can also be produced by some mechanical ways. Just as we can make magnets from electricity, we can also use magnets to produce electricity. We know that if a magnet is moved quickly through a coil of copper wire, electrons move in the wire and thus electricity is produced. Electricity can also be produced by rotating a coil between the opposite poles of a magnet (Figure 11.2). The mechanical system to produce electricity in this way is called electric generator or dynamo . Thus, due to relative motion between a coil and magnet, electric current starts to flow through the coil which can be connected to an external circuit. The current produced by electric generators is not unidirectional. Its direction changes again and again after an equal interval of time. Such a current is called alternating current (A.C). For the production of electricity of higher voltage, a generator should have:

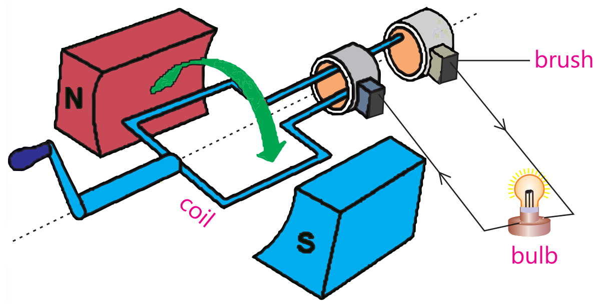
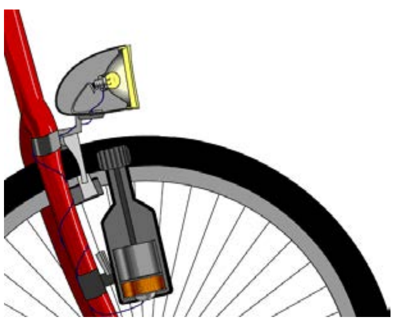


Figure 11.2: Working of a generator

- stronger magnets
- more turns in its coil
- quick relative motion between the magnet and coil

11.1.1 Bicycle Dynamo - a Small Generator

Your bicycle may have a dynamo to light up its lamp. The dynamo is a small portable generator which produces electricity from the energy of your body when you pedal a bicycle.



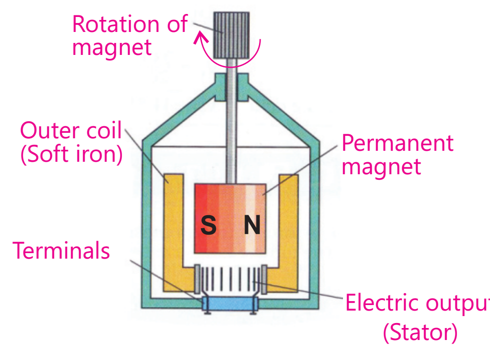


Figure 11.3: Working of a dynamo

Figure 11.3 shows a bicycle dynamo. The working principle of this small generator is the same as that of a big generator. In a dynamo the coil is held stationary while the magnet rotates inside the coil with the rotating wheel of the bicycle.

> **? Point to ponder**
>
> It is economical to have lights lit by dynamo and not by batteries. Can you tell its reason?

11.1.2 Power Plant Generators

The development of a country highly depends on the availability of the power resources. We need large amount of electricity for our domestic and commercial use. For these purposes, electricity is mostly generated in places called power stations.

In a power plant generator, the coils are kept stationary while magnet is rotated inside the coil. The stationary coil is called stator while the moving magnet is called rotor

(Figure 11.4). The running water of a stream or a river is used to run generator for producing electricity. Similarly, fuels like coal, oil or gas are also used to run generators. For example, in coal-fired electricity generation, the burning coal heats water in a boiler, producing steam. The steam pushes the blades of a turbine fixed at the lower end of the rotor shaft. As the rotor spins inside the stator, electric power is generated (Figure 11.5).

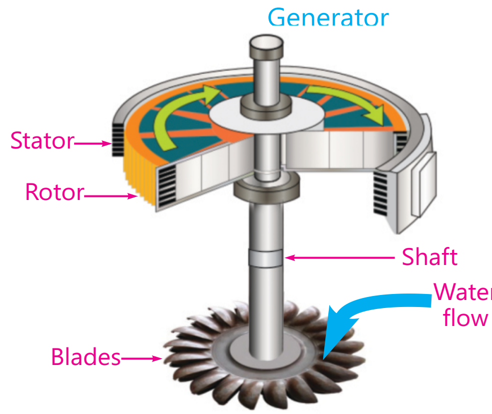


Figure 11.4: Turbine

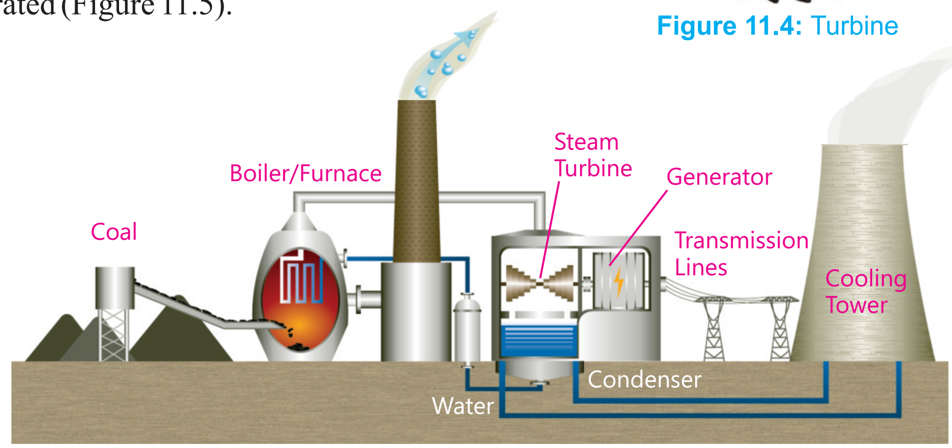


Figure 11.5: Generation of coal-fired electricity

In a hydro power station, water falls down from a high reservoir (lake) through the tunnels. The falling water turns the blades of a turbine fixed to the lower end of the rotor

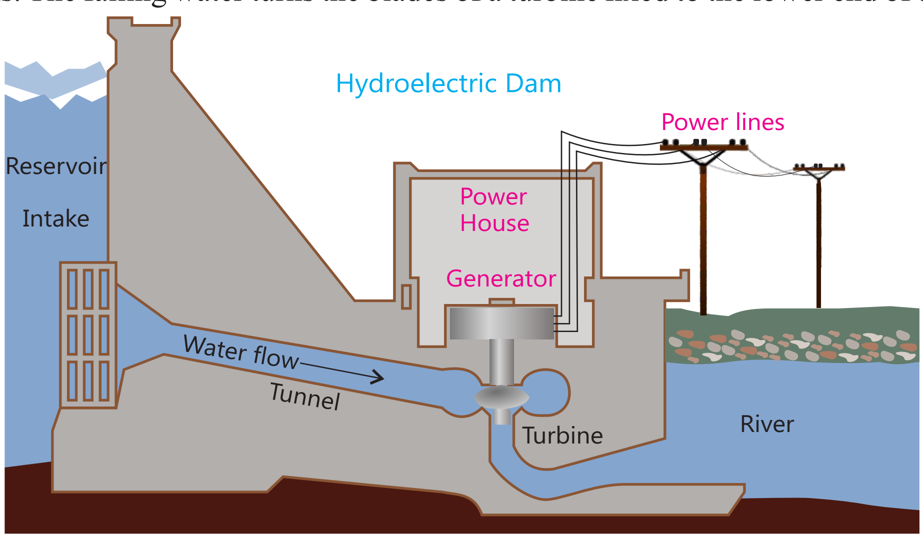


Figure 11.6: Hydro power generation

shaft. The rotating shaft turns the rotor, which generates electricity in the stator coils (Figure 11.6). The electricity is transmitted to various parts of the country through power transmission system. Hydro power generation is very economical and environmental friendly.

11.2 Energy Sources to Generate Electricity

Electricity is not only generated by mechanical generators but there are some other ways as well to generate electricity. But due to the continuous increase in prices of gas, oil and coal the cost of electricity is becoming unaffordable for people. Scientists are now searching the most cheaper ways to generate electricity. Sources used most often in the modern technology are solar, nuclear, wind and biomass energy to generate electricity.

1. Solar Energy

Solar energy is used through solar panels which are an inter-connected assembly of photo voltaic cells that produce electricity in the brighter sunlight (Figure 11.7). During daytime, this electricity can be used directly to run appliances. It can also be stored in batteries for use during night. Solar electricity is environmental friendly. The trend to generate electricity by solar penals is increasing day by day in Pakistan due to the increase in prices of traditional thermal electricity.

Figure 11.7: Solar panels

2. Wind energy

The kinetic energy of wind in coastal areas is used to turn huge blades mounted on high poles. The turning blades run the generator to produce electricity (Figure 11.8).

Figure 11.8: Wind power

3. Nuclear energy

When nuclei of heavy elements are broken by a special process called 'fission' a large amount of heat energy is released. This heat is used to make steam that rotates the turbine which runs the electric generator (Figure 11.9).

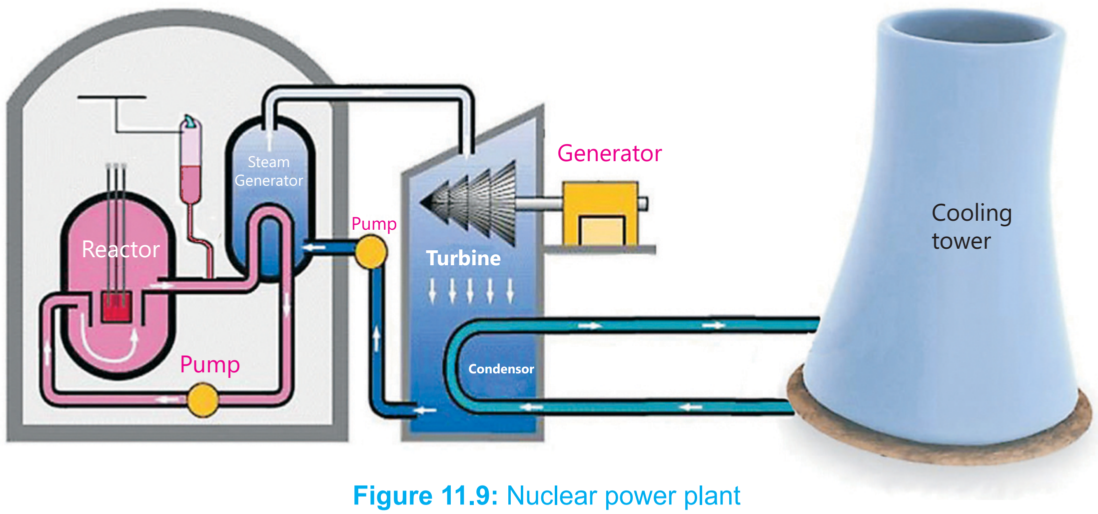


Figure 11.9: Nuclear power plant

11.3 Problems Involved in Generating Electricity

Various types of problems are involved in generating electricity. Some of these problems are described below:

1. Hydroelectric power is one of the commonly used methods of producing electricity. It is the cheapest way of getting electricity, but some problems are there in this method. For hydroelectric power generation dams are constructed. The water table in the nearby areas of a dam rises which causes water logging and land becomes uncultivable. In winter due to the shortage of water, electricity cannot be generated on large scale. Moreover, the population of area is shifted to some other places if a dam is to be constructed in that area.
2. Electricity production by thermal energy needs fossil fuels (oil, gas, coal). These are non-renewable energy sources. That is why are running short day by day and their prices are shooting up. Moreover, fossil fuels release smoke and other harmful gases in the atmosphere.
3. Many advanced countries use nuclear energy for production of electricity. Although it is not very expensive but sometimes it becomes very risky. The danger of harmful radiation leakage is always there. Another problem with this method is the proper disposal of waste material which is also highly radioactive.
4. Solar power is becoming very popular these days. Solar energy is renewable source of energy and is available to everyone free of cost. Production of electricity by using solar energy is safe and causes no pollution, but still has certain problems. The major problem is the high initial cost of solar panels and storage batteries.
5. Wind energy is also a renewable source of energy. It does not produce pollution.

The initial cost is very high. Moreover, wind farms cover large areas of expensive land and are very noisy.

11.4 Electronic Systems

We are living in an electronic age. Radio, television, computer, amplifiers, hi-fi sound system, worldwide communication systems, mobile phones, artificial satellites etc., are common electronic systems. They use electricity to perform their functions like processing input data and obtaining, altering, transmitting or storing information. All these functions are done by controlling the motion of electrons. The branch of physics that concerns with the behaviour and control of motion of electrons is called **electronics**. Electronic systems use short pulses of electric current to carry information in the form of signals. Later on, these signals can be changed into sounds, pictures or other information.

A well-known example of an electronic system is television. Without going through the details of internal working of its different parts, we can describe its functions by a block diagram as shown in Figure 11.10.

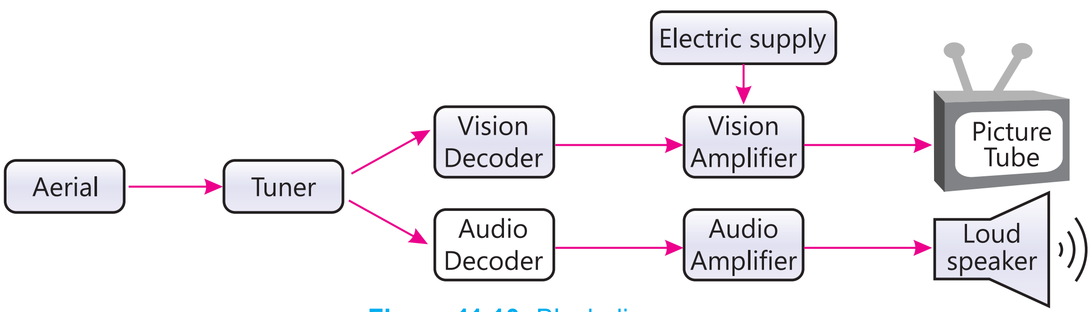


Figure 11.10: Block diagram

The following steps will explain how the system operates:

1. A camera converts picture and a microphone converts sound into electronical signals at the TV station.
2. These signals are mixed with carrier waves and are transmitted through transmitter antenna or cable.
3. Signals are received by TV in the form of a weak alternating current.
4. These signals are amplified by the amplifiers already installed in the TV.
5. The circuits inside the TV separate video and audio signals.
6. Video signals go to the picture tube that displays motion picture on the screen.
7. Audio signals go to the speaker that converts them back into sound.

11.4.1 Basic Components of an Electronic System

Resistors, semiconductor diodes, transistors, silicone chips and integrated circuits (ICs) are some basic components of an electronic system.

Semiconductors

Semiconductors are materials in which motion of electrons can be controlled. The most common semiconductor material is silicone. The devices made from semiconductor materials are widely used in electronic systems to amplify and process electronic signals. Two most common semiconductor devices are semiconductor diode and transistor.

Semiconductor Diodes

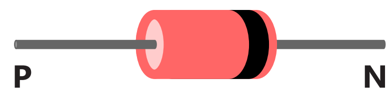


Figure 11.11: Semiconductor diode

Semiconductor diode is a device in which electric current can flow in one direction (Figure 11.11). A semiconductor diode has two terminals P and N. Current can flow from P to N but not in opposite direction. For this reason, semiconductor diodes are often used for converting alternating current into direct current.

Transistors

Figure 11.12: Transistors

A transistor is a semiconductor device with three terminals. Transistors are used as switches. Some types of transistors are shown in Figure 11.12.

Integrated Circuits

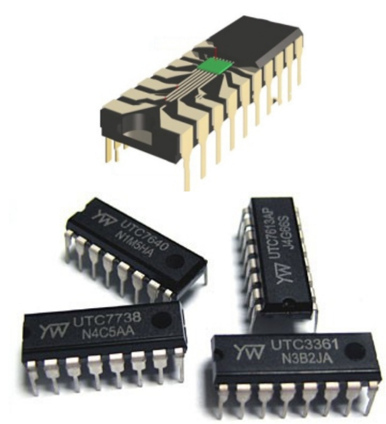


Figure 11.13: Integrated chips

Very tiny electronic circuits are called integrated circuits. These are commonly called as Ics (Figure 11.13). An integrated circuit consists of a tiny silicone chip with many components incorporated on it. In some ICs, about 1000 components are constructed on just a 3 mm square silicone chip. Before the advent of ICs, components in an electronic circuit were connected to one another by connecting wires that took too much space. ICs eliminated the need of such clumsy wiring.

11.5 Uses of Various Devices (Input, Processor, Output)

Electronic devices are mainly of three types.

(i) Input devices (ii) Processors (iii) Output devices

11.5.1 Input Devices

Any device that changes non-electronical energy into electrical energy in an electronic system is called an input device. A microphone is an input device. It converts sound into electrical signal. Similarly, an electronic camera also converts a picture to electrical signals. Both are input devices (Figure 11.14). Other examples of input devices are the 'keyboard' and 'mouse' which are used to enter information into a computer. Scanner is also an input device. These devices feed information, pictures and documents etc. to the computer in the form of electrical signals.

Microphone Camera Keyboard and mouse Scanner

Figure 11.14: Input devices

11.5.2 Processors

A processor is the main component in an electronic system that converts the 'input' into 'output'. Amplifier, tape recorder, television etc. are also common processors (Figure 11.15). The amplifier increases the energy of electrical signals of sound fed by the microphone and sends them to the loudspeaker. The television converts the electrical signals fed to it through antenna or cable, into picture and sound (Figure 11.16).

Figure 11.15: Processor

The microprocessor of a computer is a very good example of it. It controls different parts of the computer to display output result on the screen of monitor.

Amplifier

Television

Figure 11.16: Some common processors

11.5.3 Output Devices

An output device converts electrical energy into other forms of energy. For example, a loudspeaker converts electrical signals into sound, so it is an output device. The screen of a TV is also an output device. It converts electrical signals into a picture. The output devices of computer system are the monitor and printer (Figure 11.17).

11.17: Output devices

The output component of various devices are widely used in our schools and surrounding. Electrical appliances such as tape recorder, TV, computers, electric meters, and electric bells are commonly used in homes and schools. Loudspeakers are used in masajid, halls, cinemas and theaters. Robots are used in the factories for mega projects.

KEY POINTS

- When a magnet is moved quickly through a coil of copper wire, electrons move in the wire and electricity is produced. The mechanical system to produce electricity in this way is called generator.
- In power plant generators, the coils are kept stationary while magnet is turned inside the coil. The stationary coil is called stator while the moving magnet is called rotor.
- Because of modern technologies, new sources of energy to run power generators are now being used everyday instead of traditional sources.
- The branch of physics that concerns with the behaviour and control of motion of electrons is called electronics.
- Resistors, semiconductor diodes, transistors, silicone chips and integrated circuits (ICs) are some basic components of electronic system.
- Semiconductor diodes has the ability to control current mainly in one direction.
- A transistor is a semiconductor device with three terminals. Transistors are used as switches and amplifiers.
- Any device that changes non-electronical energy into electrical energy in an electronic system is called an input transducer or input device.
- An output device converts electrical energy into other forms of energy.

QUESTIONS

11.1 Encircle the correct option.

(i) Which power plant is almost free from environmental pollution problems?
a. Thermal power plant b. Nuclear power plant
c. Hydro power plant d. Solar power plant

(ii) Which is the cheapest source of energy to produce electricity?
a. Hydel b. Atomic c. Solar d. Thermal

(iii) Electronics is the branch of physics that concerns with the behaviour and control of motion of:
a. protons b. electrons c. neutrons d. atoms

(iv) Which of the following is an input device?
a. Mouse b. Monitor c. Printer d. Hard disc

(v) Which of the following is an output device?
a. Printer b. Mouse c. Scanner d. Hard disc

(vi) The component which converts A.C into D.C is called:
a. amplifier b. semiconductor diode
c. transformer d. semiconductor

(vii) Which of the following is a processor?
a. Mouse b. Tape recorder c. Keyboard d. Monitor

11.2 Give short answers.

(i) State the principle of power generator.
(ii) What are input devices? Give at least three examples.
(iii) What are output devices? Give at least three examples.
(iv) What is difference between A.C and D.C?
(v) Name some basic components of electronic system.
(vi) What is the function of a solar panel?

11.3 Sketch an electrical generator and its important parts.

11.4 Describe the working of power generator.

11.5 Discuss the problems involved in:

(i) Hydel power generation (ii) Thermal power generation
(iii) Solar power generation

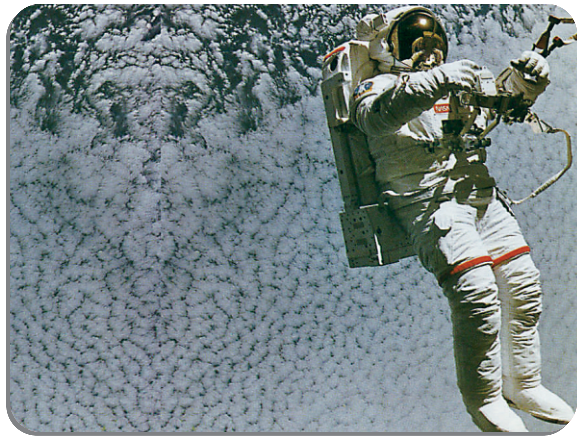
11.6 What is an electronic system? Draw the block diagram to show the functions of different stages of television.

Project

Using internet, library and other resources, write a time line of discovery of electricity.

Chapter 12

EXPLORING SPACE



STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Describe development of tools and technologies used in space exploration.
- ☑ Analyze the benefits generated by the technology of the space exploration.
- ☑ Explain how do astronauts survive and research in space?
- ☑ Suggest ways to solve the problems that have resulted from space exploration.
- ☑ Identify the technological tools used in space exploration.
- ☑ Identify new technologies used on the Earth that have developed as a result of the development of space technology.
- ☑ Design a spacecraft and explain the key features of design to show its suitability as a spacecraft.

Knowing about space is one of the top priorities of scientific development. Scientists have been using telescopes to look into the space to study the space objects since long. Now-a-days many more techniques and facilities are available for further research about space. Telescope, spectroscope, spacecraft, etc., are some of the latest technologies in this regard. In this chapter, we will study the technological tools used in space exploration and their benefits in everyday life.

12.1 Telescope, Spectroscope and Spacecraft

Telescope

The instrument which is used for observing distant objects is called telescope. Galileo was the first who invented and used telescope in 1610. The invention of telescope opened the gate way to scientific study of space and heavenly bodies in different ways. The modern telescopes are much bigger and equipped with latest accessories.

Types of Telescope

Optical telescopes are of two basic types, i.e., refracting telescope and reflecting telescope.

Refracting Telescope

A simple refracting telescope consists of a long tube fitted with two lenses one at each end of the tube. The lens which refracts the light coming from distant objects at a point (focus) is called **objective lens**. The lens through which the image formed by the objective lens is seen is called **eyepiece** (Figure 12.1).

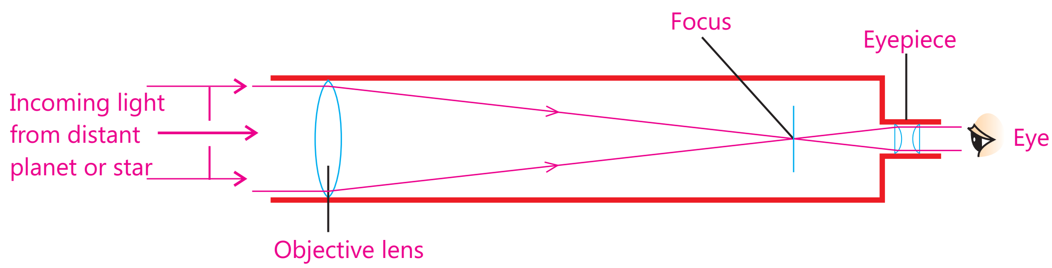


Figure 12.1: Working of Refracting Telescope

Reflecting Telescope

The main parts of a reflecting telescope are a large concave mirror, an eyepiece and a tube that holds them. The **objective mirror** which is a concave mirror reflects and converges the light on an eyepiece directly or through another reflecting mirror. The eyepiece magnifies the image formed by the objective mirror. Reflecting telescope can be made much larger than a refracting telescope, so that a better and bright image can be seen (Figure 12.2).

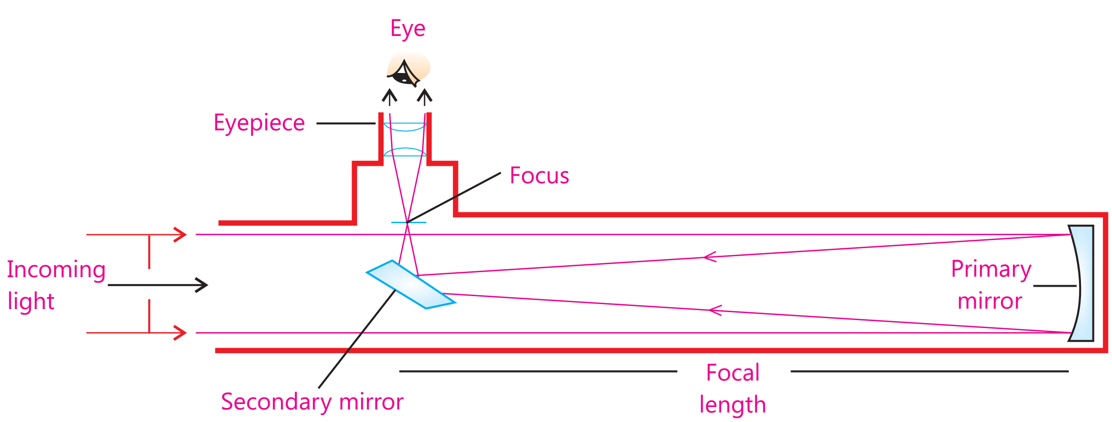


Figure 12.2: Working of reflecting telescope

Ground based telescopes have the disadvantage that dim light coming from stars passes through atmosphere, and the images so formed are not clear. In order to overcome this problem, telescopes have been sent into space.

Hubble space telescope is the first space-based reflecting telescope launched in 1990 (Figure 12.3). It orbits around the Earth at a height of 600 km and works round the clock. It has taken clear pictures of galaxies, billions of kilometres away.

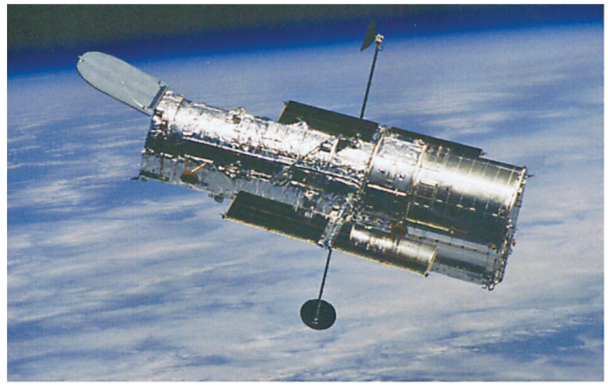
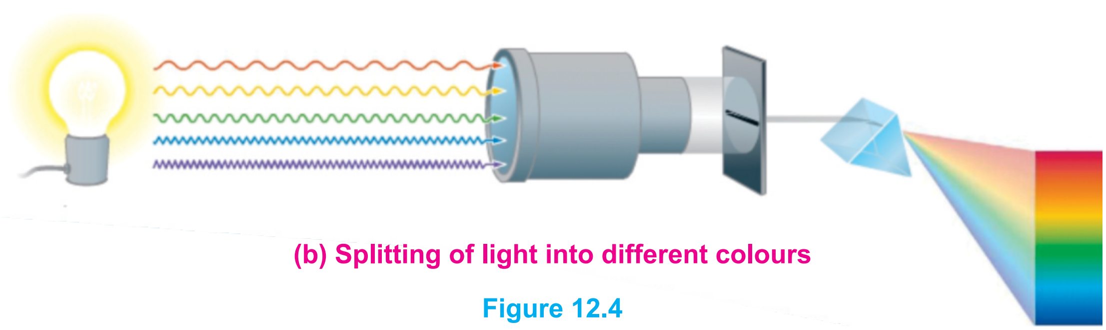


Figure 12.3: Hubble telescope

Spectroscopes

A spectroscope is an instrument which is used to examine different wavelengths (colours) of a light. It consists of a series of prisms that split white light into different colours. The set of different colours obtained in this way is called **spectrum**. Spectroscope also measures the wavelengths of different colours of the spectrum (Figure 12.4). The wavelengths of light coming from the stars help the scientists to know about the elements and compounds present in the stars. Spectroscopes are mostly attached with the telescopes.

(a) Spectroscope



(b) Splitting of light into different colours

Figure 12.4

Spacecraft

Spacecraft is a vehicle designed to travel in space (Figure 12.5). It is used for different purposes like communication, Earth's observation, meteorology, navigation, planetary exploration and transportation of humans and cargo in space.

There are two major classes of spacecraft; robotic space craft and manned spacecraft. Robotic spacecraft are sent into space for collection of data about space, planets and other heavenly bodies such as asteroids. A robotic spacecraft is controlled from the centre on Earth. Voyager I and voyager II were two robotic spacecrafts which were used for collecting data about planets Mars and Jupiter.

Figure 12.5: Spacecraft

Manned spacecrafts carry humans and equipments to space. These spacecrafts are larger and have specially built compartments which have the facilities necessary for human survival such as oxygen, pressurized cabins, food, water and specially built bathrooms. They also have special structure to protect from dangerous radiations which are very intense in space.

Space Stations

For very long stay in space or for performing experiments in space, large spacecraft called **space stations** are used (Figure 12.6). A space station is built in space by carrying its many small parts to space and then assembling them there. It has more facilities for prolonged living in space. It may have television for entertainment, bags for sleeping, exercise machine and kitchen for fresh food. One important part of a space station is the scientific laboratory where astronauts perform such experiments that cannot be done on Earth because of its gravity. Now-a-days a large space station orbits the Earth. Russians, Americans and other scientists jointly work in this space station. This is called international space station.

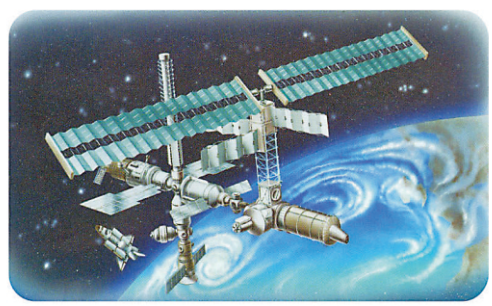


Figure 12.6: Space station

Space shuttle

It is an especially developed manned space craft which can be used many times. It is sent into space with the help of a rocket (Figure 12.7). It carries scientists and equipments. It docks with the space station to transfer its load. After performing its task, it returns and lands back on Earth like an aeroplane.

Figure 12.7: Space shuttle

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.

12.2.1 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:

Health and Medicine

Figure 12.8
High intensity LED unit

- In the field of health and medicines, space exploration has enabled man to develop medical devices such as WARP 10 and hand-held high intensity LED unit etc. These machines are used for getting relief in muscle, joint pains and arthritis (Figure 12.8).
- The infrared thermometer has been developed to measure the temperature of body without contact (Figure 12.9).

Figure 12.9
Infrared ear thermometer

- 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.

Global Navigation

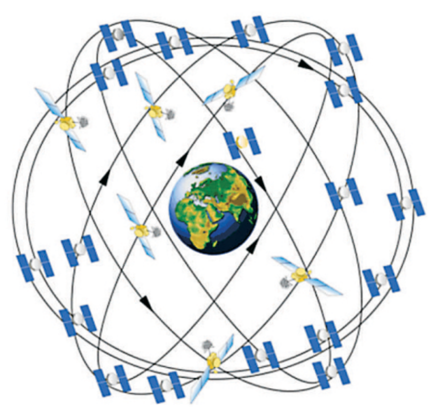


Figure 12.10
GPS satellites around the Earth

- 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 catch signals from the satellites moving around the globe.
- 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 boats or desert hikers also use the GPS in mobile phones to find their positions and get information about the surroundings.

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.

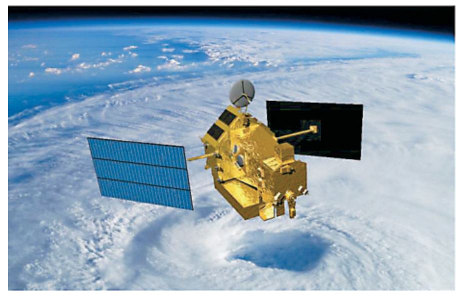


Figure 12.11: Weather satellite

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.

Locating Minerals, Fossil Fuels and Water Reserves

- 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.

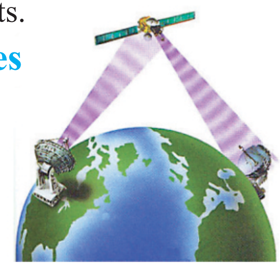


Figure 12.12: Locating ores and resources

12.2.2 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 at 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, they 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

12.2.3 Problems Created by Space Exploration and their Solutions

Space sickness, effects of weightlessness, conditions resulting from exposure to radiation and many unwanted side effects are the problems created during the stay in space. Pollution caused by burning of rocket fuel and disposal of rocket parts, etc. is one of the major problems created by space exploration.

1. Hazards for the space crew on missions are the main problems. Many deaths have resulted during the manned spaceflights. Space scientists and engineers need continuous work to improve safety in space missions.
2. Skylab fell from its orbit to Earth in 1979. This type of incidences could be dangerous for population.
3. Space programmes are very costly. These are causing economic burden on common man. Involvement of private sector in missions could be a possible solution.

12.2.4 Technological Tools Used in Space Exploration

A few of the tools which are used in space exploration programmes are mentioned as follows:

1. Space Rockets

Space rockets are the means of transporting spacecrafts, space shuttles and space stations into the space (Figure 12.14).

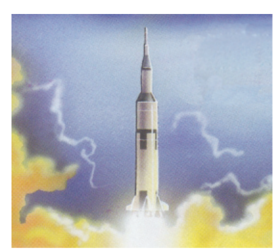


Figure 12.14: Space rocket

2. 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.

3. 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.

Figure 12.15
Rocket launching pad

4. 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.

12.2.5 New Technologies Developed on the Earth as a Result of Space Exploration

We have learnt in section 12.2.1 about the technologies and benefits of space exploration. In order to reiterate 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. In case of illness, astronauts have difficulty in swallowing medicine pills in space. Special medicines have been developed for use in space. These medicines, directly pass through the skin and enter the body of the patient. These medicines are now being manufactured for the patient on the Earth who finds it difficult to swallow the pills.
4. Special sensors and computers were developed for monitoring the physical

conditions of astronauts such as pulse rate, blood pressure, blood sugar, etc. Now-a-days the same technology is used to monitor patients present at in-accessible areas, with the help of satellite communications. A doctor in an advanced city hospital can check a patient who is far away in a remote village and suggest medicine for him. By this method doctor can even perform surgical operations on remote patients.

KEY POINTS

- Telescope is an instrument that helps to see heavenly objects clearly.
- Hubble telescope can produce clear images of astronomical objects which are very far from the Earth.
- There are two types of spacecrafts, robotic spacecraft and manned spacecraft.
- A spectroscope is an instrument which is used to examine different wavelengths (colours) present in a light radiation coming from stars.
- Geostationary satellites and Global Positioning System (GPS) help a television receiver, or a mobile phone to catch signals from the satellites moving around the globe.
- Knowledge gained from space exploration has enabled man to develop technologies to serve the humankind in the 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 Earth.

QUESTIONS

12.1. Encircle the correct option.

(i) An instrument that helps for seeing heavenly objects:

a. microscope b. telescope c. spectroscope d. kaleidoscope

(ii) Telescopes on the Earth suffer from the fact that the light coming from the stars has to pass through:

a. space b. water c. air d. sea

(iii) A vehicle, designed to carry satellite in outer space is:

a. rocket b. air bus c. air jet d. spacecraft

(iv) Spectroscope is an instrument used to examine the wavelengths of:

a. light waves b. water waves

c. air waves d. sound waves

(v) Physical exploration of space is conducted both by human spaceflights and:

a. telescope b. robotic spacecraft

b. rocket d. spectroscope

12.2 Give short answers.

(i) How does reflecting telescope differ from refracting telescope?

(ii) What are rockets?

(iii) What is the advantage of putting a telescope in space?

(iv) What is remote sensing?

(v) For what GPS stands for?

12.3 Describe the benefits generated by technology of space exploration.

12.4 Explain how do astronauts survive and work in space.

12.5 Describe the technological tools used in space exploration.

12.6 Describe four problems created from space exploration and their solutions.

12.7 Write short notes on the following:

(i) Hubble Space Telescope (ii) Space Probes (iii) Space Stations

Critical Thinking

Extended Activity

Sketch the design of a spacecraft and describe its key features for its suitability as a spacecraft.

GLOSSARY

Acid:	A compound which produces hydrogen ions in its aqueous solution.
Acid rain:	The rain which is unusually acidic.
Addition reaction:	A chemical change in which simpler substances are combined to form a single compound.
Aerosol:	A substance packed under pressure with a device to release it as fine spray.
Alkali:	A compound which produces hydroxide ions in its aqueous solution.
Bimetallic strip:	Two metallic strips joined together that bends on heating.
Biotechnology:	A technology which uses living things for human welfare.
Chemical equation:	Representation of a chemical reaction in the form of symbols and formulae.
Chemical reaction:	A change in which new substances are formed.
Concave lens:	A lens which is thinner in the middle and thicker at the edges.
Convex lens:	A lens which is thicker in the middle and thinner at the edges.
Decomposition reaction:	A chemical change in which a compound is broken down into simpler substances.
Deforestation:	Cutting of forests.
Dialysis:	Cleaning of blood by artificial methods.
Diode:	Electronic device that changes AC to DC.
Effector:	A body part which receives message from brain or spinal cord and produces response.
Endothermic reaction:	A chemical change during which heat is absorbed.
Exothermic reaction:	A chemical change during which heat is evolved.
Fertilization:	Fusion of a sperm with an egg.
Focal length:	The distance between the optical centre and principal focus of a lens.
Gene:	Basic unit of heredity.
Genetic modification:	Removal, addition or repair of genetic material.
Global warming:	An increase in average temperature of the Earth.
Glomerulus:	Tuft of blood capillaries in the renal corpuscles of the nephron in kidney.
Heredity:	Transmission of characters from parents to offspring.
Hydraulic system:	Transmission system for using pressurized liquid to drive hydraulic machinery.
Indicator:	Organic compound which gets specific colour on dissolving in an acidic or alkaline medium.
Input devices:	The devices used to enter data into an electronic system.
Lens:	A solid piece of glass or other transparent materials like plastic whose one or both sides are curved.
Long-sightedness:	Defect of vision in which one can see distant objects clearly but not the nearby objects.

Meiosis:	Nuclear division during which the number of chromosomes in the daughter nuclei reduces to half as compared to that in the parent cell nucleus.
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 CNS to effectors.
Neuron:	Basic structural and functional unit of nervous system.
Neutralization:	Chemical reaction of an acid with an alkali to form salt and water.
Optical centre:	Centre of a lens.
Output devices:	Devices that transform the current or voltage signal into useful physical form.
Ozone depletion:	Decrease in the concentration of ozone in the atmosphere due to certain pollutant gases.
pH:	Negative logarithm of hydrogen ion concentration.
Pneumatics:	Branch of science which deals with the study and application of pressurized gas to produce mechanical work.
Pressure:	Force per unit area.
Receptor:	Body organ, tissue or cell that detects stimuli.
Recycling:	Collection and reuse of waste materials.
Reflex action:	An immediate and involuntary response to the stimulus.
Resistor:	An electrical component which resists or tries to limit the flow of electric current in an electric circuit.
Riveting:	Joining two metal plates with the help of a rivet.
Rocket:	A mean of transporting into the space.
Salt:	A compound formed by the reaction of an acid with an alkali.
Second:	SI unit of time.
Sensory Neurons:	Neurons that carry nerve impulses from receptors to CNS.
SI Units:	An internationally recognized system of units for measuring physical quantities.
Short-sightedness:	Defect of vision in which one can see nearby objects clearly but not the distant objects.
Space exploration:	Exploration of nature outside Earth.
Spacecraft:	A vehicle designed to travel in outer space.
Spectroscope:	An instrument which is used to measures the property of light (wavelength).
Stimulus:	Environmental change that provokes a response in the body.
Telescope:	An instrument used to see far objects.
Thermal Expansion:	Increase in size of an object on heating.
Thermostat:	A device which controls the temperature of an electrical appliance.
Transgenic bacteria:	Bacteria with foreign genes.
Virtual Image:	Image that cannot be obtained on the screen.
Volume:	Space occupied by something.

INDEX