ABOUT THE AUTHORS

LAKHMIR SINGH did his M.Sc. from Delhi University in 1969. Since then he has been teaching in Dyal Singh College of Delhi University, Delhi. He started writing books in 1980. Lakhmir Singh believes that book writing is just like classroom teaching. Though a book can never replace a teacher but it should make the student feel the presence of a teacher. Keeping this in view, he writes books in such a style that students never get bored reading his books. Lakhmir Singh has written more than 15 books so far on all the science subjects: Physics, Chemistry and Biology. He believes in writing quality books. He does not believe in quantity.

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It is the team-work of Lakhmir Singh and Manjit Kaur which has given some of the most popular books in the history of science education in India. Lakhmir Singh and Manjit Kaur both write exclusively for the most reputed, respected and largest publishing house of India : S. Chand and Company Pvt. Ltd.

An Open Letter

Dear Friend,

We would like to talk to you for a few minutes, just to give you an idea of some of the special features of this book. Before we go further, let us tell you that this book conforms to the NCERT guidelines prescribed by the Central Board of Secondary Education (CBSE). Just like our earlier books, we have written this book in such a simple style that even the weak students will be able to understand science very easily. Believe us, while writing this book, we have considered ourselves to be the students of the concerned class and tried to make things as simple as possible.

The most important feature of this book is that we have included a large variety of different types of questions for assessing the learning abilities of the students. This book contains:

(i) Objective type questions,
(ii) Subjective type questions,
(iii) Multiple Choice Questions (MCQs),
(iv) Questions based on High Order Thinking Skills (HOTS), and
(v) Activities.

Please note that answers have also been given for the various types of questions, wherever required. All these features will make this book even more useful to the students as well as the teachers. “A picture can say a thousand words”. Keeping this in mind, a large number of coloured pictures and sketches of various scientific processes, procedures, appliances, manufacturing plants and everyday situations involving principles of science have been given in this book. This will help the students to understand the various concepts of science clearly. It will also tell them how science is applied in the real situations in homes, transport and industry.

We are sure you will agree with us that the facts and formulae of science are just the same in all the books, the difference lies in the method of presenting these facts to the students. In this book, the various topics
of science have been explained in such a simple way that while reading this book, a student will feel as if a teacher is sitting by his side and explaining the various things to him. We are sure that after reading this book, the students will develop a special interest in science and they would like to study science in higher classes as well.

We think that the real judges of a book are the teachers concerned and the students for whom it is meant. So, we request our teacher friends as well as the students to point out our mistakes, if any, and send their comments and suggestions for the further improvement of this book.

Wishing you a great success,

Yours sincerely,

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Books by Lakhmir Singh and Manjit Kaur

1. Lakhmir Singh’s Science for Class 3
2. Lakhmir Singh’s Science for Class 4
3. Lakhmir Singh’s Science for Class 5
4. Lakhmir Singh’s Science for Class 6
5. Lakhmir Singh’s Science for Class 7
6. Lakhmir Singh’s Science for Class 8
7. Science for Ninth Class (Part 1) PHYSICS
8. Science for Ninth Class (Part 2) CHEMISTRY
9. Science for Tenth Class (Part 1) PHYSICS
10. Science for Tenth Class (Part 2) CHEMISTRY
11. Science for Tenth Class (Part 3) BIOLOGY
12. Rapid Revision in Science (A Question-Answer Book for Class X)
15. Science for Ninth Class (Hindi Edition) : PHYSICS and CHEMISTRY
17. Saral Vigyan (A Question-Answer Science Book in Hindi for Class X)

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1. NUTRITION IN PLANTS
   Modes of Nutrition: Autotrophs and Heterotrophs; Photosynthesis; Conditions Necessary for Photosynthesis; How to Test the Presence of Starch in Leaves; Leaves of Various Colours; Importance of Photosynthesis; Other Modes of Nutrition in Plants: Parasites and Saprophytes; Insectivorous Plants and Symbiotic Plants; How Nutrients are Replenished in the Soil; Cells

2. NUTRITION IN ANIMALS
   Animals Take in Food by Different Methods; Human Digestive System; To Study the Effect of Saliva on Starch Present in Food; Teeth: Milk Teeth and Permanent Teeth; Tooth Decay; Tongue and its Functions; Diarrhoea; Some Animals Eat Grass as Food: Ruminants; Digestion in Grass Eating Animals; Amoeba: Feeding and Digestion

3. FIBRE TO FABRIC
   Animal Fibres: Wool and Silk; Animals That Yield Wool: Sheep, Goat, Yak, Camel, Llama and Alpaca; Some Indian Breeds of Sheep; Production of Wool; Occupational Hazard: Sorter’s Disease; Silk From Silkworms; Life History of Silk Moth; Production of Silk; Different Varieties of Silk; Natural Silk and Artificial Silk; Discovery of Silk

4. HEAT
   Hot and Cold; Temperature; Measuring Temperature: Laboratory Thermometer, Clinical Thermometer, Digital Thermometer, and Maximum-and-Minimum Thermometer; Transfer of Heat; Conduction: Good and Poor Conductors of Heat; Why do We Wear Woollen Clothes in Winter; Convection in Water and Air; Sea-Breeze and Land-Breeze; Radiation; Absorbers and Emitters of Heat Radiations
5. **ACIDS, BASES AND SALTS**

Indicators for Testing Acids and Bases: Litmus, China Rose, Turmeric and Phenolphthalein; Acids: Organic Acids and Mineral Acids; Strong Acids and Weak Acids; Acid Rain and its Effects; Bases: Strong Bases and Weak Bases; Neutral Substances; Neutralisation; Neutralisation in Everyday Life; Salts: Neutral Salts, Acidic Salts and Basic Salts

6. **PHYSICAL AND CHEMICAL CHANGES**

Types of Changes: Physical Changes and Chemical Changes; Differences Between Physical Changes and Chemical Changes; Importance of Chemical Changes: A Protective Shield of Ozone; Rusting of Iron; Conditions Necessary for Rusting; Rusting Damages Iron Objects; How do We Prevent Rusting of Iron; The Case of Ships; Iron Pillar at Delhi; Crystallisation

7. **WEATHER, CLIMATE AND ADAPTATIONS OF ANIMALS TO CLIMATE**

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8. **WINDS, STORMS AND CYCLONES**

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9. **SOIL**

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12. REPRODUCTION IN PLANTS
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13. MOTION AND TIME
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14. ELECTRIC CURRENT AND ITS EFFECTS
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15. **LIGHT**
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16. **WATER: A PRECIOUS RESOURCE**
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18. **WASTEWATER STORY**
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Nutrition in Plants

All the living organisms (plants and animals) require food. The organisms need to take food (i) to obtain energy (ii) to obtain materials for growth, and (iii) to obtain materials for the repair of damaged parts of the body. The process of taking food by an organism as well as the utilisation of this food by the organism is called nutrition. Plants can make their own food but animals (including human beings) cannot make food themselves. They obtain food from plants or other animals that eat plants. Thus, human beings and animals depend on plants for their food, directly or indirectly. We will now discuss the various modes of nutrition in organisms.

MODES OF NUTRITION

The methods of obtaining food are called modes of nutrition. On the basis of their modes of nutrition, all the organisms can be divided into two main groups:

1. Autotrophs (or Autotrophic), and
2. Heterotrophs (or Heterotrophic).

We will now describe both these modes of nutrition of organisms in detail, one by one.

**Autotrophs : Autotrophic Mode of Nutrition**

Those organisms which can make food themselves from simple substances (like carbon dioxide and water) by the process of photosynthesis, are called autotrophs (and their mode of nutrition is called autotrophic). All the green plants are autotrophs. This is because green plants can make their own food from simple substances like carbon dioxide and water present in their surroundings by the process of photosynthesis. In other words, green plants have autotrophic mode of nutrition. For example, wheat plants are autotrophs (having autotrophic mode of nutrition). Autotrophs contain a green pigment called chlorophyll which helps them make food by absorbing energy from sunlight. Most of the plants are green
and hence synthesise (make) their own food (see Figure 1). This means that most of the plants have autotrophic mode of nutrition. The green plants produce food not only for themselves, they also make food for non-green plants as well as for animals (including human beings).

Our body (and that of other animals) cannot make food from carbon dioxide and water present around us by the process of photosynthesis (like the plants do) because our body does not have the green pigment called chlorophyll (which the plants have). The green pigment chlorophyll is necessary to absorb energy from sunlight required for making food by photosynthesis.

**Heterotrophs : Heterotrophic Mode of Nutrition**

Those organisms which cannot make food themselves by the process of photosynthesis and take food from green plants or animals, are called heterotrophs (and their mode of nutrition is called heterotrophic). All the non-green plants and animals (including human beings) are heterotrophs. The non-green plants do not have chlorophyll for carrying out the process of food making called photosynthesis. So, they depend on other organisms (plants or animals) for obtaining their food. The non-green plants called fungi (such as mushroom, yeast and bread mould) are heterotrophs. They have heterotrophic mode of nutrition. Certain bacteria are also heterotrophs. All the animals (including human beings) are categorised as heterotrophs because they cannot make their own food, they depend on plants or other animals for obtaining their food. Thus, all the animals like cat, dog, goat, cow, buffalo, deer, lion, tiger and human beings are heterotrophs having heterotrophic mode of nutrition (see Figure 2).

**PHOTOSYNTHESIS : FOOD MAKING PROCESS IN PLANTS**

Green plants are autotrophic and synthesise (or make) their own food by the process of photosynthesis. The green plants make their food from simple inorganic substances like carbon dioxide and water in the presence of sunlight. The plants use the energy in sunlight to prepare food in the presence of a green colouring matter called ‘chlorophyll’ present in the leaves of a green plant. We can now define photosynthesis as follows:

The process by which green plants make their own food (like glucose) from carbon dioxide and water by using sunlight energy (in the presence of chlorophyll) is called photosynthesis. The process of photosynthesis can be represented by a word equation as follows:

\[
\text{Carbon dioxide} + \text{Water} \xrightarrow{\text{Sunlight}} \text{Glucose} + \text{Oxygen}
\]

\[
\begin{array}{c}
\text{(From air)} & \text{(From soil)} & \text{(A carbohydrate)} & \text{(Goes into air)} \\
\text{(Food)} & \text{} & \text{} & \text{}
\end{array}
\]

Chlorophyll is present in the green leaves. So, the process of photosynthesis takes place in the leaves of a plant. **Oxygen gas is produced during photosynthesis.** This oxygen goes into the air. The oxygen gas released in photosynthesis is utilised by all the living organisms for their survival. The process of photosynthesis can be shown with the help of a diagram given in Figure 3.
The process of photosynthesis first produces a simple carbohydrate called ‘glucose’ as food. The glucose carbohydrate then gets converted into a complex carbohydrate called ‘starch’. This starch gets stored as food in the various parts of plant including leaves. In fact, the presence of starch in the leaves shows the occurrence of photosynthesis in a plant. Some of the glucose is also converted into other types of plant foods such as fats and oils, proteins as well as vitamins. The synthesis of food (or making of food) occurs in the leaves of a plant (or tree). So, leaves are the food factories of a plant. The leaves of a plant can synthesise food because they contain a green pigment chlorophyll (which is necessary for making food). Other parts of a plant usually cannot synthesise food because they do not contain chlorophyll.

**Conditions Necessary for Photosynthesis**

The presence of carbon dioxide, water, chlorophyll and sunlight is necessary for the process of photosynthesis to take place. Photosynthesis cannot occur in the absence of any one of these conditions. We will now describe how the leaves of a plant get carbon dioxide and water required for making food by photosynthesis and what are the roles of chlorophyll and sunlight in photosynthesis.

1. **How the Plants Obtain Carbon Dioxide for Photosynthesis.** The plants take carbon dioxide gas needed for photosynthesis from the air. The plants take carbon dioxide gas from air through the tiny pores (called stomata) present on the surface of leaves (The singular of stomata is stoma). Actually, there are a large number of tiny pores called stomata on the the surface of leaves of plants (see Figure 4). Each pore (or stoma) is surrounded by a pair of guard cells. The opening and closing of stomatal pores in the leaves is controlled by the guard cells. Figure 4(a) shows open stomatal pores whereas Figure 4(b) shows the stomatal pores in closed position. The carbon dioxide gas present in air enters the leaves of a plant through the stomatal pores present on their surface and utilised in photosynthesis. The oxygen gas produced in the leaves during photosynthesis goes out into air through the same stomatal pores. The stomatal pores of leaves open only when carbon dioxide is to be taken in or oxygen is to be released otherwise they remain closed.
2. How the Plants Obtain Water for Photosynthesis. The plants take water needed for photosynthesis from the soil. Soil always contains some water in it. Water present in the soil is absorbed by the roots of a plant and then transported to the leaves through the vessels which run like inter-connected pipes throughout the roots, stem, branches and leaves. The tiny, pipe-like vessels which transport water from the roots of a plant to its leaves are called xylem.

The plants also need minerals to make foods other than carbohydrates. For example, plants need nitrogen mineral to make proteins. The minerals are present in the soil (and have to be transported to the leaves). The minerals dissolve in water present in the soil and get transported with it. So, we can now say that: Water and minerals present in the soil are absorbed by the roots of a plant and transported to its leaves through the inter-connected pipe-like xylem vessels present throughout the roots, stem, branches and leaves of the plant.

3. The Role of Chlorophyll in Photosynthesis. Chlorophyll is a green substance which is present in the leaves of plants. In fact, it is the presence of chlorophyll which makes the leaves look green. Chlorophyll can absorb the energy from sunlight. The sunlight energy absorbed by chlorophyll is used to combine carbon dioxide and water in the green leaves to produce food (like glucose). We can now write the role of chlorophyll in photosynthesis as follows: **Chlorophyll absorbs light energy from the sun and supplies this energy to the leaves to enable them to carry out photosynthesis for making food.** Since the combination of carbon dioxide and water to make food (like glucose) occurs in the presence of sunlight, the process is called photosynthesis (Photo = light, and synthesis = to combine). Please note that chlorophyll is present in every leaf of a plant in the form of hundreds of tiny structures called chloroplasts (see Figure 5).

4. The Role of Sunlight in Photosynthesis. The sunlight supplies energy for the food making process called photosynthesis. The sun’s energy (or solar energy) is captured by plant leaves with the help of chlorophyll and converted into chemical energy of food. Thus, solar energy is converted into chemical energy during photosynthesis. This chemical energy gets stored in the form of plant food. So, when plants (or animals) utilise the food made by photosynthesis, they actually use the solar energy stored in it in the form of chemical energy. **Since all the food on this earth is made by utilising solar energy, therefore, sun is the ultimate source of energy for all the living organisms.**
**ACTIVITY TO TEST THE PRESENCE OF STARCH IN LEAVES**

Leaves make starch as food by photosynthesis. The presence of starch in leaves can be tested as follows:

(i) Pluck a green leaf from a plant.
(ii) Boil the leaf in alcohol to remove the green pigment chlorophyll from it.
(iii) Wash the decolourised leaf with water to remove any chlorophyll sticking to it.
(iv) Pour dilute iodine solution from a dropper over the decolourised leaf.
(v) Appearance of blue-black colour in leaf shows the presence of starch in it.

**Leaves of Various Colours**

Most of the plants have green coloured leaves. Some of the plants, however, have leaves of other colours such as red, violet, brown, etc. (see Figure 6). The leaves having colours other than green also have chlorophyll in them. Actually, the large amount of red, violet, brown or other pigments in such leaves masks the green colour of chlorophyll. So, photosynthesis also takes place in leaves having colour other than green.

**Photosynthesis by Plant Parts Other Than Leaves**

Normally photosynthesis takes place only in the leaves of plants. In some plants, however, photosynthesis also takes place in other parts of plants such as “green stems” and “green branches”. The green stems and green branches can do photosynthesis because they contain chlorophyll. For example, the desert plants such as cactus have tiny, spine-like leaves to reduce the loss of water by transpiration. These tiny, spine-like leaves of a cactus plant cannot do photosynthesis. The stem and branches of a cactus plant are green which contain chlorophyll (see Figure 7). So, the green stem and green branches of a cactus plant carry out the process of photosynthesis to make food for the plant. Please note that only those stems and branches which are green in colour can do photosynthesis. Now, the stems and branches of all the plants and trees are not green. So, the stems and branches of all the plants and trees cannot do photosynthesis.
Photosynthesis by Algae

Many times we have seen patches of slimy, green layer floating on the surface of a pond or lake, or even in the stagnant parts of a river (see Figure 8). It also develops in the swimming pools which have not been cleaned for a long time. This green layer is formed by the growth of tiny green plant-like organisms called algae (Algae is pronounced as algee. The singular of algae is alga). It is called *shaival* in Hindi. **Algae are a large group of simple, plant-like organisms.** Algae contain chlorophyll and produce food by photosynthesis just like plants. **Algae, however, differ from plants because they do not have proper roots, stems and leaves.** The green colour of algae is due to the presence of chlorophyll in them.

Synthesis of Plant Foods Other Than Simple Carbohydrate (Glucose)

The simplest food synthesised by the plants by photosynthesis is a simple carbohydrate called ‘glucose’. The glucose carbohydrate is made up of three elements: carbon, hydrogen and oxygen. The plants use the simple carbohydrate glucose to make many other foods such as starch, oils (or fats), proteins and vitamins. This is discussed below.

**(i) Plants Make Starch as Food.** Some of the simple carbohydrate ‘glucose’ made by the plants through photosynthesis is converted naturally into a complex carbohydrate called ‘starch’. The starch is a food which is stored in various parts of a plant such as roots, stem, leaves and seeds. For example, the seeds (or grains) of wheat and rice have a lot of starch in them. Potato and carrot plants store a lot of starch in their roots.

**(ii) Plants Make Oils (or Fats) as Food.** Certain plants convert the simple carbohydrate glucose made during photosynthesis into oils and store them in their seeds. Such seeds are called oil-seeds and give us oil (or fats) for cooking food. For example, the seeds of sunflower plant contain a lot of oil stored in them. We can extract oil from sunflower seeds and use it as a food. The oils obtained from plant seeds are commonly known as vegetable oils. Please note that just like carbohydrates glucose and starch, oils (and fats) are also made up of the same three elements: carbon, hydrogen and oxygen.

**(iii) Plants Make Proteins as Food.** In addition to carbon, hydrogen and oxygen, proteins also contain nitrogen element. Plants combine some of the glucose carbohydrate made during photosynthesis with nitrate minerals (obtained from soil) to make amino acids which are then made into proteins. In this way, plants make proteins as food.

Proteins are nitrogenous substances which contain nitrogen element. We will now discuss from where do the plants obtain nitrogen for making proteins. This happens as follows: Nitrogen element is present in abundance in air in the form of nitrogen gas. However, the plants cannot absorb nitrogen gas for their needs (like making proteins). Now, the soil has certain bacteria which convert nitrogen gas of air into nitrogen compounds (like nitrates) and release them into soil. Nitrates are the water soluble nitrogen compounds which are absorbed by the plants from the soil along with water. In this way, the plants fulfil their requirement of nitrogen. The plants also obtain nitrogen from the nitrogenous fertilisers which the farmers add to the soil in the fields from time to time.

**(iv) Plants Make Vitamins as Food.** Vitamins are highly complex substances which are an important part of our food. Vitamins are made by plants. Vitamins are contained in vegetables, fruits and cereals made by plants. Animals usually cannot make vitamins.
Importance of Photosynthesis

Photosynthesis is important for the existence of life on this earth. In the absence of photosynthesis, life would be impossible on this earth. This is due to the following reasons:

(i) **Photosynthesis by plants provides food to animals (including human beings).** So, the survival of animals (including human beings) depends on the food made by plants by photosynthesis. In the absence of photosynthesis, there would be no plants on this earth and hence no animals will survive.

(ii) **The process of photosynthesis by plants puts oxygen gas into the air.** It is this oxygen gas which the animals (including human beings) use for breathing and respiration. In the absence of photosynthesis, there would be no oxygen in air and hence no animals could exist on this earth.

OTHER MODES OF NUTRITION IN PLANTS

Most of the plants have green pigment called chlorophyll and can make their own food. They are called autotrophic. Some plants, however, do not contain chlorophyll and hence cannot synthesise their food. They are called heterotrophic and depend for food on other organisms. Depending on their mode of obtaining food, all the heterotrophic plants can be divided into two main groups:

(i) Parasites, and
(ii) Saprophytes.

Thus, just like animals, some plants have also heterotrophic modes of nutrition. We will now discuss the two types of plants called parasites and saprophytes which have heterotrophic mode of nutrition.

Parasites

A plant (or animal) which lives on or inside another organism (called host) and derives the food from it, is called a parasite. Those non-green plants which obtain their food from the living bodies of other plants (or animals) are called plant parasites (or just parasites). The living organism (from whose body food is obtained) is called ’host’ of the parasite. The parasite plants climb on the host plants from which they get all the food. A parasite plant produces certain special type of roots (called sucking roots) which penetrate into the host plant. The parasite sucks the food materials from the host through these special roots.

An example of parasite plant is *Cuscuta*. It is called *Amarbel* in Hindi. *Cuscuta* plant does not have chlorophyll (so it is not green in colour). We can see *Cuscuta* plant as a yellow, tubular structure twining around the stem and branches of a tree (see Figure 9). The tree on which *Cuscuta* plant climbs is called its host. *Cuscuta* is a non-green plant having a yellow colour. Since *Cuscuta* plant does not have the green pigment called chlorophyll, it cannot synthesise its own food. *Cuscuta* plant takes readymade food from the tree (or plant) on which it climbs. Since *Cuscuta* plant deprives the host tree of valuable nutrients, it is called a parasite. We find that *Cuscuta* plant depends on other plants for obtaining food, therefore, *Cuscuta* plant has heterotrophic mode of nutrition. Please note that another name of *Cuscuta* is Dodder. In addition to *Cuscuta*, some other examples of plant parasites are: Mistletoe, Wheat rust and Corn smut.

In the above discussion, at many places we have used the term ‘plant parasite’ instead of just ‘parasite’. This is because many animals also live as parasites. For example, the animals such as lice, bed-bugs, leeches and mosquitoes (which suck our blood) are also parasites.

Saprophytes

Those non-green plants which obtain their food (or nutrition) from dead and decaying organic
mature are called saprophytes (Dead and decaying organic matter means dead and decaying plants and animal remains). The non-green plants called fungi (read as: funjaee) derive their food from dead and decaying organic matter, so fungi are saprophytes. Some of the common fungi are mushrooms, bread mould and yeast, so we can also say that the fungi such as mushrooms, bread mould and yeast are saprophytes. In other words, the fungi such as mushrooms, bread mould and yeast have saprophytic mode of nutrition (which is a heterotrophic mode of nutrition). Certain bacteria are also saprophytes. They are called saprophytic bacteria.

Many times we see small, fluffy, umbrella-like plants growing on rotting wood during the rainy season (see Figure 10). These are a kind of fungus called mushrooms (Fungus is the singular of fungi). They take their nutrition from the rotting wood of a dead tree, so they are saprophytes. The saprophytic plants (like fungi) do not have chlorophyll and hence they cannot make their own food by photosynthesis. The non-green saprophytic plants (such as fungi) obtain their food as follows: The saprophytic plants (fungi) secrete digestive juices on the dead and decaying organic matter and convert it into a solution. They absorb the nutrients from this solution. This mode of nutrition in which plants take in nutrients from dead and decaying organic matter is called saprophytic nutrition. The plants which use saprophytic mode of nutrition are saprotrophs.

**ACTIVITY TO GROW FUNGUS ON BREAD**

We can grow fungus on bread ourselves as follows: Take a slice of bread and moisten it with water. Keep it in a moist and warm place for 2 or 3 days. We will find that some fluffy patches appear on the surface of the slice of bread (see Figure 11). These patches are of fungus plants. The patches of fungus may be white, green, brown, black or any other colour. If we look at this slice of bread through a magnifying glass, the fungus plants growing on its surface will appear to be cotton-like threads spread on the slice of bread. We will now describe how the fungus grows on the slice of bread. The tiny spores of fungus plants are always present in air (but we cannot see them with naked eyes). When these tiny spores land on wet objects under warm conditions, they germinate and grow into new fungus plants. It was one such air-borne spore which settled and grew on the moist slice of bread kept aside by us at a warm place for a few days. Please note that the spores are a kind of seeds of fungus plants.

Fungi also grow on pickles, leather objects, clothes and other articles which are left uncleaned in hot and humid weather for a considerable time. The growth of fungi may spoil many things during the rainy season. It is due to the growth of fungus that our leather shoes kept in the house sometimes get spoiled during the rainy season.

**Fungi can be useful as well as harmful.** For example, fungi such as mushrooms and yeast are useful. Mushrooms are eaten as a vegetable whereas yeast is used for producing alcohol. Some fungi are also used for making medicines. For example, the Penicillium fungus is used in making an antibiotic called penicillin. Fungi also cause diseases in plants and human beings. Sometimes the whole crops standing in the fields are destroyed by fungus. The skin disease (called ringworm) in humans is caused by fungus.

In addition to parasitic and saprophytic modes of nutrition in some plants, there are also some other plants whose modes of nutrition are somewhat peculiar. These are called insectivorous plants and symbiotic plants. Let us discuss these peculiar modes of nutrition in plants in detail, one by one.
**Insectivorous Plants**

There are some green plants which obtain their food partly from the soil and atmosphere, and partly from small insects. **Those green plants which obtain their food partly from insects are called insectivorous plants.** Insectivorous plants are also known as carnivorous plants. The insectivorous plants have specialised leaves to catch the insects. The insectivorous plants grow only in those soils which do not contain sufficient nitrogen mineral. These insectivorous plants trap insects by various methods, kill them and digest them to obtain nitrogen compounds (like amino acids) for their growth. **Some common examples of the insectivorous plants (or carnivorous plants) are: Pitcher plant, Sundew, Venus fly-trap and Bladderwort.** The insectivorous plant called pitcher plant is shown in Figure 12. The pitcher plant uses a pitcher like organ to trap insects and digest them. This is explained below.

In the pitcher plant, the lamina (or blade) of the leaf is modified into a hollow tube called pitcher (see Figure 12). The leaf apex (top part of leaf) forms a lid which can open or close the mouth of the pitcher. Inside the pitcher, there are hair which are directed downwards. When an insect falls in the pitcher, the lid closes automatically. The trapped insect gets entangled in the hair of the pitcher and hence cannot come out. After some time, the insect dies in the pitcher. The walls of the pitcher secrete digestive juices which digest the proteins present in the body of insect to form simpler nitrogen compounds (like amino acids). These simpler nitrogen compounds are absorbed by the walls of the pitcher and used by the whole pitcher plant.

Please note that insectivorous plants are green and carry out photosynthesis to obtain a part of the food required by them. But they do not get the ‘nitrogen’ nutrient from the soil in which they grow. So, **insectivorous plants feed on insects to obtain the nitrogen compounds needed for their growth.** We can now say that the insectivorous plants are “partial heterotrophs”. They get some food by photosynthesis and some by eating insects.

**Symbiotic Plants**

The living together of two different species of plants as if they are parts of the same plant and help each other in obtaining food is called symbiosis (and such plants are known as symbiotic plants). This type of nutrition involving symbiosis occurs in the plants called ‘lichens’ (see Figure 13). In lichens, the green coloured plant called ‘alga’ (autotroph) and non-green plant ‘fungus’ (saprophyte) live together. The fungus holds the alga cells in its mat of web-like hyphae (thin filaments). The fungus plant absorbs the water and mineral salts from the surroundings and supplies them to alga. The alga plant being green, prepares the food by photosynthesis and shares it with fungus. Thus, both alga and fungus gain mutually from one another by living together. This is an example of symbiosis. The plants which exhibit symbiosis are called symbiotic plants. **The condition where two different organisms live together and help each other to survive is called symbiotic relationship.** Symbiotic relationship is advantageous to both the organisms.

Another example of symbiotic relationship is provided by *Rhizobium* bacteria and leguminous plants. *Rhizobium* bacteria cannot make their own food. *Rhizobium* bacteria live in the root nodules of leguminous
plants (such as gram, peas, beans, pulses, etc.). *Rhizobium* bacteria convert nitrogen gas of air into water soluble nitrogen compounds (called nitrates) and give them to the leguminous plants for their growth. In return, leguminous plants give food and shelter to *Rhizobium* bacteria. Thus, *Rhizobium* bacteria and leguminous plants have a symbiotic relationship.

Certain fungi live in the roots of trees. These fungi take up water and minerals from the soil and supply them to the roots of the tree. The tree, in return, provides food to these fungi. This symbiotic relationship is important for the survival of fungi as well as the tree.

**HOW NUTRIENTS ARE REPLENISHED IN THE SOIL**

The main nutrients required by the plants are nitrogen, phosphorus and potassium. These are called ‘mineral nutrients’ or just ‘minerals’. The plant nutrients like nitrogen, phosphorus and potassium are present in the soil naturally. When the plants are grown, they absorb the nutrients from the soil due to which the amount of plant nutrients in the soil goes on decreasing. And when the crop plants are grown in the same fields again and again, then the soil becomes deficient in plant nutrients like nitrogen, phosphorus and potassium. Due to this, the plant nutrients (or minerals) need to be added from time to time to enrich the soil and restore its fertility. The plant nutrients (or minerals) are replenished (or put back) in the soil in the following two ways:

1. **Nutrients are Replenished in the Soil by Adding Fertilisers and Manures**

   Fertilisers and manures contain plant nutrients (or minerals) such as nitrogen, phosphorus and potassium, etc. So, when fertilisers and manures are added to the soil in the fields, then the soil gets enriched with nutrients like nitrogen, phosphorus and potassium, etc. The crop plants can then grow well in this soil. Thus, plant nutrients are added in the cultivated fields in the form of fertilisers and manures so as to get good crops. In fact, many times we see the farmers spreading fertilisers and manures in the fields (see Figure 14). The gardeners also put fertiliser and manure in the lawns and potted plants. This is done to provide essential nutrients for the growth of plants so that we get healthy plants. The two most common fertilisers which are used to provide plant nutrients (or minerals) in the fields are NPK and Urea. NPK fertiliser provides Nitrogen (N), Phosphorus (P) and Potassium (K) to the soil in the fields whereas urea provides only nitrogen.

   Out of all the plant nutrients (or minerals), **the crop plants grown in the fields require nitrogen in maximum amount to make the proteins**. The crop plants take this nitrogen from the soil in the fields. So, after the harvest, the soil in the fields becomes deficient in nitrogen. This nitrogen deficient soil is incapable of growing another good crop. Now, **one way to make this soil fertile again is to add nitrogen containing fertilisers. Another way is to grow leguminous crops in this soil**. How the growing of leguminous crops enriches the soil with nitrogen will become clear from the following discussion.

2. **Nitrogen Can be Replenished in the Soil by Growing Leguminous Crops.**

   Though a lot of nitrogen gas is present in the air but the plants cannot use nitrogen in gaseous form. The plants need nitrogen in the form of water soluble compounds (such as nitrates). The plants such as gram (*chana*), peas, pulses (*moong*, etc.) and beans are called leguminous plants (or legumes). The leguminous plants have root nodules in them which contain *Rhizobium* bacteria (see Figure 15). *Rhizobium* bacteria can convert nitrogen gas of air into nitrogen compounds (like nitrates). So, when a leguminous...
crop is grown in a field, the *Rhizobium* bacteria present in the root nodules of leguminous plants convert nitrogen gas of air into nitrogen compounds (like nitrates). Some of these nitrogen compounds are used by the leguminous plants for their own growth. The remaining nitrogen compounds made by *Rhizobium* bacteria mix with the soil in the field and enrich it. Thus, the soil in the fields gets enriched with nitrogen compounds in the natural way. The growing of leguminous crops in the fields is of great importance to the farmers. This is because **the farmers do not need to put nitrogen fertiliser in the fields in which leguminous crops have been grown earlier.** This saves a lot of money.

**CELLS**

In biology, a cell is the smallest unit of life. All the living things (plants and animals) are made from cells. Just as a house is made of small units called bricks, in the same way, the bodies of living organisms are made of tiny units called cells. Thus, **cells are the building blocks of plants and animals.** Cells are very, very small in size which cannot be seen with naked eyes. Cells can be seen only under a microscope. We can, however, see the plants and animals around us because they are made up of millions and millions of tiny cells joined together.

Some organisms are made of only one cell but others are made of many, many cells joined together. For example, the simplest animal called *Amoeba* is made up of only one cell but a complex organism like a rose plant or a man is made up of millions of cells. All living cells come only from other living cells. **The cells are mainly of two types: Animal cells and Plant cells.** Though many things are common between animal cells and plant cells but they differ in some ways.

A cell consists of a jelly-like material enclosed in a thin membrane (see Figure 16). The jelly-like material which fills the cell is called *cytoplasm*. The thin outer covering of the cell is called *cell membrane*. There is a large spherical structure floating in the centre of a cell which is called the *nucleus*. The nucleus is surrounded by jelly-like material called cytoplasm. A number of small bodies called *mitochondria* are also present in the cell. There are tiny air spaces in the cytoplasm of an animal cell which are called *vacuoles*. The general diagram of an animal cell is shown in Figure 16.

![Figure 16. The general diagram of an animal cell.](image)

We will now give the functions of all the parts of a cell. The cell membrane protects the cell and also controls the passage of materials which ‘go into the cell’ or ‘go out from the cell’. The function of nucleus is to control all the activities of the cell (like cell growth, etc.). The function of mitochondria is to carry out respiration for releasing energy from food. The function of small vacuoles is to hold air, water or particles of food. And the function of cytoplasm is to carry out all the activities of life processes (or metabolism).
All the parts of animal cells such as cell membrane, cytoplasm, nucleus and mitochondria are also present in plant cells. In addition to these, the plant cells have three more parts in them. These are **cell wall**, **chloroplasts** and **large vacuoles**. These parts make the plant cells different from animal cells. The general diagram of a plant cell is given in Figure 17. All the plant cells have a thick cell wall around the cell membrane. The cell wall protects the cell, gives it a fixed shape and makes it rigid (strong). The chloroplasts contain chlorophyll and make food in green plants by the process of photosynthesis. The large vacuoles in plant cells are filled with cell sap (which is a solution of sugars and other substances).

The animals are made up of animal cells joined together whereas plants are made up of plant cells combined together. Since the animals and plants are made up of different types of cells, therefore, animals and plants look different and behave in different ways. We are now in a position to **answer the following questions**:

**Very Short Answer Type Questions**

1. Name the pores through which leaves exchange gases.
2. Name the process by which plants make food.
3. What is photosynthesis?
4. State whether the following statements are true or false:
   - (a) Carbon dioxide is released during photosynthesis.
   - (b) Solar energy is converted into chemical energy during photosynthesis.
   - (c) The product of photosynthesis is not a protein.
   - (d) A plant having red leaves cannot do photosynthesis.
   - (e) Plants which synthesise their food themselves are called saprotrophs.
5. Name any one plant which has nitrogen-fixing *Rhizobium* bacteria in its roots.
6. What do the patches of green layer floating on the surface of stagnant water bodies like ponds and lakes consist of?
7. Why are algae green?
8. (a) Name a gas used in photosynthesis.
    (b) Name a gas produced in photosynthesis.
9. What name is given to those organisms:
   - (a) which can make their own food?
   - (b) which depend on other organisms for food?
10. *Rhizobium* bacteria and leguminous plant help each other in survival. What is this relationship known as?
11. What name is given to the relationship between an alga and fungus in lichens?
12. Where does the synthesis of food in a plant usually take place?
13. Why are the leaves of a plant usually green?
14. Name the green pigment present in the leaves of a plant.
15. Name three plant nutrients commonly present in fertilisers and manures.
16. Name the bacteria which convert nitrogen gas of air into nitrogen compounds.
17. What type of plants have *Rhizobium* bacteria in their root nodules?
18. Name any two leguminous plants.
19. Name one autotrophic plant and one heterotrophic plant.
20. Name a parasitic plant with yellow, slender and tubular stem.
21. Name a plant which has both autotrophic as well as heterotrophic modes of nutrition.
22. Name one plant in which photosynthesis occurs in plant part other than leaves. Name the plant part.
23. Name four foods made by plants which are an important part of our diet.
24. The heterotrophic plants can be divided into two groups on the basis of their mode of nutrition. Name these two groups.
25. Fill in the following blanks with suitable words:
   - (a) Fungi like .......... and .......... are useful.
   - (b) Saprotrophs secrete digestive juices on dead and decaying matter and convert it into a .......... 
   - (c) The tiny spores of fungus plants are always present in..........
(d) In lichens, the chlorophyll containing partner is an............
(e) The leather objects that are left in hot and humid weather for long time are spoiled due to the growth of ..........
(f) The food synthesised by plants is stored as...........
(g) In photosynthesis, solar energy is captured by the pigment called ..........
(h) During photosynthesis, plants take in ............ and release...........
(i) The gas produced during photosynthesis which is essential for the survival of all organisms is........
(j) The simplest carbohydrate made as food by photosynthesis is........
(k) Crop plants require a lot of nitrogen to make ..........
(l) The bodies of living organisms are made up of tiny units called ........

Short Answer Type Questions

26. Match the items given in column I with those in column II :

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Chlorophyll</td>
<td>(a) Rhizobium bacterium</td>
</tr>
<tr>
<td>(ii) Nitrogen</td>
<td>(b) Heterotrophs</td>
</tr>
<tr>
<td>(iii) Amarbel</td>
<td>(c) Pitcher plant</td>
</tr>
<tr>
<td>(iv) Animals</td>
<td>(d) Leaf</td>
</tr>
<tr>
<td>(v) Insects</td>
<td>(e) Parasite</td>
</tr>
</tbody>
</table>

27. How would you test the presence of starch in leaves ?
28. What is special about the leaves that they can synthesise food but other parts of a plant cannot ?
29. In addition to carbon dioxide and water, state two other conditions necessary for the process of photosynthesis to take place.
30. Consider the following organisms :
   Lichen, Mushroom, Cuscuta, Grass, Pitcher plant
   Out of these, which one is :
   (a) an autotroph ?
   (b) a saprophyte ?
   (c) symbiotic plant ?
   (d) a partial heterotroph ?
   (e) a parasite ?
31. Why do organisms need to take food ? What are the two main modes of nutrition in organisms ?
32. What is meant by an autotroph ? Name one autotroph.
33. What is meant by a heterotroph ? Give one example of a heterotroph.
34. Explain why, we cannot make food ourselves by photosynthesis like the plants do.
35. What are insectivorous plants ? Name an insectivorous plant.
36. Why do farmers spread fertilisers and manures in the fields ?
37. What are plant parasites ? Name one plant which is a parasite.
38. What are saprophytes ? Name one saprophyte.
39. Proteins are nitrogenous (nitrogen-containing) foods. How do plants get nitrogen for making proteins ?
40. (a) Name the large, spherical structure usually located in the centre of a cell.
     (b) The nucleus in a cell is surrounded by a jelly-like material. Name this material.
     (c) Name the thin, outer covering which encloses a cell.
     (d) Name any two parts which are present in plant cells but not in animal cells.

Long Answer Type Questions

41. Give a brief description of the process of synthesis of food in green plants. What is chlorophyll ? What is the role of chlorophyll in photosynthesis ?
42. (a) How do plants get carbon dioxide for making food by photosynthesis ?
     (b) Explain how, water and minerals are transported to the leaves of a plant to be used in food making by photosynthesis.
43. Describe briefly how nutrients are replenished in the soil ? How is the growing of a leguminous crop in the fields beneficial to the farmer ?
44. (a) A person observes that some plants have deep red, violet and brown coloured leaves. Can these leaves carry out photosynthesis ? Give reason for your answer.
     (b) Describe the importance of photosynthesis for the existence of life on the earth.
45. (a) What are the various modes of nutrition in plants? Give one example of each.
(b) What do you understand by symbiosis? Explain with an example.

**Multiple Choice Questions (MCQs)**

46. Which part of the plant gets carbon dioxide from air in photosynthesis?
(a) root hair (b) stomata (c) leaf veins (d) sepals

47. Plants take carbon dioxide from the atmosphere mainly through their:
(a) roots (b) stems (c) flowers (d) leaves

48. *Cuscuta (Amarbel)* is an example of:
(a) autotroph (b) parasite (c) saprotroph (d) host

49. The plant which traps and feeds on insects is:
(a) Cuscuta plant (b) China rose plant (c) Pitcher plant (d) Rose plant

50. When dilute iodine solution is poured over a decolourised green leaf, a blue-black colour is produced. This shows that the green leaf contains:
(a) glucose (b) cellulose (c) starch (d) sucrose

51. The stem of one of the following plants can do photosynthesis. This plant is:
(a) mushroom (b) croton (c) cuscuta (d) cactus

52. Which of the following plant has a heterotrophic mode of nutrition?
(a) money plant (b) croton plant (c) cuscuta plant (d) alga plant

53. One of the following is not a parasite. This one is:
(a) Lice (b) Leech (c) Alga (d) Cuscuta

54. Which of the following are not present in an animal cell?
A. Mitochondria  B. Cytoplasm  C. Chloroplast  D. Large vacuole
(a) A and B (b) B and C (c) A and C (d) C and D

55. Which of the following can make its own food?
(a) giraffe (b) goat (c) grass (d) gorilla

56. One of the following is an autotroph. This one is:
(a) alligator (b) algae (c) antelope (d) ant

57. The process of photosynthesis converts solar energy into:
(a) kinetic energy (b) chemical energy (c) potential energy (d) nuclear energy

58. Which of the following plants is an example of autotroph?
(a) mushroom (b) yeast (c) bread mould (d) mimosa

59. Which one of the following is a heterotroph?
(a) mimosa (b) mushroom (c) mango (d) mangrove

60. Which of the following are saprophytes?
A. Mango  B. Mushroom  C. Yeast  D. Yak
(a) A and B (b) B and C (c) C and D (d) A and D

61. The green insectivorous plants trap insects, kill them and digest them to obtain mainly:
(a) glucose (b) starch (c) nitrogen (d) oxygen

62. Which of the following show symbiosis?
A. Alga and fungus  B. Alga and fish  C. *Rhizobium* and pea plant  D. *Rhizobium* and money plant
(a) A and B (b) B and C (c) A and C (d) C and D

63. The mineral needed by plants to make proteins is:
(a) neon (b) iodine (c) nitrogen (d) calcium

64. The tubes (or pipes) which transport water and dissolved minerals from the soil to the leaves of a plant are called:
(a) xylem (b) phloem (c) epidermis (d) stomata
65. Which of the following is not required for photosynthesis by the green leaves of a plant?
   (a) carbon dioxide  (b) oxygen  (c) sunlight  (d) water

66. The simplest food produced during photosynthesis is:
   (a) starch  (b) cellulose  (c) glucose  (d) sucrose

67. Which part of a plant is called its food factory?
   (a) stem  (b) roots  (c) branches  (d) leaves

68. In a cactus plant, food is made by:
   A. Branches  B. Roots  C. Leaves  D. Stem
   (a) A and B  (b) B and C  (c) only C  (d) A and D

69. Which of the following gas is given out during photosynthesis?
   (a) nitrogen  (b) carbon dioxide  (c) oxygen  (d) water vapour

70. The carnivorous plants usually have one of the following specialised organs to catch their prey:
   (a) stems  (b) branches  (c) leaves  (d) modified roots

Questions Based on High Order Thinking Skills (HOTS)

71. The leaves of a plant combine a gas A taken from air and a liquid B taken from the soil in the presence of sunlight to make a simple food C by the process called D. Some of the simple food C gets converted into a complex food E which is stored in the various parts of the plant including its leaves.
   (a) What are (i) gas A, and (ii) liquid B?
   (b) What are (i) food C, and (ii) food E?
   (c) Name the process D.
   (d) Which of the two foods, C or E, will give blue-black colour with dilute iodine solution?
   (e) Name the pigment present in leaves which helps in carrying out the food making process D.

72. The plant X is found in abundance in desert areas which get meagre rainfall. The modified leaves of this plant can reduce the loss of water from this plant by transpiration. This plant has long roots which go deep into the soil so as to obtain water.
   (a) What could the plant X be?
   (b) Which part/parts of this plant take part in photosynthesis?
   (c) How does the photosynthesis in this desert plant differ from those of ordinary plants found in a garden?
   (d) What is the colour of the stem of this plant?

73. The organs A of a tree have a large number of tiny pores called B on their surface. Each pore is surrounded by a pair of cells called C. The opening and closing of pores in A is controlled by C. The gas D present in air enters the organs A through pores B and utilised in food making process E. The gas F produced during process E goes out through the same pores B. What are A, B, C, D, E, and F?

74. The lamina of the leaf of a plant P is modified into a hollow tube. The leaf apex forms a kind of lid which can open or close the mouth of hollow tube. When an organism Q falls in the hollow tube, the lid closes automatically killing the organism. The walls of hollow tube secrete digestive juices which digest the complex substances R present in the body of the organism to form simpler substances S. These simpler substances are then absorbed by the walls of the hollow tube and used by the plant P.
   (a) What could the plant P be?
   (b) Name the organism Q.
   (c) What could the complex substances R be?
   (d) Name the simpler substances S.
   (e) What is the general name of plants like P?

75. Two different species of plants X and Y live together as if they are parts of the same plant Z. The plant X is an autotroph whereas plant Y is a saprophyte. The plant Y holds the cells of X in its mat of web-like hyphae and supplies water and minerals to cells of plant X. The plant X makes food by photosynthesis and shares it with plant Y.
   (a) What could plants (i) X (ii) Y, and (iii) Z be?
   (b) Which of the two plants, X or Y, is green in colour?
   (c) What is the relationship exhibited by plants X and Y known as?
   (d) Give another example of this type of relationship.
1. Stomata  
2. Photosynthesis  
4. (a) False (b) True (c) True (d) False (e) False  
5. Pea plant  
6. Algae  
8. (a) Carbon dioxide  (b) Oxygen  
9. (a) Autotrophs (b) Heterotrophs  
21. Pitcher plant  
23. Starch, Oils (or Fats), Proteins and Vitamins  
25. (a) mushroom; yeast (b) solution (c) air (d) alga (e) fungus (f) starch (g) chlorophyll (h) carbon dioxide; oxygen (i) oxygen (j) glucose (k) proteins  
26. (i) d (ii) a (iii) e (iv) b (v) c  
30. (a) Grass  (b) Mushroom (c) Lichen (d) Pitcher plant  
(e) *Cuscuta*  
46. (b)  
47. (d)  
48. (b)  
49. (c)  
50. (c)  
51. (d)  
52. (c)  
53. (c)  
54. (d)  
55. (c)  
56. (b)  
57. (b)  
58. (d)  
59. (b)  
60. (b)  
61. (c)  
62. (c)  
63. (c)  
64. (a)  
65. (b)  
66. (c)  
67. (d)  
68. (d)  
69. (c)  
70. (c)  
71. (a) (i) Carbon dioxide (ii) Water  (b) (i) Glucose (ii) Starch  (c) Photosynthesis  
(d) Food  
(e) Chlorophyll  
72. (a) Cactus plant  
(b) Stem and Branches  
(c) The photosynthesis in this desert plant is carried out by its green stem and branches whereas the photosynthesis in ordinary garden plants is carried out by their green leaves  
(d) Green  
73. A : Leaves; B : Stomata; C : Guard cells; D : Carbon dioxide; E : Photosynthesis; F : Oxygen  
74. (a) Pitcher plant (b) Insect (c) Proteins (d) Amino acids (e) Insectivorous plants  
75. (a) (i) Alga (ii) Fungus (iii) Lichen (b) X is green in colour (c) Symbiotic relationship  
(d) *Rhizobium* bacteria and Leguminous plants.
Nutrition in Animals

We have studied in the previous chapter that plants can make their own food by the process of photosynthesis. Animals, however, cannot make their own food by photosynthesis. Since animals cannot make their own food, they need readymade food. This readymade food comes from ‘plants’ or from ‘other animals’. Thus, animals obtain their food from plants or from other animals (which eat plants). Some animals, however, eat both plant food as well as animal food. We (human beings) are also animals. We obtain foods like wheat, rice, pulses (dal), fruits and vegetables from plants. And the foods like milk, curd, cheese and eggs are obtained from animals. Some people also eat meat, chicken and fish as food. These foods are also obtained from animals (which eat plants as food).

All animals (including human beings) require food for obtaining energy, growth and repair of damaged body parts. The process of taking in food by an animal and its utilisation in the body is called animal nutrition. Nutrition in animals takes place in five steps: Ingestion, Digestion, Absorption, Assimilation and Egestion.

1. The process of taking food into the body is called ingestion.
2. The process in which the food containing large, insoluble substances is broken down into small, water soluble substances (which can be absorbed by the body) is called digestion.
3. The process in which the digested food passes through the intestinal wall into blood stream is called absorption.
4. The process in which the absorbed food is taken in by body cells and used for energy, growth and repair, is called assimilation.
5. The process in which the undigested food is removed from the body is called egestion.

Animals Take in Food by Different Methods

The first step in the process of nutrition in animals is ‘ingestion’ which means ‘taking food into the body’ (or eating of food). Different animals use different modes (or methods) of taking food into their body.
In fact, every animal has some special structures (or organs) for taking food inside its body. The methods used by some of the animals to take in food (or eat food) are described below.

Frog is an animal which eats flying insects as food. The frog uses its long and cleft tongue (forked tongue) to catch its prey like insects. A wall lizard and a chameleon (girgit) also catch their prey (insects, etc.) with the help of their fairly long tongue. The butterfly belongs to the category of insects. The food of butterfly is nectar (Nectar is a sugary liquid present inside the flowers). The butterfly uses its long feeding tube to suck nectar from flowers (just as we sip Pepsi or Coca-Cola) (see Figure 1). Bees and hummingbirds also suck the nectar from flowers in plants. Both male and female mosquitoes feed by sucking nectar from flowers. The female mosquitoes also suck blood from other animals (including human beings). Infants (small babies) of humans and many other animals (such as cows, dogs, etc.) feed on mother’s milk by sucking. Lice are wingless insects which live on hair. Lice feed by sucking blood from the skin of scalp. Houseflies feed on filth and refuse. They take in only liquid food by sucking. Houseflies spit out saliva on solid food to convert it into a liquid and then suck this liquid. Ants feed on plant material and other animals by biting and chewing. Snails feed on algae by scraping it from rocks. Snakes are flesh eaters. They eat animals like rats, etc. Snakes (including pythons) swallow the animal ‘whole’ which they prey upon. Eagle is a large bird which feeds on the flesh of its prey by tearing its flesh with powerful hooked beak. Amoeba is a tiny aquatic animal which ingests its food with the help of its pseudopodia (or false feet).

Hydra is an animal which uses its tentacles with sting cells to kill the prey and put it into the mouth (body cavity). A spider weaves a web (jaal) to catch its prey. A crow uses its long beak to put the food into its mouth. Starfish is a sea animal which has an amazing way of taking in food (or ingestion). Starfish feeds on sea animals (such as shellfish and oysters, etc.) which are covered by hard shells of calcium carbonate. After opening the shell of its prey, the starfish pops out its own stomach through its own mouth. This stomach surrounds the soft body of the prey (which is inside the shell). The starfish then brings back its stomach containing the prey (or food) into the body. This food is digested slowly by the starfish. From the above discussion it is clear that there are many different methods of eating food (or ingesting food) in the animal world.

**Digestion**

Our food consists mainly of substances such as carbohydrates (like starch), fats and proteins (with small amounts of minerals and vitamins). Now, starch carbohydrate, fats and proteins are all large, insoluble substances which cannot pass through the walls of our intestine and get absorbed as such. So, before the food can be used by us for various functions like getting energy or for growth, it must be broken down into small, water soluble substances which can be absorbed by our body. The process in which the food containing large, insoluble substances is broken down into small, water soluble substances which can be absorbed by our body, is called digestion. In most simple terms, digestion means dissolving of solid food. Digestion makes the food soluble so that it can be absorbed and utilised by the body.

We use both physical and chemical methods for digesting (breaking up) the large substances present in food. Physical methods include chewing and grinding the food in mouth and chemical methods include the addition of digestive juices to food by the body itself. During the process of digestion, the complex starch carbohydrate present in our food is broken down into a simple sugar called glucose. Fats are broken into simpler substances called fatty acids and glycerol. And proteins are broken down into simple substances called amino acids. Now, glucose, fatty acids, glycerol and amino acids are all water soluble, simple substances which can pass through the wall of our small intestine into the blood and hence get...
absorbed in the body. The process of digestion takes place inside our body. Before we describe the human digestive system in detail, we should know the meaning of alimentary canal. This is described below.

**Alimentary Canal**

A long tube running from mouth to anus of a human being (or other animals) in which digestion and absorption of food takes place is called alimentary canal. Alimentary canal is also known as gut or digestive tract. It is about 8 to 9 metres long in humans. The alimentary canal is a continuous canal which has many parts such as mouth (buccal cavity), oesophagus (food pipe), stomach, small intestine, large intestine, rectum and anus. Three glands are also associated with alimentary canal. These are salivary glands, liver and pancreas. The food enters the alimentary canal at the mouth (buccal cavity). As the food travels through the various parts of alimentary canal, it gradually gets digested. During the passage of food through alimentary canal, the various glands (salivary glands, liver, pancreas) and inner walls of stomach and small intestine, secrete digestive juices. These digestive juices convert the complex substances of food into simpler substances which can be absorbed by the body. The undigested part of food is defecated (thrown out) through the last part of alimentary canal called anus.

An important question now arises: How does food move forward in the alimentary canal? **The food moves forward in the alimentary canal by the process of peristalsis.** Peristalsis is the wave-like movement caused by the alternate contraction and relaxation of the muscles of alimentary canal which pushes the food forward in the alimentary canal. We will also be using a term called ‘buccal cavity’. The mouth cavity by which food is taken into the alimentary canal and chewed is called buccal cavity. We will now describe what happens to the food when it passes through the different parts of the alimentary canal (or digestive tract).

**HUMAN DIGESTIVE SYSTEM**

When we eat food, it gets broken down into smaller and soluble substances during digestion. The digested food is absorbed and utilised by our body. The undigested and unabsorbed portion of food is removed from the body in the form of waste material called faeces. We will now discuss the human digestive system in detail.

**The human digestive system consists of the alimentary canal and its associated glands.** The various organs of the human digestive system in sequence are: **Mouth (Buccal cavity), Oesophagus (or Food pipe), Stomach, Small intestine, Large intestine, Rectum and Anus.** The glands which are associated with human digestive system and form a part of human digestive system are: **Salivary glands, Liver and Pancreas.** Salivary glands are located in our mouth (or buccal cavity). Liver is a reddish-brown gland situated in the upper part of abdomen on the right side. Liver is the largest gland in the body. Pancreas is a large, cream coloured gland located just below the stomach. The ducts (or pipes) of various glands open into the alimentary canal and pour the secretions of their digestive juices into the alimentary canal. The human digestive system is shown in Figure 2. We will now describe how food gets digested when it passes through the various parts of alimentary canal.

1. **In the Mouth (or Buccal Cavity)**

Food is taken into the body (or ingested) through the mouth. The digestion of food starts as soon as we put the food in our mouth. The mouth (or buccal cavity) contains teeth, tongue and salivary glands. The teeth cut the food into small pieces, chew and grind it. The salivary glands secrete a watery liquid called saliva. The tongue helps in mixing saliva with food. Saliva is a digestive juice which helps to digest the starch present in the food partially. The slightly digested food is swallowed by the tongue and goes down into oesophagus (or food pipe) (see Figure 2).
2. In the Oesophagus (or Food Pipe)

The oesophagus is a tube (or pipe) which connects the mouth (or buccal cavity) to stomach. Oesophagus is commonly known as food pipe. It runs along the neck and chest. Oesophagus carries the slightly digested food from the mouth to the stomach (see Figure 2). The food coming from mouth moves down through oesophagus by peristalsis. This happens as follows: When the food enters oesophagus at the top end, the muscles in the walls of oesophagus start alternate contractions and relaxations producing a wave-like movement which pushes the food downwards towards the stomach. (During vomiting, however, the food moves in the opposite direction, from stomach to mouth, by the process of anti-peristalsis in the food pipe).

3. In the Stomach

The stomach is a thick walled bag present on the left side of the abdomen (see Figure 2). It is the widest part of the alimentary canal. Oesophagus (or food pipe) brings the slightly digested food from the mouth into stomach. The food is further digested in the stomach. The food is churned in the stomach for about three hours. During this time, the food breaks down into still smaller pieces and makes a semi-solid paste. The inner lining of stomach secretes mucus, hydrochloric acid and digestive juices. Mucus protects the lining of stomach (from its own secretions of hydrochloric acid). Hydrochloric acid kills any bacteria which may enter the stomach with food. Hydrochloric acid also makes the medium in the stomach acidic (which is necessary for the proper action of digestive juices on proteins in the stomach). The digestive juices secreted by the stomach lining break down the proteins present in our food into simpler substances (This happens in the acidic medium). The partially digested food then goes from the stomach into the small intestine.

4. In the Small Intestine

The small intestine is a very long tube. It is about 7.5 metres long. Though small intestine is very long, it is called small intestine because it is a quite narrow tube. The small intestine is arranged in the form of a coil in our belly (see Figure 2). The small intestine in human beings is the site of complete digestion of food. The small intestine is also the main region for the absorption of digested food. This happens as follows.

(a) Complete Digestion of Food in Small Intestine. The partially digested food from stomach comes into small intestine. The small intestine receives secretions of digestive juices from the liver, pancreas and its own walls. All these digestive juices carry out the complete digestion of food as follows: Liver secretes a liquid called bile (which is stored temporarily in the sac called gall bladder). The bile plays an important part in the digestion of fats. Actually, bile converts fats into tiny droplets so that their further breakdown becomes easy. Pancreas secretes pancreatic juice. Pancreatic juice breaks down fats completely into fatty acids and glycerol. Pancreatic juice also breaks down starch carbohydrate and proteins into simpler forms. The walls of small intestine secrete a digestive juice called ‘intestinal juice’. Intestinal juice breaks down the starch carbohydrate completely into the simplest sugar called glucose, and the proteins into amino
acids. In this way, our food breaks down completely into very small, water soluble substances like glucose, fatty acids, glycerol and amino acids. This is called digested food.

(b) Absorption of Digested Food in Small Intestine. The digested food can now pass into the blood vessels in the walls of the small intestine. This process is called absorption. The small intestine is especially adapted for absorbing the digested food. This happens as follows: The inner surface of the small intestine has millions of tiny, finger-like outgrowths called villi (read as vee-la-ee; singular of villi is villus). The presence of villi gives the inner walls of the small intestine a very large surface area (which helps in the rapid absorption of food). Thus, the role of villi in the small intestine is to increase the surface area for the rapid absorption of digested food. Each villus has a network of thin and small blood vessels (called blood capillaries) close to its surface. The surface of villi absorbs the digested food materials into blood flowing through them. Blood carries the absorbed food materials to the cells in all the parts of the body. In the cells, food is used for energy, growth and repair. This is called assimilation. Glucose breaks down in the cells with the help of oxygen to form carbon dioxide and water, and releases energy. Fatty acids and glycerol build components of cells and form fats to be stored in the body as food reserves. Amino acids are used to make proteins required for the growth and repair of the body.

A part of the food which we eat cannot be digested by our body. This undigested food cannot be absorbed in the small intestine. The food that remains undigested and unabsorbed passes from the small intestine into large intestine.

5. In the Large Intestine

The large intestine is about 1.5 metres long. It is called large intestine because it is a quite wide tube. The undigested and unabsorbed food from the small intestine enters into large intestine. The large intestine absorbs most of the water from the undigested food material. Due to the removal of water, the undigested food becomes semi-solid. This undigested food (or waste material) is stored in the last part of the large intestine called rectum for some time. When we go to toilet, the undigested, semi-solid waste is passed out from our body through anus in the form of faeces. This is called egestion.

**ACTIVITY TO STUDY THE EFFECT OF SALIVA ON STARCH PRESENT IN FOOD**

Our mouth contains salivary glands which secrete saliva. During digestion, saliva breaks down complex carbohydrate ‘starch’ present in food into a ‘sugar’. We can observe the effect of saliva on starch containing food by performing a simple activity as described below. Since our common food ‘rice’ contains starch, so we will use boiled rice as a source of starch in this activity.

Take one teaspoonful of crushed boiled rice in a beaker and add about 20 mL water to it. Stir with a glass rod. In this way, we will get a mixture of crushed boiled rice with water which contains starch carbohydrate. Divide this mixture into two parts.

(i) Take one part of crushed boiled rice and water mixture in a test-tube and add 2 or 3 drops of dilute iodine solution to it. A blue-black colour is produced [see Figure 3(a)]. This shows that boiled rice contains starch.

![Figure 3](image_url)
(ii) Take the second part of crushed boiled rice and water mixture in another test-tube and add saliva from mouth into it. Keep this test-tube in warm water for about 15 to 20 minutes. Then add 2 or 3 drops of dilute iodine solution. No blue-black colour is produced in this case [see Figure 3(b)]. This shows that there is no starch in the boiled rice which has been treated with saliva.

The above observation can be explained on the basis of action of saliva on starch as follows: When the mixture of boiled rice and water is treated with saliva, then saliva breaks down the starch present in boiled rice to form a sugar. Since no starch is left in the test-tube after treatment of boiled rice with saliva, therefore, no blue-black colour is produced on adding dilute iodine solution. Thus, saliva breaks down starch into sugar (The sugar which is formed by the breakdown of starch with saliva is called maltose).

Why Do We Get Hiccups

The windpipe (called trachea) carries air from nostrils to our lungs. And food pipe (called oesophagus) carries food from mouth to stomach. The windpipe runs adjacent to the food pipe in the body. Inside the throat, however, air and food share a common passage. Then how the food which we eat is prevented from entering our windpipe? This happens as follows: Normally, when we swallow food, then a flat piece of cartilage (called epiglottis) drops over the mouth of windpipe forming a bridge over which food passes and goes into food pipe (without falling into windpipe). Sometimes, however, when we eat too fast in a hurry, or talk too much or laugh while eating, then a little of windpipe remains open due to which food particles may enter the windpipe. When food particles enter the windpipe we may get hiccups (or a choking sensation). Hiccups produce a characteristic ‘gulping sound’ repeatedly. Hiccup is called ‘hichki’ in Hindi. The blockage in windpipe caused by food particles is usually cleared by coughing.

**TEETH**

Before food can be used by the body, it must be broken down into small pieces. The first part of this breakdown of food is done by the teeth. We chew the food with the teeth and break it down mechanically into small pieces. This is discussed below.

There are four types of teeth in our mouth. These are:
(i) Incisors,
(ii) Canines,
(iii) Premolars, and
(iv) Molars.

The four types of teeth are shown in Figure 4. The upper part of a tooth (which we can see in the mouth) is called crown, the middle part of a tooth (which is inside the gums) is called neck whereas the lower part of a tooth (which is embedded in the jaw bone) is called root. Every tooth is held in a separate socket in the jaw. The positions of four types of teeth in the mouth are shown in Figure 5. Different types of teeth differ in appearance and perform different functions. This is discussed below.

(i) Incisors are the chisel shaped teeth at the front of the mouth (see Figure 5). **The incisors are for biting and cutting the food.** There are four incisors in the centre of each jaw.

(ii) Canines are the large, pointed teeth just behind the incisors (see Figure 5). **The canines are for piercing and tearing the food.** There are two
canines in each jaw, one behind the left incisor and the other behind right incisor.

(iii) Premolars are the large teeth just behind the canines on each side (see Figure 5). Premolars have large, flat surfaces. **The premolars are for chewing and grinding the food.** There are four premolars in a jaw, two on each side.

(iv) Molars are very large teeth which are present just behind the premolars, towards the back of our mouth (see Figure 5). The molars have a larger surface area than premolars. The function of molars is the same as that of premolars. That is, **molars are for chewing and grinding the food.** There are six molars in each jaw, three on each side. Please note that molars are present only in the permanent set of teeth. They are not present in the temporary set of teeth called milk teeth.

Most of the adult men and women have a total of 32 teeth. Of these, 16 are in the upper jaw and 16 are in the lower jaw. The 16 teeth of each jaw consist of 4 incisors, 2 canines, 4 premolars and 6 molars. The teeth of upper jaw match with the teeth of lower jaw.

**Milk Teeth and Permanent Teeth**

In human beings, the teeth grow twice. First time the teeth grow when one is a small baby (or infant). This set of teeth is called milk teeth. Thus, **the first set of teeth which grow during infancy (babyhood) are called milk teeth.** Milk teeth are a temporary set of teeth. The milk teeth loosen and begin to fall off at the age between 6 and 8 years. When milk teeth fall off in a child, then another set of teeth grow in their place. So, second time the teeth grow when one is a child. **The second set of teeth is called permanent teeth.** The permanent teeth grow in place of milk teeth. The permanent set of teeth remains till the old age. But when old people lose their permanent teeth, then new teeth do not grow in their place.

**Tooth Decay**

The white, hard outer covering of tooth is called enamel (see Figure 6). The part of tooth below the enamel is called dentine. Dentine is similar to bone. Inside the dentine is pulp cavity which contains nerves and blood vessels. If the teeth are not cleaned regularly, then tooth decay can take place. **Tooth decay is a process in which the tooth becomes rotten due to the formation of cavities (holes) inside it leading to toothache.** Tooth decay occurs as follows.

If we do not clean our teeth and mouth after eating food, then many harmful bacteria begin to grow and live on the teeth. These bacteria act on the sugar present in the left-over food particles sticking to the teeth to form acid. The acid thus formed eats up the enamel and dentine of the tooth gradually and ultimately makes a cavity (or hole) in the tooth [see Figure 7(a)]. When this cavity (or hole) reaches the pulp cavity of the tooth (which contains nerves), our tooth becomes painful and we get toothache [see Figure 7(b)]. If the cavities

![Figure 6. Parts of a tooth.](image)

![Figure 7. Tooth decay.](image)
caused by tooth decay are not treated in time (by fillings, etc.) by a dentist, then it causes severe toothache. In extreme cases, tooth decay can lead to the loss of whole tooth (because it may require extraction). **Excessive use of sugar containing foods such as sweets, chocolates, toffees, ice cream and cold drinks, etc., are the major cause of tooth decay.** Tooth decay can be prevented in the following ways:

1. We should rinse the mouth thoroughly with clean water after every meal.
2. We should clean our teeth with a brush and toothpaste at least twice a day.
3. A dental floss should be used to take out food particles trapped between the teeth. (Dental floss is a soft thread used to clean between the teeth).
4. We should eat less of sugary foods such as sweets, chocolates, toffees, and ice cream, etc. Too many cold drinks should also be avoided (this is because *sugar + bacteria = acid* which eats up tooth).

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**TONGUE**

The tongue is a fleshy muscular organ in the mouth which is attached at the back to the floor of the buccal cavity (mouth cavity). It is free at the front and can be moved in all directions. The various functions of the tongue are as follows:

1. The tongue helps in mixing saliva with food during chewing (which is essential for the digestion of food).
2. The tongue helps in swallowing the food into the food pipe.
3. The tongue helps in getting the taste of food.
4. The tongue is essential for talking (or speaking).

We have just said that the tongue helps in getting the taste of food. Let us discuss it in somewhat detail. **There are four types of tastes: sweet, salty, sour and bitter.** For example, sugar solution has a sweet taste, common salt solution has a salty taste, lemon juice has a sour taste whereas an extract of neem leaves or bitter gourd (karela) has a bitter taste. The cold, strong and unsweetened coffee, and medicines like aspirin also have a bitter taste.

The tongue has taste buds which detect different tastes of food. In fact, our tongue has four kinds of taste buds which detect sweet, salty, sour and bitter tastes. The taste buds for each of these tastes are located in different parts of the tongue. Thus, all the parts of the tongue do not sense all the four tastes. Different parts of the tongue are sensitive to different tastes. Figure 8 shows the positions of different taste buds on the tongue.

(i) Most taste buds at the front of the tongue detect sweet and salty tastes. The maximum effect of sweet taste is felt at the tip of the tongue whereas the maximum effect of salty taste is felt just behind the tip of the tongue (see Figure 8).

(ii) Most of the taste buds on the sides of the tongue detect sour taste (see Figure 8).

(iii) Most of the taste buds at the back of the tongue detect bitter taste (see Figure 8).

We can distinguish between ice and ice cream (even with our eyes closed) from their taste. A piece of ice kept on the tongue will appear to be tasteless whereas a piece of ice cream will give a sweet taste.

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**DIARRHOEA**

The condition in which a person passes out watery stools frequently is called diarrhoea. Diarrhoea is called ‘dast’ in Hindi. Diarrhoea may be caused by an infection (due to disease-causing microorganisms), food poisoning or indigestion. Diarrhoea is a kind of disease. Diarrhoea is very common in India particularly among children. In fact, diarrhoea is one of the major causes of death of small children in our country. Diarrhoea leads to the loss of water and salts from the body of a person (through frequent watery stools). The loss of water from the body of a person through watery stools is called dehydration.
The sudden loss of too much water (or dehydration) makes a person dangerously ill in a very short time. Excessive dehydration of body caused by diarrhoea can even lead to death. So, diarrhoea should never be neglected.

In order to prevent dehydration, the person suffering from diarrhoea should be given a solution of sugar and salt in clean water, many times a day. The solution of sugar and salt in water is called Oral Rehydration Solution (ORS) (because it is given to the person orally, through mouth). We can make an oral rehydration solution ourselves by dissolving a teaspoonful of sugar and a pinch of salt in a glass of clean water. The water used for this purpose should be first boiled and then cooled (so as to make it germ-free). Oral rehydration solution makes up the loss of water and salt in the body. The sugar gives energy which helps in speedy recovery. Thus, the dehydration of body can be prevented during diarrhoea by giving oral rehydration solution regularly to the patient. Meanwhile, a doctor should be called in for giving medicines to cure the cause of diarrhoea.

**SOME ANIMALS EAT GRASS AS FOOD**

The herbivorous animals such as cattle (cows, buffaloes), goat, sheep, deer, antelope and giraffe, etc., eat mainly grass and other plant leaves as food. Grass is rich in a carbohydrate called cellulose (which acts as a source of energy). Cellulose carbohydrate is a quite tough material so ‘more times’ it is chewed by the animal, the better. The cellulose carbohydrate present in grass can be digested by the action of certain bacteria which are present only in the stomach of animals called ruminants like cattle (cows, buffaloes), goat, sheep, deer, antelope, giraffe, etc. Thus, in herbivorous animals (grass eating animals), the stomach is adapted to digest the food like grass and leaves. We will now describe the digestion in grass-eating animals like cow in detail.

**DIGESTION IN GRASS-EATING ANIMALS**

The animals (such as cow) which eat grass have a special stomach to digest the tough cellulose carbohydrate present in grass. The stomach of a cow is large and consists of four compartments (or four chambers). The first compartment of a cow’s stomach is the biggest and it is called ‘rumen’ (see Figure 9). When cow eats grass as food while grazing, it does not chew it completely (because it has no time for it). The cow swallows the grass quickly with little chewing and stores it in the rumen (which is the first compartment of stomach). The rumen contains cellulose digesting bacteria. The bacteria present in the rumen of a cow start to digest cellulose carbohydrate present in grass food. Thus, the grass is partially digested in the rumen. The partially digested food (or partially digested grass) in the rumen of a cow is called cud.

After some time, when the cow is resting, the cud from rumen is brought back to the mouth of cow in small amounts at a time. The cow now chews the cud thoroughly. This is why many times we see a cow (or buffalo) moving its jaws from side to side and chewing continuously even when it is not eating grass. The process by which the cud (partially digested food) is brought back from the stomach to the mouth of the animal and chewed again is called rumination (or chewing the cud). All the animals which chew the cud are called ruminants.

When the cud is thoroughly chewed in the mouth of the cow, it is swallowed again. But this chewed cud does not go back to rumen. The thoroughly chewed cud now goes into the other compartments of the cow’s stomach and then into the small intestine for complete digestion and absorption.
The ruminants (like cow) cannot chew their food (grass) completely at the time when they eat it because they have very short time available for grazing grass. So, they want to store as much grass as possible in their stomach in the short time available to them. The animals called ruminants can survive on grass as food because they have certain bacteria in the rumen part of their stomach which can digest the cellulose carbohydrate present in grass (and other plant leaves). The cellulose digesting bacteria are not present in the body of human beings due to which human beings cannot digest cellulose carbohydrate present in plant foods. We (human beings) cannot survive by eating only grass (or raw leafy vegetables) because these foods contain mainly cellulose carbohydrate and our body does not have bacteria which can digest cellulose carbohydrate.

So far we have discussed the digestion in human beings and other animals which possess digestive system (made up of a number of organs working together). There are, however, many small animals which do not have a mouth and a digestive system. One example of an organism having no fixed mouth and no digestive system is a tiny animal called Amoeba. We will now discuss how such organisms take in food (ingest food) and digest it.

**AMOEBA**

Amoeba is a microscopic organism (very small organism) which consists of a single cell (see Figure 10). Actually, Amoeba is the simplest animal. Amoeba lives in pond water. Amoeba is so small that it can hardly be seen with naked eyes. The structure of Amoeba given in Figure 10 is as seen through a microscope. Amoeba has a cell membrane, a round, dense nucleus, and many small bubble-like vacuoles in its cytoplasm. The vacuoles in Amoeba are of two types: food vacuoles and contractile vacuoles. A food vacuole consists of a bubble of water containing the food particle captured by Amoeba. The contractile vacuole is a bubble of liquid. It controls the amount of water present in the body of Amoeba. The most important feature of Amoeba is that it has no fixed shape. The shape of Amoeba keeps on changing constantly. The shape of Amoeba changes because it can make its cytoplasm flow in any direction it wants to. The body of Amoeba has finger-like projections which are called pseudopodia (or false feet). Amoeba can produce pseudopodia on any side by pushing the cytoplasm in that side. Amoeba moves very slowly with the help of pseudopodia (which keep on appearing and disappearing when it moves). Amoeba also uses its pseudopodia to catch food particles from the surroundings.

**Feeding and Digestion in Amoeba**

Amoeba eats (or feeds on) tiny plants and animals present in pond water where it lives. Amoeba takes in food (or ingests food) by using pseudopodia. When a food particle comes near Amoeba, then Amoeba...
produces two pseudopodia around the food particle and surrounds it [see Figure 11(a)]. The two pseudopodia then join around the food particle and trap the food particle with a little water forming a food vacuole inside the *Amoeba* [see Figure 11(b)]. The food vacuole is like a temporary stomach of *Amoeba*. The food is digested in food vacuole. This happens as follows: The surrounding cytoplasm secretes digestive enzymes into the food vacuole [see Figure 11(b)]. The digestive enzymes break the food particle into simpler substances. In this way, the food gets digested. The digested food present in food vacuole is absorbed directly into the cytoplasm by the process of diffusion [see Figure 11(c)]. After the absorption of food, the food vacuole disappears. The absorbed food is used for the production of energy, maintenance and growth of *Amoeba* [see Figure 11(d)]. *Amoeba* has no fixed place (like anus) for removing the undigested food. When a considerable amount of undigested food collects inside *Amoeba*, then its cell membrane suddenly ruptures at any place and the undigested food is thrown out (or egested) from the body of *Amoeba* [see Figure 11(e)].

A similarity between the nutrition in *Amoeba* and human beings is that in both the cases digestive juices break down the complex food particles into simpler substances (which can be absorbed). A difference is that *Amoeba* has no mouth and no digestive system whereas a human being has a mouth and a digestive system made up of many organs. We are now in a position to answer the following questions:

**Very Short Answer Type Questions**

1. What is the scientific name of the process of ‘taking food into the body’?
2. Name the substance which mixes with food in the mouth during chewing by teeth.
3. Name the process which moves the food forward in the food pipe as well as the whole alimentary canal.
4. (a) Where is the water from undigested food absorbed in the body?
   (b) Where is the digested food absorbed into the blood?
5. What is the other name of food pipe?
6. The bacteria present on uncleaned teeth convert the sugar in food into a substance X which causes tooth decay. Name the substance X.
7. Name the type of teeth which are:
   (a) for chewing and grinding food.
   (b) for piercing and tearing food.
   (c) for biting and cutting food.
8. What is the name of the set of teeth:
   (a) which grow in a small baby?
   (b) which grow in a child?
9. Which teeth in human beings are replaced by permanent teeth?
10. At what age do the milk teeth fall off in children?
11. Which organ helps in getting the taste of food which we eat?
12. Which two tastes can be detected by the front part of the tongue?
13. Which taste of food can be detected:
   (a) by the sides of the tongue?
   (b) by the back part of the tongue?
14. What is the special name of the animals which can chew the cud?
15. What type of micro-organisms digest cellulose carbohydrate present in the grass food of a ruminant?
16. Which single-celled organism has pseudopodia?
17. Name a single-celled organism (animal) which constantly changes its shape.
18. What are the false feet of *Amoeba* known as?
19. Name the parts of *Amoeba* which help it in moving and also in capturing the food.
20. Name the condition in which a person passes out frequent watery stools.
21. Name one condition (or disease) which can lead to the dehydration of our body.
22. Write the full form of ORS.
23. What happens when glucose breaks down in body cells with the help of oxygen?
24. State whether the following statements are true or false:
   (a) The tongue helps in mixing saliva with food.
(b) Digestion of starch starts in the stomach.
(c) The gall bladder stores bile temporarily.
(d) The ruminants bring back swallowed grass into their mouth and chew it for sometime.

25. Fill in the following blanks with suitable words:
(a) The largest gland in the human body is .................
(b) The stomach releases hydrochloric acid and .......... juices which act on food.
(c) The inner wall of the small intestine has many finger-like outgrowths called .................
(d) When the digestion of food is completed, the carbohydrates get broken down into ......, proteins into ...... and fats into ...... and ........
(e) The alimentary canal together with the associated glands constitutes the ...... system.
(f) Permanent teeth grow in place of ............... teeth.
(g) Tooth decay happens when the bacteria present in mouth turn the sugar present in our food into ............
(h) The partially digested food which is brought back from stomach to mouth of an animal for re-chewing is known as ..........
(i) An example of the animal which can chew the cud is .............
(j) The finger-like projections on the body of Amoeba are called .............
(k) Amoeba digests its food in the ..........

Short Answer Type Questions

26. (a) What is the role of mucus in stomach ?
(b) What is the role of hydrochloric acid in stomach ?
27. What is alimentary canal ? Name the various parts of alimentary canal and the associated glands.
28. Match the items of column I with those given in column II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food components</td>
<td>Products of digestion</td>
</tr>
<tr>
<td>(i) Carbohydrates</td>
<td>(a) Fatty acids and glycerol</td>
</tr>
<tr>
<td>(ii) Proteins</td>
<td>(b) Sugar (Glucose)</td>
</tr>
<tr>
<td>(iii) Fats</td>
<td>(c) Amino acids</td>
</tr>
</tbody>
</table>

29. What is the action of saliva on food ?
30. Which part of the alimentary canal is involved in :
   (a) absorption of food ?
   (b) chewing of food ?
   (c) killing of bacteria ?
   (d) complete digestion of food ?
   (e) formation of faeces ?
31. Which organ of the body secretes bile ? Where is bile stored ? What is the function of bile in the digestion of food ?
32. What is the food of a butterfly ? How does butterfly get this food ?
33. What are the modes of taking food into the body used by the following animals ?
   Frog, Snakes, Mosquitoes, Lice, Housefly, Ant, Snail
34. Match the items of column I with suitable items in column II :

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Salivary glands</td>
<td>(a) Bile juice secretions</td>
</tr>
<tr>
<td>(ii) Stomach</td>
<td>(b) Storage of undigested food</td>
</tr>
<tr>
<td>(iii) Liver</td>
<td>(c) Saliva secretion</td>
</tr>
<tr>
<td>(iv) Rectum</td>
<td>(d) Acid release</td>
</tr>
<tr>
<td>(v) Small intestine</td>
<td>(e) Digestion is completed</td>
</tr>
<tr>
<td>(vi) Large intestine</td>
<td>(f) Absorption of water</td>
</tr>
<tr>
<td>(vii) Anus</td>
<td>(g) Release of faeces</td>
</tr>
</tbody>
</table>
35. What are villi ? Where are villi located ? What is the function of villi ?
36. Where is the bile produced ? Which component of food does it digest ?
37. Why do we get instant energy from glucose ?
38. What is Amoeba ? Where is it found ? Write one similarity and one difference between the nutrition in Amoeba and human beings.
39. How does Amoeba take in (ingest) the food? From which part of the body undigested food is egested in Amoeba?

40. Name the various kind of teeth in our mouth. State their functions.

41. How many teeth does an adult man have? What is the number of the following types of teeth in one jaw?
   (a) incisors  (b) canines  (c) premolars  (d) molars

42. How would you distinguish between ice and ice-cream with your eyes closed?

43. State the various functions of the tongue? Name four different tastes which can be detected by our tongue.

44. Can we survive only on grass and raw leafy vegetables? Give reason for your answer.

45. Which parts of the tongue detect the following tastes?
   (a) Bitter  (b) Sweet  (c) Sour  (d) Salty

Long Answer Type Questions

46. What is meant by digestion? Name the various organs of the human digestive system. Also name the associated glands. Draw a labelled diagram of the human digestive system.

47. What is meant by tooth decay? Name some of the foods which are the major cause of tooth decay. What are the various ways of preventing tooth decay?

48. Describe with the help of labelled diagrams, how feeding and digestion in Amoeba takes place.

49. (a) What are ruminants? Which of the following are ruminants?
    Fish, Amoeba, Cow, Humans, Dogs, Sheep, Buffalo, Deer, Goat, Giraffe
    (b) Name the type of carbohydrate that can be digested by ruminants but not by humans. Give the reason also.

50. Name the three things secreted by the inner lining of our stomach. Also state their functions. What is the function of large intestine?

51. What are incisors, canines, premolars and molars? State their functions.

52. (a) What is the taste of neem leaves extract or bitter gourd (karela)? Which part of the tongue can detect this taste?
    (b) What is the taste of lemon juice? Which part of the tongue can detect this taste?
    (c) Draw a sketch of the tongue. Label the parts of the tongue which detect sweet, salty, sour and bitter tastes.

53. (a) What is meant by the term “rumination”? Name any two ruminants.
    (b) Explain why, a cow can digest grass but we cannot.

54. What is diarrhoea? How is diarrhoea caused? Why does dehydration take place during diarrhoea? How can dehydration be prevented?

55. What is oral rehydration solution? How can you make the oral rehydration solution at home? When is it given to a person?

Multiple Choice Questions (MCQs)

56. Which of the following foods is not obtained from plants?
    (a) maize  (b) milk  (c) mango  (d) melon

57. The process of taking in food by an animal and its utilisation in the body is called:
    (a) ingestion  (b) digestion  (c) nutrition  (d) egestion

58. Which one of the following does not suck nectar from flowers?
    (a) butterfly  (b) bee  (c) lizard  (d) hummingbird

59. The aquatic animal which ingests food with the help of pseudopodia is:
    (a) Eagle  (b) Fish  (c) Aquatic snake  (d) Amoeba

60. Which of the following is digested by saliva?
    (a) glucose  (b) starch  (c) cellulose  (d) sucrose

61. Mucus, hydrochloric acid and digestive juices are secreted by the inner lining of:
    (a) pancreas  (b) stomach  (c) small intestine  (d) salivary glands

62. The site of complete digestion and absorption of food in the human digestive system is:
    (a) stomach  (b) small intestine  (c) large intestine  (d) rectum

63. The millions of tiny outgrowths on the inner surface of small intestine are called:
    (a) capillaries  (b) buds  (c) villi  (d) veins
64. The length of small intestine in adult human beings is about:
   (a) 1.5 m (b) 2.5 m (c) 7.5 m (d) 4.5 m

65. The amino acids present in digested food in our body are used to make:
   (a) fats (b) proteins (c) minerals (d) carbohydrates

66. The fat present in our food is completely digested in the:
   (a) stomach (b) mouth (c) small intestine (d) large intestine

67. Water from the undigested food is absorbed mainly in the:
   (a) stomach (b) food pipe (c) small intestine (d) large intestine

68. The digestion of a particular food in the small intestine produces amino acids. This food must contain mainly:
   (a) carbohydrates (b) fats (c) vitamins (d) proteins

69. The digestion of groundnut oil present in food produces:
   (a) Amino acid (b) Glycerol (c) Alcohol (d) Fatty acid

70. Some crushed boiled rice, water and saliva mixture is warmed in a test-tube for about 15 to 20 minutes and 2 or 3 drops of dilute iodine solution are added to it. The colour produced will be:
   (a) violet (b) green (c) blue-black (d) none of these

71. The teeth in our mouth which are for piercing and tearing the food are called:
   (a) incisors (b) canines (c) molars (d) premolars

72. Which of the following are for biting and cutting the food?
   (a) premolars (b) canines (c) molars (d) incisors

73. In human beings, the 16 teeth of each jaw consist of:
   (a) 2 incisors, 4 canines, 4 premolars and 6 molars
   (b) 4 incisors, 2 canines, 6 premolars and 4 molars
   (c) 4 incisors, 2 canines, 4 premolars and 6 molars
   (d) 2 incisors, 4 canines, 6 premolars and 4 molars

74. The part of our tooth which contains nerves and blood vessels is called:
   (a) gum (b) pulp cavity (c) enamel (d) dentine

75. Excessive use of sugar containing foods is a major cause of:
   (a) indigestion (b) stomach pain (c) headache (d) tooth decay

76. Which of the following carbohydrate can be digested by a cow but not by a man?
   (a) glucose (b) cellulose (c) starch (d) canesugar

77. *Amoeba* catches food particles from the surrounding water by using its:
   (a) tentacles (b) food vacuole (c) pseudopodia (d) cilia

78. An animal which has no mouth and no digestive system is:
   (a) Antelope (b) Amoeba (c) Alligator (d) Angora

79. Which of the following is an incorrect statement in respect of *Amoeba*:
   (a) It has no fixed shape (b) It has no fixed mouth
   (c) It has false feet (d) It has a digestive system

80. Which of the following can digest cellulose carbohydrate present in its food?
   (a) cow (b) lion (c) cat (d) man

**Questions Based on High Order Thinking Skills (HOTS)**

81. When food is put in our mouth, the teeth cut, chew and grind it. The glands A present in mouth secrete a watery liquid B which helps to digest component C present in the food partially. This partially digested food then passes through tube D into an organ E. The inner walls of organ E secrete mucus, hydrochloric acid and digestive juices.
   (a) What are (i) A (ii) B (iii) C (iv) D, and (v) E ?
   (b) Name the component of food which is broken down by the digestive juices secreted by E.

82. The partially digested food coming from the stomach enters into a long and narrow tube P. Here, liver secretes a liquid called Q which converts fats into tiny droplets. Pancreatic juice breaks down fats completely into R and S. The intestinal juice breaks down the starch carbohydrate completely into T.
whereas proteins are broken down into U.

(a) What are (i) P (ii) Q (iii) R (iv) S (v) T, and (vi) U?
(b) Name the sac in which liquid Q is stored temporarily.

83. The digested food in small intestine is absorbed into blood vessels in the walls of small intestine through millions of tiny finger-like outgrowths called W. The undigested and unabsorbed food from the small intestine enters into another organ X. The organ X absorbs most of the water from the undigested waste food material making it semi-solid. This semi-solid waste is stored in part Y of organ X for some time. It is passed out from the body through part Z in the form of faeces.
(a) What are (i) W (ii) X (iii) Y, and (iv) Z?
(b) What is the name of the process in which undigested waste is thrown out of the body?

84. If we do not clean our teeth and mouth after eating food, then many harmful micro-organisms called A begin to grow and live on the tooth. These micro-organisms act on the substance B present in the left-over food material making it semi-solid. This semi-solid waste is stored in part Y of organ X for some time. It is passed out from the body through part Z in the form of faeces.
(a) What are (i) A (ii) B (iii) C (iv) D (v) E, and (vi) F?
(b) What name is given to the process in which the tooth becomes rotten due to the formation of holes in it?

85. Some crushed boiled rice is put in water in a test-tube and a few drops of dilute iodine solution are added to it. A blue-black colour is produced which shows the presence of X in rice. If, however, the crushed boiled rice and water are first warmed with saliva for some time and then dilute iodine solution is added, then no blue-black colour is produced. This shows that saliva converts X into product Y which does not produce blue-black colour with dilute iodine solution.
(a) Name (i) X, and (ii) Y?
(b) What does the above activity tell us about the role of saliva in the digestion of food?

ANSWERS

1. Ingestion  2. Saliva  3. Peristalsis  4. (a) Large intestine  (b) Small intestine  5. Oesophagus
6. Acid  14. Ruminants  15. Cellulose digesting bacteria  20. Diarrhoea  21. Diarrhoea  22. Oral Rehydration Solution  23. Energy is produced  24. (a) True  (b) False  (c) True  (d) True  25. (a) liver (b) digestive (c) villi (d) glucose ; amino acids ; fatty acids ; glycerol (e) digestive (f) milk (g) acid (h) cud (i) cow (j) pseudopodia (k) food vacuole  28. (i) b (ii) c (iii) a  34. (i) c (ii) d (iii) a (iv) b (v) e (vi) f (vii) g  37. Glucose is a kind of pre-digested food (so it has not to go through the slow digestive process in our body). Glucose solution is immediately absorbed by our body. The absorbed glucose then combines with oxygen to give us quick energy (or instant energy)  49. (a) Cow, Sheep, Buffalo, Deer, Goat, Giraffe  (b) Cellulose  56. (b) 57. (c) 58. (c) 59. (d) 60. (b) 61. (b) 62. (b) 63. (c) 64. (c) 65. (b) 66. (c) 67. (d) 68. (d) 69. (d) 70. (d) 71. (b) 72. (d) 73. (c) 74. (b) 75. (d) 76. (b) 77. (c) 78. (b) 79. (d) 80. (a) 81. (a) Salivary glands (ii) Saliva (iii) Starch (iv) Oesophagus (or Food pipe) (v) Stomach (b) Proteins  82. (a) (i) Small intestine (ii) Bile (iii) Fatty acids (iv) Glycerol (v) Glucose (vi) Amino acids (b) Gall bladder  83. (a) (i) Villi (ii) Large intestine (iii) Rectum (iv) Anus (b) Egestion  84. (a) (i) Bacteria (ii) Sugar (iii) Acid (iv) Enamel (v) Dentine (vi) Pulp cavity (b) Tooth decay  85. (a) (i) Starch (ii) A sugar (Maltose)  (b) Saliva helps in digesting starch carbohydrate present in food.
Natural fibres are threads obtained from plants and animals. In Class VI we have learnt about some fibres obtained from plants which are used to make fabric (or cloth). For example, cotton plants give us cotton fibres which are used for making cotton fabrics (or cotton cloth). Cotton, flax and jute are all plant fibres. In this chapter we will study about the fibres which are obtained from animals and hence called animal fibres. The two important animal fibres are:

1. Wool,
2. Silk.

Wool comes from animals such as sheep, goat and yak, etc., whereas silk comes from silkworms. So, wool and silk are animal fibres. Wool is used for knitting sweaters and weaving shawls and other woollen cloth. Silk is used for making saris and other dresses. We will now discuss the production of wool and silk in detail, one by one. Let us start with wool.

**WOOL**

Wool is the most commonly used animal fibre. Wool is the soft, wavy (or curly) hair which covers the body of a sheep. Actually, wool is a modified form of hair that grows with a waviness. Because of the waviness of wool, the woollen fabrics have a greater bulk (than cotton fabrics) and hence trap more air. Due to this, woollen fabrics keep us more warm during cold, winter days. Wool comes from sheep. Actually, wool is obtained from the fleece (or hair) of sheep. Sheep grow wool on their body and once a year, this wool is sheared (cut off). Though wool comes mainly from sheep, some other animals also give us wool. This is discussed below.

**Animals That Yield Wool**

Wool comes from the animals like sheep, goat, yak, camel, llama and alpaca. In other words, the wool-yielding animals are sheep, goat, yak, camel, llama and alpaca (see Figure 1). The wool-yielding animals bear a thick coat of hair on their body. It is this hair which gives us wool. Actually, the wool-yielding
Figure 1. The animals which provide us wool.

**Figure 1. The animals which provide us wool.** The hair (or wool) trap a lot of air. *Air is a poor conductor of heat.* So, the air trapped in hair (or wool) of these animals prevents their body heat from being lost to cold surroundings and keeps them warm in winter. This is why the hair (or wool) of these animals is removed only once in a year at the beginning of summer season. They can survive in hot weather without hair. And by the time winter comes, the thick hair (or wool) grows again on the body of these animals.

**Wool is most commonly obtained from sheep.** Sheep are reared in many parts of India for getting wool. The names of some of the breeds of sheep reared in our country for obtaining wool, the quality of wool obtained and the names of states where these sheep are found, are given in the table below.

<table>
<thead>
<tr>
<th>Name of breed of sheep</th>
<th>Quality of wool</th>
<th>Name of the state where found</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lohi</td>
<td>Good quality wool</td>
<td>Rajasthan, Punjab</td>
</tr>
<tr>
<td>2. Rampur bushair</td>
<td>Brown fleece</td>
<td>Uttar Pradesh, Himachal Pradesh</td>
</tr>
<tr>
<td>3. Nali</td>
<td>Carpet wool</td>
<td>Rajasthan, Haryana, Punjab</td>
</tr>
<tr>
<td>4. Bakharwal</td>
<td>For woollen shawls</td>
<td>Jammu and Kashmir</td>
</tr>
<tr>
<td>5. Marwari</td>
<td>Coarse wool</td>
<td>Gujarat</td>
</tr>
<tr>
<td>6. Patanwadi</td>
<td>For hosiery</td>
<td>Gujarat</td>
</tr>
</tbody>
</table>

The hairy skin of sheep has two types of fibres that form its fleece (or wool coat): *(i)* the coarse beard hair, and *(ii)* the fine, soft under-hair, close to the skin. The fine hair provide the fibres for making wool. Some breeds of sheep possess only fine under-hair. Their parent sheep are specially chosen so as to give birth to sheep which have only soft under-hair. **The process of selecting parent sheep for obtaining special characteristics in their offspring (such as soft under-hair) is called ‘selective breeding’.** The natural colour of wool is generally creamy white though some breeds of sheep produce wool having brown and black colours.

Wool is also obtained from ‘goat hair’. The under-fur of Kashmiri goat is soft. It is woven into fine shawls called ‘Pashmina shawls’. Angora wool is obtained from Angora goats which are found in the hilly
regions such as Jammu and Kashmir. Yaks have thick and long hair on their body which yield wool. Yak wool is common in the hilly regions of Tibet and Ladakh. The hair (or fur) on the body of camels are also used as wool. The animals called llama and alpaca (which are found in South America) have hair on their body which are processed to yield wool. Please note that though the hair on the body of animals such as sheep, goat and yak, etc., constitute wool, but in everyday language wool means the ‘processed wool’ which is the ‘wool yarn’ used for knitting sweaters or making shawls, etc.

**PRODUCTION OF WOOL**

**Wool comes mainly from sheep.** In order to obtain wool, sheep are reared and bred; their hair is cut and processed into wool. We will first discuss the rearing and breeding of sheep, and then describe how the sheep’s hair (called fleece) are cut and processed to make wool (or wool yarn).

**Rearing and Breeding of Sheep**

Rearing of sheep means to look after the sheep by providing them feed (food), shelter and health care. The persons who look after the sheep (or rearers) are called shepherds. Sheep are herbivores and prefer to eat grass and leaves. So, shepherds take the herds of sheep to countryside for grazing. Apart from grazing grass, the sheep are also fed mixture of pulses, corn, jowar, oil cakes (oil cake is the material left after the extraction of oil from oil-seeds), and minerals. In winter, sheep are kept indoors and fed on leaves, grains and dry fodder.

Certain breeds of sheep have a thick coat of hair on their body which yields good quality wool in large quantities. These are called sheep of good breeds. Such sheep are ‘selectively bred’ by choosing at least one parent sheep of good breed. So, the breeding of sheep is done to obtain such breeds of sheep which yield good quality wool in large quantities. This raises the quality and quantity of wool produced.

Once the reared sheep have developed a thick coat of hair, the hair is cut off for getting wool. The cut off ‘wool coat’ of a sheep (alongwith a thin layer of skin) is called fleece. The fleece consists of soft woollen fibres. The fleece of sheep is usually kept in ‘one piece’.

**How Wool is Obtained From Sheep**

The ‘yarn’ which we use for knitting sweaters or weaving shawls, etc., is called wool. Wool is obtained from the sheep by a long process which involves the following steps : Shearing, Scouring, Sorting, Dyeing, Combing and Spinning. We will now describe all these steps for obtaining wool, one by one.

(i) **Shearing.** The hair of sheep alongwith a thin layer of skin (called fleece) are removed from the body of sheep. The process of removing hair (or cutting off hair) from the body of a sheep in the form of fleece is called shearing (see Figure 2). The hair of sheep are cut off by using a cutting machine similar to that used by barbers. The hairy skin of sheep is removed in ‘one piece’ (and it is called fleece). Shearing does not hurt the sheep because the uppermost layer of the skin of sheep is ‘dead’. The shearing (cutting the hair) of sheep is done in the hot weather of summer so that sheep may survive without their protective coat of hair. The hair of sheep grow again before the onset of winter and protect them in cold weather. The fleece (or hair) of sheep provide woollen fibres. Woollen fibres are then processed to obtain woollen yarn.

(ii) **Scouring.** The fleece of sheep (or cut hair of sheep) contain dust, dirt, dried sweat and grease, etc. So, the fleece must be cleaned before it can be processed into wool yarn. The fleece (or sheared hair) of sheep is thoroughly cleaned by washing with soap (or detergent) and a lot of water in tanks. The fleece of sheep contain dust, dirt, dried sweat and grease, etc. So, the fleece must be cleaned before it can be processed into wool yarn. The fleece (or sheared hair) of sheep is thoroughly cleaned by washing with soap (or detergent) and a lot of water in tanks.
The process of washing the fleece (cut hair of sheep) that removes dust, dirt, dried sweat and grease is called scouring (see Figure 3). Scouring makes the fleece of sheep clean. The scoured fleece (or washed fleece) is then dried.

(iii) Sorting. The wool is not uniform in all the parts of fleece of a sheep. Some parts of fleece have fine wool fibres whereas others have coarse wool fibres. Some parts of fleece have long wool fibres whereas others have short wool fibres. So, the fleece of even same sheep has wool of different qualities. In sorting, the fleece is sent to a factory where it is broken and separated into sections of different quality fibres. The process of separating the fleece of a sheep into sections according to the quality of woollen fibres (such as fine, coarse, long, short, etc.) is called sorting. Every section of wool obtained after sorting contains the same quality wool (or uniform wool). The same quality wool obtained from the fleece of large number of sheep are then mixed together.

(iv) Dyeing. The natural fleece or hair of sheep (or goats) is white, brown or black in colour. The white woollen fibres obtained by sorting can be dyed in different colours.

(v) Combing. Combing is a method to prepare woollen fibres for spinning the yarn. This is done by using combs having metal teeth. The process of combing straightens the entangled woollen fibres and also removes the small fluffy fibres (called ‘burrs’) which may be caught in them.

(vi) Spinning. The long woollen fibres are spun (or twisted) into thick yarn called ‘wool’ (which is used for knitting sweaters, etc.). The short woollen fibres are spun into fine yarn and then woven on a loom to make woollen cloth (like shawls, etc.).

From the above discussion we conclude that the sheep’s hair is sheared off from the body, scoured, sorted, dyed, combed and spun to obtain wool (for knitting sweaters) and woollen yarn (for weaving woollen cloth). The quality of woollen cloth depends on the breed of sheep from which wool is obtained.

**Occupational Hazard**

Wool industry is an important source of livelihood for many people in our country. The people who do the job of sorting (separating) the fleece of sheep into fibres of different qualities are called ‘sorters’. The sorter’s job is very risky because sometimes they get infected by the bacteria called ‘anthrax’ which cause a deadly blood disease called ‘sorter’s disease’. The risks faced by people working in any industry due to the ‘nature of their work’ are called occupational hazards. Sorter’s disease is an occupational hazard.

**SILK**

Silk is a fine, strong, soft and shining fibre produced by silkworms in making their cocoons. Silk is called ‘resham’ in Hindi. Silk is a natural fibre which is obtained from an insect (called silk moth). So, silk is an animal fibre. Silk fibre is made of a protein. Silk is the strongest natural fibre. The soft looking silk yarn is as strong as a comparable thread of steel! Silk fibres are converted into silk yarn which is used for making silk cloth. This silk cloth is then used for making saris and other dresses.

The rearing of silkworms for obtaining silk is called sericulture. ‘Sericulture’ means ‘silk farming’. Sericulture is a very old occupation in India. India produces a lot of silk on commercial scale. Before we go further and describe the process of obtaining silk, it is necessary to know the life history of silk moth. This is described on the next page.
**Life History of Silk Moth**

Silk moth is a kind of insect (which resembles a butterfly). Life history of silk moth is interesting because silk moth is not formed as such from the eggs directly. The silk moth passes through a worm-like stage called ‘larva’ or ‘caterpillar’ (which is also called silkworm) and an encased form called ‘pupa’ during its development between the hatching of egg and formation of adult silk moth. This can be written as:

Egg $\rightarrow$ Larva (or Caterpillar) $\rightarrow$ Pupa $\rightarrow$ Silk moth (Silkworm)

The larva (or caterpillar) and pupa stages in the life history of a silk moth are totally different in appearance from the adult silk moth. It is the larva (or caterpillar) of a silk moth which produces silk and not the adult silk moth. The larva (or caterpillar) of a silk moth which produces silk is called silkworm.

We can describe the life history of silk moth as follows.

(i) The female silk moth lays eggs on the leaves of a tree (such as mulberry tree) [see Figure 4(a)].

(ii) The eggs hatch to form worm-like larvae [see Figure 4(b)]. The larvae of silk moth are called ‘caterpillars’ or ‘silkworms’. The silkworms feed on the leaves of mulberry tree and grow bigger in size. Silk is formed in liquid form in the two glands in the silkworm’s head.

(iii) When the silkworm (or caterpillar) is ready to enter the next stage of its development called pupa, it first weaves a net to hold itself. Then it swings its head from side to side in the form of figure of ‘eight’ (8). During these movements of head, the silkworm secretes silk in liquid form through the tiny opening in its head which solidifies on exposure to air and becomes a silk fibre (or silk thread). Soon the silkworm (or caterpillar) covers itself completely by silk fibres. The silky covering spun by the silkworm (or caterpillar) of silk moth is called cocoon. The cocoon is made by silkworm to protect its development as ‘pupa’. Pupa is a stage in the life history of silk moth when the caterpillar (or silkworm) becomes ‘encased’ in a hard shell of silk fibres called cocoon [see Figure 4(c)]. The silkworm continues to develop in the form of pupa inside the cocoon to form the silk moth.

(iv) When the pupa (encased in cocoon) develops fully to form an adult silk moth, then the cocoon splits up and a beautiful silk moth comes out [see Figure 4(d)]. The adult female silk moth then lays more eggs. In this way, the life history of silk moth is completed.

Please note that in order to produce silk, the silkworm developing inside the cocoon (as pupa) is not allowed to mature into an adult silk moth. So, as soon as the cocoon is formed it is used to obtain silk fibres and the developing silkworm (as pupa) gets killed. This is because if the silkworm (as pupa) is allowed to mature into a silk moth, then the fully formed silk moth secretes a liquid to dissolve a part of silk of the cocoon to break it so as to come out of it and fly away. This breaking of cocoon causes damage...
to its silk threads and hence lowers the quality of silk. This is why the cocoons having developing silkworms inside them are used to obtain silk. Some of the silkworms (as pupae) are, however, allowed to live and mature into silk moths so that they can lay eggs to produce more silkworms. Silk production involves cultivation of mulberry trees and rearing of silkworms. Mulberry is a small tree whose leaves are used for feeding silkworms. Mulberry is called 'shehtoot' in Hindi. We will now describe how silk is actually produced.

**PRODUCTION OF SILK**

In order to obtain silk, mulberry trees are cultivated (grown), silkworms are reared, and their cocoons collected to get silk fibres. We will now describe the rearing of silkworms, processing of cocoons to obtain silk fibres and making of silk fabrics (silk cloth) from silk fibres.

(i) Rearing of Silkworms to Obtain Cocoons

A female silk moth lays hundreds of eggs at a time [see Figure 5(a)]. The eggs of silk moths are stored carefully on paper strips (or cloth strips) and sold to silkworm farmers. The farmers keep these eggs at suitable temperature and humidity under hygienic conditions. The eggs are then warmed to a suitable temperature for hatching. When the eggs hatch, silkworms (larvae or caterpillars) come out of eggs.

![Female silk moth lays eggs](image)
![Silkworms hatched from eggs feed on mulberry leaves](image)
![Cocoons of silk fibres spun by silkworms](image)

Figure 5. Production of silk.

The silkworms are fed cut-up mulberry leaves [see Figure 5(b)]. The silkworms eat day and night and grow big in size. After about 25 to 30 days, the silkworms stop eating and get ready to spin cocoons. The silkworms climb the twigs placed near them and spin cocoons of silk fibres. The silkworms enclose themselves completely inside the silken cocoons in two or three days [see Figure 5(c)].

(ii) Processing of Cocoons to Obtain Silk Fibres

All the cocoons are collected at one place. The pile of cocoons is used for obtaining silk fibres. This is done as follows: The pile of cocoons is placed in hot water. Hot water makes the silk fibres of cocoons to separate out. The long silk fibres are obtained by unwinding the threads from cocoons. The process of taking out silk fibres from the cocoons for use as silk is called reeling. Reeling is done in special machines which unwind the fibres of silk from cocoons.

(iii) Converting Silk Fibres into Silk Cloth

Silk fibres obtained from cocoons are spun (twisted) to form silk threads called ‘silk yarn’. The silk yarn is then woven on looms into silk cloth by the weavers.

**Different Varieties of Silk**

There is a variety of silk moths which look very different from one another. The silk produced by the silkworms of different varieties of silk moths is different in texture (coarse, smooth, shiny, etc.). Some of the varieties of silk are: Mulberry silk; Tassar silk; Mooga silk; Kosa silk; and Eri silk. These silks are obtained from cocoons spun by the silkworms of different types of silk moths. The most common silk
moth is the mulberry silk moth. The silk obtained from the cocoons of mulberry silk moth is called
mulberry silk. Mulberry silk is soft, lustrous (shiny) and elastic, and can be dyed in beautiful colours. Thus,
the most common variety of silk is mulberry silk.

**Natural Silk and Artificial Silk**

Natural silk is obtained from the cocoons of silkworms and it is made of a ‘protein’. Natural silk is an
animal fibre. Artificial silk (called rayon) is obtained from wood pulp and it is made of modified plant
material ‘cellulose’ (Paper is also made of cellulose obtained from wood pulp). We can distinguish
between natural silk (or pure silk) and artificial silk by performing the ‘burning test’.

**ACTIVITY TO DISTINGUISH BETWEEN NATURAL SILK AND ARTIFICIAL SILK**

Take a piece of natural silk fabric and another piece of artificial silk fabric, burn them separately and
observe the smell produced:

(i) The fabric which burns giving a smell of **burning hair** will be natural silk (or pure silk).
(ii) The fabric which burns giving a smell of **burning paper** will be artificial silk (or rayon).

Just like silk, wool is also made of proteins. So, a piece of wool (or woollen fabric) also burns giving the
smell of burning hair.

**Discovery of Silk**

The discovery of silk was made in China a long time back. It is said that the Chinese empress Si-lung-
Chi was asked by the emperor Huang-ti to find the cause of the damaged leaves of mulberry trees in their
garden. The empress found some white worms eating up mulberry leaves. She also noticed that these
worms were spinning shiny cocoons around them. A cocoon dropped into her cup of tea accidently and
delicate silk threads separated from the cocoon. This is how silk was discovered by chance. The discovery
of silk led to the beginning of silk industry in China. The silk production in China was kept a secret for
hundreds of years. Later on traders and travellers coming from China introduced silk to other countries.
The route on which they travelled is still called ‘silk route’. Even today, China leads the world in silk
production. India is also among the leading silk producing countries of the world. In India, a large number
of women are engaged in various activities related to silk production such as rearing of silkworms, reeling
of silk from cocoons and processing of raw silk into fabrics. We are now in a position to answer the
following questions:

**Very Short Answer Type Questions**

1. Name two fibres obtained from animals.
2. Which type of wool is common in Tibet and Ladakh?
3. Where are Angora goats found in our country?
4. Which animal produces wool for making fine Pashmina shawls?
5. Where are the wool-yielding animals called llama and alpaca found?
6. Name any two breeds of sheep found in India.
7. State whether sheep are herbivores or carnivores.
8. What terms are used for the following processes?
   (a) Removing hair of sheep alongwith a thin layer of skin.
   (b) Washing of sheep’s fleece to remove dust, dirt and grease.
   (c) Separating sheep’s fleece into fibres of different qualities.
9. What causes sorter’s disease?
10. Which step comes first in the production of woollen yarn from sheep: scouring or shearing?
11. Name a natural fibre obtained from insects.
12. State whether the following statement is true or false:
    - The adult silk moth spins cocoons from which silk is obtained.
13. Name the tree whose leaves provide food for the silkworms.
14. What are the natural colours of the fleece of sheep and goats?
15. Which stage comes earlier in the life history of a silk moth—pupa or larva?
16. Which of the following actually makes the silk fibres?
   Larva, Pupa, Adult silk moth
17. Which of the following terms is related to silk production?
   Floriculture, Tissue culture, Silviculture, Apiculture, Sericulture
18. Name two fibres which are made of proteins.
19. State whether artificial silk is an animal fibre or a plant fibre.
20. Fill in the following blanks with suitable words:
   (a) The process of selecting parents for obtaining special characteristics in their offsprings is called selective .......... 
   (b) Angora wool is obtained from Angora ........
   (c) Llama and alpaca also yield ........
   (d) Sheep are ........ and prefer grass and leaves.
   (e) Lohi and nali are breeds of ........
   (f) Silk is obtained from the ........ of a silk moth.
   (g) Silk fibres are made of a ........
   (h) Silkworms are ........ of silk moth.
   (i) Silkworms spin ........ of silk fibres.
   (j) The process of taking out threads from the cocoons for use as silk is called .......... the silk.

Short Answer Type Questions

21. What type of feed (or food) is given to sheep?
22. What is meant by the ‘rearing’ and ‘breeding’ of sheep?
23. Name the various steps involved in the production of wool from sheep.
24. Why do wool-yielding animals (like sheep) have a thick coat of hair on their body?
25. Explain why, a woollen garment keeps us very warm in winter.
26. What is an occupational hazard? Name one occupational hazard.
27. What is meant by the term ‘sericulture’?
28. Name the most common silk moth. What are the characteristics of silk fibres obtained from the cocoons of this silk moth?
29. How will you distinguish between natural silk and artificial silk?
30. What is meant by the term ‘reeling the silk’? How is it done?
31. Match the words of column I with those given in column II:

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Scouring</td>
<td>(a) Yields silk fibres</td>
</tr>
<tr>
<td>(ii) Mulberry leaves</td>
<td>(b) Wool yielding animal</td>
</tr>
<tr>
<td>(iii) Yak</td>
<td>(c) Food of silkworm</td>
</tr>
<tr>
<td>(iv) Cocoon</td>
<td>(d) Reeling</td>
</tr>
<tr>
<td></td>
<td>(e) Cleaning sheared wool</td>
</tr>
</tbody>
</table>

32. Name any five animals which yield wool. Which is the most common type of wool available in the market?
33. Name any four types of silk. State whether silk is an animal fibre or a plant fibre.
34. What is a cocoon? Name the fibre of which a cocoon is made.
35. Arrange the following steps in the correct order in which they are carried out during the production of woollen yarn from the sheep:
   Combing, Shearing, Dyeing, Scouring, Spinning, Sorting

Long Answer Type Questions

36. Describe briefly, how wool is obtained from sheep and processed to make woollen yarn.
37. What is meant by the following terms?
   (a) Shearing  (b) Scouring  (c) Sorting
38. Describe the life history of silk moth briefly. Make sketches of the two stages in the life history of silk moth which are directly related to the production of silk.
Describe briefly how silk is produced.

In what type of weather shearing of sheep is done? Why? Why does shearing not hurt the sheep?

Multiple Choice Questions (MCQs)

41. Which of the following does not yield wool?
   (a) yak  (b) camel  (c) goat  (d) woolly dog

42. The silkworm is:
   (a) a caterpillar  (b) a larva  
   (c) a caterpillar as well as larva  (d) neither caterpillar nor larva

43. The wool of sheep is removed only once a year before the beginning of:
   (a) spring season  (b) summer season  (c) winter season  (d) rainy season

44. Rampur bushair and Bakharwal are the breeds of:
   (a) goat  (b) yak  (c) sheep  (d) camel

45. Pattanwadi is an Indian breed of sheep found in:
   (a) Gujarat  (b) Punjab  (c) Haryana  (d) Rajasthan

46. The cut off ‘wool coat’ of a sheep along with a thin layer of skin is called:
   (a) grease  (b) fleece  (c) fleet  (d) skeet

47. Sorter’s disease is caused by:
   (a) bacteria  (b) virus  (c) protozoa  (d) fungus

48. The process of cleaning the fleece by using soap (or detergent) and a lot of water so as to remove dust, dirt, and grease, etc., is called:
   (a) sorting  (b) shearing  (c) scouring  (d) washing

49. Which of the following fibres are made of proteins?
   (a) silk and cotton  (b) natural silk and artificial silk  
   (c) rayon and wool  (d) wool and silk

50. The rearing of silkworms for obtaining silk is called:
   (a) agriculture  (b) sericulture  (c) silviculture  (d) pisciculture

51. Which of the following produces silk?
   (a) pupa  (b) larva  (c) baby silk moth  (d) adult silk moth

52. Silk production involves the cultivation of:
   (a) blackberry trees  (b) mulberry trees  
   (c) gooseberry trees  (d) strawberry trees

53. The process of taking out silk fibres from the cocoons for use as silk is called:
   (a) reeling  (b) shearing  (c) combing  (d) sorting

54. The most common variety of silk is:
   (a) Tassar silk  (b) Mooga silk  (c) Mulberry silk  (d) Kosa silk

55. A piece of fabric burns by giving a smell of burning hair. It is made up of:
   (a) natural silk  (b) artificial silk  
   (c) natural silk or wool  (d) natural wool

Questions Based on High Order Thinking Skills (HOTS)

56. Some animals have a thick coat of hair on their body. These hair give a material X which is used for making cardigans after suitable treatment. The material X traps a lot of Y which prevents the body heat of these animals from being lost to surroundings and keeps them warm in winter. The material X is removed from the animals at the beginning of the season Z.
   (a) What are (i) X, and (ii) Y?
   (b) Name the season Z.
   (c) Name any four animals which yield X.

57. The hair of an animal A are cut from its body in one piece along with a thin layer of its skin in the form of B. This process is called C. The B of this animal is then cleaned by using soap and a lot of water by a process D. The clean B is then converted into yarn E by the process of sorting, dyeing, combing and spinning.
(a) What could be (i) A and (ii) B ?
(b) Name the process (i) C and (ii) D.
(c) What is the yarn E ?
(d) State one use of E.

58. P, Q, R and S are all various types of fibres. The fibres P and Q are obtained from animals whereas the fibres R and S are obtained from plants. The yarn made from P is used for knitting sweaters whereas the yarn made from Q is used for weaving saris. The fibre R is used in filling quilts whereas the yarn made of fibre Q is used in making gunny bags. What are P, Q, R and S ?

59. A is an insect which looks like a butterfly. A is not formed as such from its eggs directly. The hatching of eggs produces a stage called B or C, and then an encased form D which ultimately forms insect A. The worm-like stage B or C is also known by a yet another name E. The stage E is important because it leads to the formation of an important fibre F.

(a) Name the insect A.
(b) What are stages (i) B (ii) C (iii) D, and (iv) E known as ?
(c) Name the fibre F.
(d) Name the tree on whose leaves E feed.

60. The moth A lays hundreds of eggs. The eggs hatch to produce worms B which are fed cut-up leaves of tree C. After about 25 to 30 days the worms stop eating and spin cocoons of fibres D. The fibres D are separated from cocoons by the process E. The spinning of these fibres produces a yarn which is woven on looms into fine cloth used for making saris, etc.

(a) What is moth A ?
(b) Name (i) worm B, and (ii) tree C.
(c) What are fibres D ?
(d) Name the process E.

ANSWERS

8. (a) Shearing (b) Scouring (c) Sorting 9. Bacteria called anthrax 10. Shearing 12. False 15. Larva 16. Larva 17. Sericulture 19. Plant fibre 20. (a) breeding (b) goat (c) wool (d) herbivores (e) sheep (f) cocoon 
(g) protein (h) larvae (or caterpillars) (i) cocoon (j) reeling 31. (i) e (ii) c (iii) b (iv) a 35. Shearing, Scouring, Sorting, Dyeing, Combing, Spinning 41. (d) 42. (c) 43. (b) 44. (c) 45. (a) 46. (b) 47. (a) 48. (c) 49. (d) 50. (b) 51. (b) 52. (b) 53. (a) 54. (c) 55. (c) 56. (a) 57. (a) (i) Sheep (ii) Fleece (b) (i) Shearing (ii) Scouring (c) Wool (d) Making sweaters by knitting 58. P : Wool ; Q : Silk ; R : Cotton ; S : Jute 59. (a) Silk moth (b) (i) Larva (ii) Caterpillar (iii) Pupa (iv) Silkworm (c) Silk (d) Mulberry tree 60. (a) Silk moth (b) (i) Silkworm (ii) Mulberry tree (c) Silk (d) Reeling
Heat

Heat is a form of energy. It makes a substance hotter. Heat cannot be seen by us. We can feel the heat by the ‘temperature effect’ it produces. When heat is given to a substance, its temperature increases and it becomes hotter. For example, when a utensil is kept on a gas burner, it gets heat, its temperature increases and it becomes hot. On the other hand, when heat is removed from a substance, then its temperature decreases and it becomes cold. For example, when water is kept in a refrigerator, then heat gets removed from water, its temperature decreases and it becomes cold.

HOT AND COLD

In our daily life, we come across a number of objects. Some of these objects are hot whereas other objects are cold. For example, tea is hot but ice is cold; soup is hot but ice cream is cold; the spoon kept in a cup of hot milk is hot whereas fruit juice is cold; a frying pan kept on a burning gas stove is hot but the handle of frying pan is cold. Even among the hot objects, some objects may be hotter than the others. Similarly, among the cold objects, some objects may be colder than the others. We usually decide whether an object is hot or cold just by touching it (provided it is not too hot or too cold!). Sometimes, however, our sense of touch is not reliable in telling us whether an object is really hot or cold. This point will become more clear from the following activity.

ACTIVITY

Take three bowls A, B and C. Put cold water in bowl A, hot water in bowl B and lukewarm water (slightly warm water) in bowl C (see Figure 1).

(i) We dip our left hand in cold water in bowl A and right hand in hot water in bowl B [see Figure 1(a)]. Keep the hands in this way for about 2 or 3 minutes.

(ii) Now take out the hands from bowls A and B and dip both the hands quickly in lukewarm water in bowl C [see Figure 1(b)].
Our sense of touch may misinform us about the temperature of an object (here water). We will find that the water in third bowl $C$ does not feel equally warm to both the hands. To the left hand (which was earlier in cold water), this lukewarm water appears to be hot. But to the right hand (which was earlier in hot water), this lukewarm water appears to be cold. This, however, is impossible because the same water cannot be hot as well as cold at the same time. Actually, our sense of touch is misinforming us in this case.

From the above activity we conclude that we cannot depend on our sense of touch for estimating the hotness (or coldness) of an object. We need some reliable measure for estimating the hotness (or coldness) of an object. A reliable measure of the hotness (or coldness) of an object is its temperature. The temperature of an object is measured by using a device called thermometer. We will now discuss the temperature and its measurement in detail.

**TEMPERATURE**

If we touch a utensil kept on a burning gas stove, it feels to be very hot. We say that the temperature of utensil is very high. On the other hand, if we touch a utensil placed in a refrigerator, it feels to be very cold. And we say that the temperature of utensil is very low. Thus, a hot object has a high temperature whereas a cold object has a low temperature. This gives us the following definition of temperature: The temperature of an object is the degree of hotness (or coldness) of the object. The temperature of an object tells us how hot or cold the object is. A high temperature of an object tells us that it is very hot whereas a low temperature of the object tells us that it is quite cold. For example, the temperature of boiling water is ‘hundred degrees Celsius’ (100°C), which is quite high. So, boiling water feels to be very hot. On the other hand, the temperature of melting ice is ‘zero degree Celsius’ (0°C), which is quite low. So, ice feels to be very cold to touch.

Temperature is measured by using a device (or instrument) called thermometer. A thermometer has a scale marked on it which is used to read the temperature. The most common temperature scale marked on thermometers for measuring temperatures is the ‘Celsius scale’. So, the temperature is expressed in the unit of ‘degree Celsius’ (which is written in short form as °C). In the unit °C, the small circle at the top (°) denotes the term ‘degree’ and the letter C denotes Celsius. So, the unit °C is read as ‘degree Celsius’ or just ‘degree C’. In the Celsius scale of temperature, the temperature of melting ice is given a value of 0°C (zero degree Celsius) and the temperature of boiling water (or steam formed from it) is given a value of 100°C (hundred degrees Celsius). The length of a laboratory thermometer tube between 0°C mark and 100°C mark is divided into 100 equal divisions. Each such division is called a degree. Please note that the temperature of an object should always be stated with its unit: °C (degree Celsius).

**MEASURING TEMPERATURE : THERMOMETERS**

A thermometer is a device for measuring the temperature of an object. There are two common types of thermometers: Laboratory thermometer and Clinical thermometer. Both these thermometers are based
on the Celsius scale of temperature. The laboratory thermometer as well as clinical thermometer are mercury thermometers. When heat is supplied to the thermometer bulb containing mercury (by the hot body whose temperature is to be measured), the mercury expands and rises in the glass tube of thermometer. This fact is used in measuring the temperature of the hot body (or hot object). We will now describe the construction and working of a laboratory thermometer and a clinical thermometer in detail, one by one. Let us discuss the laboratory thermometer first.

**Laboratory Thermometer**

A laboratory thermometer is used for measuring the temperature in a science laboratory. A laboratory thermometer is made up of a long glass tube \( T \) having a thin bore in it (see Figure 2). There is a glass bulb \( B \) containing mercury which is joined at the lower end of the glass tube. The top end of glass tube is sealed (after removing air). The whole length of thermometer glass tube is graduated (or calibrated) in degrees Celsius. The graduations marked on the tube of a commonly used laboratory thermometer are from, \(-10^\circ\text{C}\) to \(110^\circ\text{C}\) (minus ten degree C to hundred ten degree C). So, a common laboratory thermometer can measure temperatures from, \(-10^\circ\text{C}\) to \(110^\circ\text{C}\). This is called the range of thermometer. Thus, the range of a laboratory thermometer is generally from, \(-10^\circ\text{C}\) to \(110^\circ\text{C}\) (see Figure 2).

This means that a common laboratory thermometer can measure a lowest temperature of, \(-10^\circ\text{C}\) and a highest temperature of \(110^\circ\text{C}\). If we look at the temperature markings of say, \(0^\circ\text{C}\) and \(10^\circ\text{C}\) on the thermometer tube, we will find that there are 10 small divisions in-between them (see Figure 2). Now, since 10 small divisions on this laboratory thermometer tube represent a temperature of 10 degrees Celsius, therefore, 1 small division on the laboratory thermometer will represent a temperature of 1 degree Celsius (or \(1^\circ\text{C}\)). We can see a thin silvery thread of mercury in the narrow glass tube of the thermometer. The upper end of this mercury thread (or column) tells us the temperature of the object in which the thermometer bulb is placed.

We will now describe how temperature is measured by using a laboratory thermometer. We will measure the temperature of hot water kept in a beaker.
**ACTIVITY**

Take a laboratory thermometer. Hold the thermometer from its glass tube and immerse the bulb of thermometer in hot water taken in a beaker (see Figure 3). The bulb of thermometer should not touch the sides or the bottom of the beaker. We will see the shining thread of mercury moving up in the thermometer tube. After some time the mercury thread will stop rising and stand at one place. So, wait till the mercury thread becomes steady. We then read the temperature on thermometer tube which corresponds to the top of mercury thread. This will give us the temperature of hot water. For example, in Figure 3, the thermometer shows that the temperature of hot water taken in the beaker is 80°C. Please note that whenever we measure the temperature of hot water (or anything else), we should wait until the mercury stops rising in the thermometer tube. We should note down the temperature reading by keeping the thermometer bulb still immersed in hot water. This is because if the thermometer bulb is taken out of hot water, its mercury thread will start falling. This will give a wrong reading for the temperature of hot water. Another point to be noted is that if we put the thermometer bulb in a beaker containing cold water, then the mercury of thermometer bulb will contract (by losing heat) and the level of mercury thread in the thermometer tube will fall showing a lower temperature for cold water.

**Precautions in Using a Laboratory Thermometer**

1. The laboratory thermometer should be held vertically (or upright) while measuring temperature. It should not be tilted.
2. The thermometer bulb should be surrounded from all sides by the substance whose temperature is to be measured.
3. The thermometer bulb should not touch the sides or bottom of the container in which the substance is taken.
4. Read the thermometer while its bulb is still in touch with the substance whose temperature is being measured.
5. Read the thermometer by keeping the level of mercury along the line of sight.
6. Do not hold the thermometer by the bulb.
7. Handle the thermometer with care. It can break if hit against any hard object.

*A laboratory thermometer cannot be used to measure the human body temperature*. This is because as soon as we take out the bulb of the laboratory thermometer from our mouth, the level of mercury in its tube will start falling quickly (due to cooling of its bulb by air). This will give a wrong value of the body temperature. It is clear that for measuring the body temperature, we should use a thermometer in which the mercury level does not fall even when its bulb is removed from the mouth. A clinical thermometer is such a thermometer. Before we describe the clinical thermometer, we should know the meaning of the term ‘kink’. *The kink is a narrow and sharp bend (or curve) in the bore of a clinical thermometer tube.* Kink is also known as constriction. The clinical thermometer is also called Doctor’s thermometer.

**CLINICAL THERMOMETER**

The normal temperature of human body is 37°C (thirty seven degree Celsius). When a person gets fever, his body temperature rises (and he feels hot). *The thermometer used for measuring the temperature of human body is called clinical thermometer*. A clinical thermometer is used to measure our body temperature by a doctor (or at home). A clinical thermometer is shown in Figure 4. A clinical thermometer consists of a long glass tube having a thin and uniform bore. There is a glass bulb at one end of the glass tube. This glass bulb contains mercury. Outside the glass bulb, a small, shining thread of mercury can be seen in the thermometer tube (see Figure 4). The other end of glass tube is sealed (after removing air). A temperature scale is marked on the glass tube of the clinical thermometer. The clinical thermometer has a temperature scale marked from 35°C to 42°C (see Figure 4).
Figure 4. A clinical thermometer.

The clinical thermometer is a mercury thermometer which has been specially designed to measure the temperature of human body. A clinical thermometer has two special features which make it different from the laboratory thermometer.

(i) A **clinical thermometer has a very short range of temperature from 35°C to 42°C** (see Figure 4). This means that a clinical thermometer can measure temperatures only from 35°C to 42°C. The short range of a clinical thermometer is due to the fact that the temperature of human body normally does not go below 35°C or above 42°C.

(ii) A **clinical thermometer has a kink (or constriction) in its glass tube just above the bulb containing mercury** (see Figure 4). The kink is to prevent the back flow of mercury into the thermometer bulb when the thermometer bulb is removed from the mouth of a patient. The kink prevents the mercury level in the thermometer tube from falling on its own. So, even when the thermometer bulb is removed from the mouth of a patient, the mercury thread will keep standing at the maximum level reached. Due to this we can read the correct body temperature of the patient even after removing the thermometer bulb from his mouth. (After noting the body temperature, the level of mercury can be brought down by giving a few jerks to the thermometer tube).

**How to Use Clinical Thermometer to Measure Body Temperature**

We can use a clinical thermometer to measure the body temperature of a patient as follows:

1. Wash the thermometer properly (preferably with an antiseptic solution). If antiseptic solution is not available, wash it with clean water.
2. Hold the thermometer tube firmly in your hand and give it a few jerks so that the mercury thread in the thermometer tube falls below the reading of 35°C. (Never hold a thermometer from its bulb).
3. Put the bulb of the thermometer under the tongue of the patient and hold the thermometer tube gently. Keep the thermometer bulb in the mouth of the patient for about one minute. Then take out the thermometer from patient’s mouth.
4. To read the temperature, hold the thermometer horizontally in your hand and rotate it slowly. A position will come when you will see a magnified image of the mercury thread in its tube. We read the temperature on thermometer tube in level with the top of the mercury thread. This will give the body temperature of the patient.

**Precautions in Using a Clinical Thermometer**

1. The clinical thermometer should be washed before and after use (preferably with an antiseptic solution).
2. Before using the clinical thermometer, we should ensure that the mercury level in its tube is below 35°C mark.
3. Read the clinical thermometer by keeping the level of mercury along the line of sight.
4. The clinical thermometer should never be held by the bulb while reading it (otherwise the bulb will break).
5. Handle the clinical thermometer with care. The thermometer can break if it hits against some hard object.

If we look at the scale marked on the clinical thermometer tube, we will find that the temperature difference indicated by the two big marks (say, 37°C and 38°C) is 1 degree (see Figure 4). We will also see that there are 10 small divisions between the 1 degree temperature. Now, since 10 small divisions represent 1 degree C temperature, therefore, 1 small division represents \( \frac{1}{10} \) degree C temperature or 0.1 degree C temperature. Thus, with a clinical thermometer, we can measure the human body temperature accurately up to one-tenth of a degree (or 0.1°C).

A clinical thermometer has usually two temperature scales marked on its glass tube on the two sides of the mercury thread: Celsius scale of temperature and Fahrenheit scale of temperature (We have not shown the Fahrenheit scale of temperature in Figure 4 to keep the diagram simple). The Fahrenheit scale of temperature marked on the clinical thermometer has a range of 94°F to 108°F (°F means degree Fahrenheit). The normal temperature of human body on Fahrenheit scale is 98.6°F. Fahrenheit scale of temperature was used in earlier days. India has now adopted the Celsius scale, so we should read the Celsius scale temperatures marked on the clinical thermometer.

The normal temperature of human body is 37°C. By saying that the normal temperature of human body is 37°C, we do not mean that each and every healthy person should have a body temperature of exactly 37°C. Actually, what we call normal temperature of human body (37°C) is the average body temperature of a large number of healthy persons. So, the normal body temperature of every healthy person may not be exactly 37°C. It could be slightly higher or slightly lower than 37°C. So, as long as a person is healthy, he should not worry even if his body temperature as shown by the clinical thermometer is slightly higher or lower than the standard body temperature of 37°C.

**How Does a Clinical Thermometer Work**

When we put the thermometer bulb in the mouth of a patient, then some of the body heat of patient is transferred to the mercury in the thermometer bulb. This heat makes the liquid mercury of the thermometer bulb to expand (increase in volume) due to which the mercury thread is pushed to a higher level in the thermometer tube. Higher the fever of a patient, greater will be his body heat and hence higher will be the level of mercury or higher will be the temperature shown by the thermometer.

A clinical thermometer cannot be used to measure high temperatures because it has been designed to measure only human body temperature which varies over a short range. If a clinical thermometer is used to measure high temperatures, it will get damaged. For example, we should not measure the temperature of hot milk by using a clinical thermometer. This is because the temperature of hot milk is very high due to which it will cause a large expansion of mercury. And since there is no extra space in the glass tube of clinical thermometer to accommodate large expansion of mercury, the thermometer tube will break. We should also avoid keeping the clinical thermometer in the hot sunshine or near other hot objects (like a flame). It may break under these conditions.

**Comparison Between Clinical Thermometer and Laboratory Thermometer**

A similarity between clinical thermometer and laboratory thermometer is that both are mercury-in-glass thermometers. The differences between a clinical thermometer and a laboratory thermometer are as follows:

(i) The clinical thermometer has a very short temperature range (35°C to 42°C) whereas a laboratory thermometer has a large temperature range (usually from –10°C to 110°C).

(ii) The clinical thermometer has a kink (or constriction) in its tube to prevent the back flow of mercury into the bulb whereas a laboratory thermometer has no kink.

(iii) The clinical thermometer measures temperature more accurately (up to 0.1°C) than a laboratory thermometer (which usually measures up to 1°C).
Digital Thermometers

Most of the common thermometers are mercury thermometers which use a liquid metal called mercury for their working. Mercury is a toxic substance (poisonous substance) and hence it is very difficult to dispose of safely if a thermometer breaks. So, there is a lot of concern over the use of mercury in thermometers. These days, digital thermometers are available which do not use mercury (see Figure 5).

Maximum-and-Minimum Thermometer

The maximum temperature of the day usually reaches in the afternoon whereas the minimum temperature usually occurs in the early morning. In weather forecasting and other meteorological work, it is necessary to know the highest and the lowest temperatures reached in the surroundings during a whole day. There is a special thermometer called maximum-and-minimum thermometer which automatically records the maximum and minimum temperatures of the day. The maximum and minimum temperatures of the previous day reported in weather reports in TV and newspapers are measured by the maximum-and minimum thermometer.

TRANSFER OF HEAT

To carry heat from one part of an object to its other part, or from one object to another object is called transfer of heat. For example, if we dip a steel spoon in a cup of hot tea, we find that the temperature of spoon rises and it becomes hot. Here, some of the heat contained in hot tea has been transferred to spoon which is placed in it. In this example, heat moves from hot tea to the cold spoon. We know that a utensil (like a frying pan) becomes hot when kept on the flame of a gas burner of the stove. This is because heat from the hot flame is transferred to the cold utensil. And when a hot utensil is removed from the gas burner, it cools down slowly. In this case, heat is transferred from the hot utensil to the surroundings.

In general, we can say that: **Heat flows from a hot object to a cold object.** In other words, heat flows from an object at higher temperature to another object at lower temperature. The flow of heat (or transfer of heat) stops when the two objects attain the same temperature. This means that no heat will be transferred from one object to another if the temperature of the two objects is the same (or equal). For example, if an iron ball at a temperature of 40°C is dropped into a bucket containing water at the same temperature of 40°C, then heat will not flow either from iron ball to water or from water to iron ball (because both, the iron ball and water, are at the same temperature of 40°C). We will now describe the various ways in which heat can be transferred from a hot object to a cold object.

Heat can be transferred from a hot object to a cold object in three different ways:

(i) by conduction,
(ii) by convection, and
(iii) by radiation (or heat rays).

In solids, heat is transferred by conduction. In liquids and gases, heat is transferred by convection. And in empty space or vacuum (having no medium like solid, liquid or gas), heat is transferred by radiation. We will now describe conduction, convection and radiation in detail, one by one. Let us start with conduction.

**CONDUCTION**

If we heat one end of a metal spoon by keeping it over a gas burner, we find that its other end also becomes hot after a while (see Figure 6). In this case, heat is transferred from the hot end of the metal spoon to its cold end. Now, when heat is transferred from the hotter end of spoon to its colder end, there is no movement of the material of the spoon (which is metal) from one end to another. Such a transfer of heat
from the hot part of a material to its colder part (without the movement of material as a whole) is called conduction. In the above case the transfer of heat by conduction takes place within the same object (same spoon). Now, if we bring the hot end of the spoon in contact with the cold end of another spoon by touching them with each other, we will find that some of the heat of the hot spoon is transferred to the cold spoon due to which the cold spoon also becomes somewhat hot (see Figure 7). Such a transfer of heat from a hot spoon to a cold spoon which are in contact with each other, is also called conduction. We can now define the process of heat transfer called conduction as follows.

**Conduction is the transfer of heat from the hotter part of a material to its colder part (or from a hot material to a cold material in contact with it) without the movement of material as a whole.** In all the solids, heat is transferred by the process of conduction. Here are some examples of transfer of heat by conduction from our everyday life. A cold metal spoon dipped in a hot cup of tea gets heated by conduction (In this case, hot tea acts only as a source of heat). A frying pan kept on a gas stove transfers the heat of gas burner through its metal bottom by the process of conduction. We will now describe an activity to demonstrate the process of conduction of heat.

**ACTIVITY TO SHOW THE CONDUCTION OF HEAT**

We take a flat aluminium rod and fix some small iron nails on it with the help of wax. This rod (alongwith its iron nails) is clamped to a stand as shown in Figure 8.

Let us heat the free end (left end) of the aluminium rod by keeping a burner below it. We will see that the iron nails attached to aluminium rod with wax start falling one by one. The nail attached nearest to the heated end of rod falls down first. And then the next ones fall. But the nail attached to the clamped end of the rod drops last of all. These observations can be explained as follows:

The burner is placed below the left end of aluminium rod. So, the left end of aluminium rod gets heated first. Now, the left end of aluminium rod is hot but the right end of rod is cold. So, heat is now transferred from the hotter left end of aluminium rod to its colder right end. As heat travels from the left side to the right side along the aluminium rod, it melts the wax which holds the nails. Due to this the nails fall down one by one. From this activity we conclude that heat is transferred from the hot end of aluminium rod to its colder end by the process of conduction.

The transfer of heat by the process of conduction takes place only in solids. This can be explained as follows: In solids, the particles are closely packed together. During conduction, heat is transferred from
particle to particle by means of back and forth vibrations of the particles (caused by the heat energy). The particles of a solid remain at their fixed positions. There is no actual movement of the particles of the solid from its hotter end to the colder end during the conduction of heat through it.

**Good Conductors of Heat and Poor Conductors of Heat**

Some materials conduct heat easily whereas other materials do not conduct heat easily. So, on the basis of conduction of heat, all the materials are classified into two groups:

1. **Good conductors of heat**
2. **Poor conductors of heat.**

‘Good conductors’ of heat are sometimes called just ‘conductors’ of heat. Poor conductors of heat are also called insulators (of heat). This classification will become more clear from the following activity.

**ACTIVITY**

We take a beaker and fill it half with hot water. Let us take two spoons, one made of metal (such as steel) and the other made of plastic. Place the metal spoon and the plastic spoon in the beaker containing hot water as shown in Figure 9. After about two minutes, we touch the top ends of both the spoons with our hand, one by one. We will find that the top end of metal spoon feels quite hot but the top end of plastic spoon does not feel hot. This is because heat from the hot water flows easily through the metal spoon and reaches its other end. But the heat does not flow easily through the plastic spoon due to which its other end remains almost cold. This activity tells us that metal spoon is a good conductor of heat whereas plastic spoon is a poor conductor of heat (or bad conductor of heat). We say that plastic is an insulator of heat.

Those materials which allow heat to pass through them easily are called good conductors of heat (or just ‘conductors’ of heat). All the metals are good conductors of heat. For example, the metals such as silver, copper, aluminium, iron and mercury are all good conductors of heat. Though all the metals are good conductors of heat, some metals are better conductors of heat than others. For example, silver metal is the best conductor of heat. Copper is one of the best conductors of heat. Aluminium is also a very good conductor of heat. Metal alloys (such as brass, steel and stainless steel) are also good conductors of heat. Copper is a much better conductor of heat than stainless steel. All the objects made of metals and metal alloys are also good conductors of heat. Since metals and their alloys are good conductors of heat, therefore, if one end of an object made of metal (or metal alloy) is heated, then its other end becomes hot very quickly. Stone (marble, etc.) and tiles are also quite good conductors of heat.

Those materials which do not allow heat to pass through them easily are called poor conductors of heat. The materials which are poor conductors of heat are called insulators. So, a poor conductor of heat is an insulator of heat. Some of the examples of poor conductors of heat (or insulators of heat) are: plastic, wood, paper, cloth, leather, cotton, wool, thermocol, rubber, asbestos, clay, bricks, cork, cane, bamboo, straw, saw-dust, glass, fibreglass, water and air. In general liquids are poor conductors of heat and gases are very poor conductors of heat. For example, water is a poor conductor of heat and air is a very poor conductor of heat. In fact, air is a very good insulator of heat. The materials which trap air (such as cotton, wool, fur, feathers, fibreglass and plastic foam) are very poor conductors of heat. In other words, materials having trapped air in them are excellent insulators of heat. If one end of an object made of a poor conductor material (or insulator material) is heated, then its other end does not become hot. It either remains almost cold or becomes only slightly hot.
Uses of Good Conductors and Poor Conductors of Heat

We make use of good conductors of heat as well as of poor conductors of heat (or insulators of heat) in many ways in our daily life. **Good conductors are used to carry heat quickly where it is wanted. Poor conductors (or insulators) are used to stop heat from going where it is not wanted.** Some of the examples of the use of good conductors and poor conductors of heat are given below.

**The cooking utensils are made of metals (or metal alloys).** This is because metals (and metal alloys) are good conductors of heat which transfer the heat from the gas stove quickly to the food placed inside the utensil (through their bottom) (see Figure 10). **The cooking utensils are provided with handles made of plastic (or wood).** This is because plastic (or wood) is a poor conductor of heat (or insulator of heat) (see Figure 10). A plastic (or wooden) handle prevents the heat from hot cooking utensil reaching our hand so that we can lift the hot cooking utensil safely from its handle (without the risk of burning our hand). For example, a frying pan is made of aluminium metal or stainless steel because aluminium metal and stainless steel are good conductors of heat which conduct the heat from gas burner of stove quickly through their bottom to the food kept inside [see Figure 10(a)]. The handle of a frying pan is made of plastic (or wood) because plastic (or wood) is a poor conductor of heat or insulator of heat. The plastic handle (or wooden handle) does not conduct the heat of hot frying pan to its other end so that we can hold even the hot frying pan from its handle safely [see Figure 10(a)]. **Some stainless steel frying pans are provided with copper bottoms.** The reason for this is that copper metal is a much better conductor of heat than stainless steel (due to which it can transfer the heat of gas stove burner to the food kept inside much more quickly).

**Mercury metal is used in making thermometers because it is a good conductor of heat.** The handle of a soldering iron is made of wood (or plastic) because wood (or plastic) is a poor conductor of heat. The wooden (or plastic) handle does not conduct the heat of hot soldering iron to our hand so that we can hold the hot soldering iron safely from its handle. An electric iron is also provided with a plastic handle so that when electric iron gets hot, its plastic handle (being a poor conductor of heat) remains cold and can be held safely with our hand. Table mats are usually made of poor conductors (or insulators) such as plastic or cork to protect the table tops from hot dishes.

**Why Do We Wear Woollen Clothes in Winter**

We wear woollen clothes in winter when it is cold outside. **Woollen clothes keep us warm during cold winter days.** This happens as follows: **Wool is a poor conductor of heat due to which woollen clothes stop the flow of heat from our warm body to the cold surroundings.** Moreover, there is air trapped in-between the fibres of the woollen clothes. Air is a very poor conductor of heat. So, **the air trapped in fibres of woollen clothes also stops the flow of heat from our warm body to the cold surroundings.** Since our body does not lose its heat, we feel warm on wearing woollen clothes in winter. A woollen blanket also keeps us warm on a cold winter night in a similar way.
If we are given the choice in winter of using either one thick woollen blanket or two thin woollen blankets joined together, then we should prefer two thin woollen blankets joined together. This is because the two thin woollen blankets joined together will have a layer of air trapped in-between them. And this extra layer of trapped air (being a very poor conductor of heat) will prevent our body heat from going away to the cold air more efficiently and hence keep us more warm. The single, thick woollen blanket does not have this extra layer of air in it. In fact, wearing more layers of clothes keeps us warmer in winter than wearing just one thick piece of clothing. This is because more layers of clothes trap more air in them and air being a very poor conductor of heat, prevents our body heat from going away to cold surroundings.

The feathers of birds keep them warm in cold weather due to air trapped in them. Air being a very poor conductor of heat, prevents the body heat of birds from escaping to the cold surroundings and hence keeps the birds warm in cold weather. Similarly, the animals having fur (such as polar bear) keep warm in cold weather because their fur traps a lot of air (which is an excellent insulator of heat).

During the hot summer days, we use electricity to run fans, coolers and air conditioners to keep our house cool. And in cold winter days, we use electricity to run room heaters or burn fuels like coal (or charcoal) to keep our house warm. In this way, a lot of energy is used up to protect us from outside heat or cold and keep us comfortable in summer as well as in winter. It is now possible to construct houses (and other buildings) in such a way that they are not affected much by the heat or cold outside. This can be done by constructing the outer walls of houses (or other buildings) by using hollow bricks (which contain trapped air). Since the hollow bricks contain a very poor conductor of heat ‘air’ trapped in them, the walls made of hollow bricks will neither allow outside heat to come in during summer nor allow inside heat to go out during winter. This will save a lot of electrical energy as well as other fuels (which are otherwise used in keeping houses cool or warm).

Sometimes two things which are at the same temperature feel like they are at different temperatures: one being cold and the other being warm. This happens because some things are good conductors of heat whereas others are poor conductors of heat. Here is an example. During winter season, a metal object kept in a room feels very cold to touch but a wooden object in the same room feels warmer to touch. This can be explained as follows: Metal object is a good conductor of heat. So, when we touch the metal object, it conducts away heat from our hand quickly. And by losing heat, our hand feels cold. On the other hand, the wooden object (being a poor conductor of heat) does not allow the heat of our hand to escape and hence feels warmer to touch.

**CONVECTION**

We have just studied that the transfer of heat in solids takes place by the process of **conduction**. The transfer of heat in liquids and gases, however, takes place by the process of **convection**.

**Convection is the transfer of heat from the hotter parts of a liquid (or gas) to its colder parts by the movement of the liquid (or gas) itself.** The transfer of heat by convection can take place only in liquids and gases because the particles in liquids and gases can move about freely. In convection, the particles of a liquid (or gas) actually move from the hotter regions to the colder regions to transfer heat. The transfer of heat by convection cannot take place in solids because the particles in the solids are fixed at a place and hence cannot move about freely. The transfer of heat by convection also cannot take place in empty space (called vacuum) because there are no particles of any kind in empty space which can move and transfer heat.

We will now describe the transfer of heat by convection through the most common liquid around us called ‘water’ and the most common gas around us called ‘air’, one by one. Before we do that please note that hot water is lighter (less dense) than cold water. Similarly, hot air is lighter (less dense) than cold air.

**CONVECTION IN WATER**

Water is a poor conductor of heat, so it cannot transfer heat by conduction. Water transfers heat by the process of **convection**. In order to heat water, we keep the vessel containing water over a gas burner.
Now, though the burner is kept at the bottom of the vessel, but it still heats all the water in the vessel. Actually, when water is heated in a vessel, it transfers heat from its hotter parts (just above the flame of burner) to its colder parts by the process of convection. This happens as follows.

When a beaker containing water is kept over a burner, water at the bottom of beaker (near the flame) gets heated, expands and becomes lighter. This hot water (being lighter) rises upwards and carries heat along with it (see Figure 11). The cold water from above (being denser) sinks downwards to take the place of hot rising water (see Figure 11). This cold water then gets heated by the burner and also rises upwards carrying its heat upwards. And more cold water sinks downwards. This process of hot water rising upwards and cold water sinking downwards takes place again and again due to which the whole water in the beaker gets heated uniformly. The circulatory movements of water in the beaker in which hot water rises and cold water sinks again and again, are called convection currents. These convection currents transfer heat from water at the bottom of the beaker to the top of beaker rapidly. The arrows drawn in the beaker in Figure 11 show the direction of convection currents which take place during the heating of water. We can now say that water in a beaker is heated by convection currents.

**ACTIVITY TO SHOW CONVECTION CURRENTS DURING HEATING OF WATER**

We can see the path of convection currents of hot and cold water taking place during the heating of water by dropping a crystal of a coloured substance called ‘potassium permanganate’ into the water to colour it. This can be done as follows.

We take a round-bottomed flask and fill it half with water. A small crystal of potassium permanganate is dropped carefully at the bottom of the flask containing water (see Figure 12). This potassium permanganate crystal dissolves slowly and forms a purple coloured solution around itself. Heat the water at the bottom of the flask by keeping a burner below it and observe the movement of this hot water (which has been coloured purple by dissolved potassium permanganate crystal). We will see the purple streaks of hot water rise from the bottom of flask up to the surface of water and then sink downward near the walls of the flask (as shown in Figure 12). These purple coloured streaks seen in the water of flask (which is being heated from below) show the convection currents taking place in the water of flask which transfer heat from the bottom to the top.

**Water is a good convector of heat.** Water can transfer heat by convection only in the upward direction because hot water (being lighter than cold water) rises upward in the vessel. This is why we heat a vessel containing water from below by keeping a burner at its bottom. The heating element of an electric kettle (used for boiling water to make tea) is also fixed at the bottom of the kettle. Please note that convection does not occur if the water is heated at the top (rather than at the bottom). If the water taken in a vessel is heated by a burner at the top, then the hot water (being lighter) stays at the top of the vessel. Since no hot water from top can sink downwards towards the bottom of the vessel, the water at the bottom of such a vessel (which is being heated at the top) will remain cold.
CONVECTION IN AIR

Air is a very poor conductor of heat, so air cannot transfer heat by the process of conduction. Air transfers heat from its hotter parts to colder parts by the process of convection (by moving itself). In order to heat air in a room during winter, we keep the heater on the floor (usually in a corner of the room). Now, though the heater is placed on the floor at the bottom of the room but it still heats all the air in the room. Actually, when air is heated by the heater in one part of the room, it transfers heat by convection. This happens as follows.

When the heater kept on the floor in a room is switched on, the air near the heater gets heated, expands and become lighter. This hot air (being lighter) rises above the top of the heater and carries its heat alongwith it (see Figure 13). The cold air from above (being denser) sinks downwards to the bottom of the heater to take the place of hot rising air (see Figure 13). This cold air also gets heated by the heater and rises upwards carrying its heat upwards. And more cold air sinks downwards towards the heater. This process of hot air rising upwards and cold air sinking downwards takes place again and again due to which all the air in the room gets heated uniformly after some time. The circulatory movements of air in the room in which hot air rises and cold air sinks again and again are called convection currents. Thus, a room heater heats all the air in a room by setting up convection currents in the air.

ACTIVITY TO SHOW THE TRANSFER OF HEAT IN AIR BY CONVECTION

Fix a lighted candle on a table. Keep one hand at a safe distance above the flame of the candle and the other hand on the side of the flame (as shown in Figure 14). We will find that the hand kept above the candle flame feels quite hot but the hand kept on the side of the flame does not feel so hot. This can be explained as follows: The air just above the candle flame gets heated first. This hot air (being lighter) rises upwards carrying the heat alongwith it. The cold air from above (being denser) sinks downwards to take the place of hot rising air. This cold air also gets heated by the flame and rises upwards. And more cold air sinks downwards to take its place. This process of hot air rising up and cold air moving down is repeated continuously. In this way, convection currents are set up in the air above the candle flame which carry more and more heat upwards. This transfer of heat by moving air makes our hand kept above the candle flame feel very hot.

Air can transfer the heat of a source by convection only in the upward direction (because hot air, being lighter, rises in the upward direction). Air cannot transfer the heat from a source by convection either on the sides or in the downward direction (below the source of heat). This means that no convection currents of hot air take place on the sides of candle flame (in the above activity) due to which the hand kept on the side of the flame does not feel so hot. Whatever small heat is felt by the hand kept on the side of the candle flame is due to the transfer of heat of candle flame by the process of radiation (which we will study after a while). Convection currents in air also occur in nature which lead to the blowing of sea-breeze and land-breeze in coastal areas.
Blowing of Sea-Breeze and Land-Breeze

Gentle wind is called breeze. The people living in coastal areas (sea-side areas) experience an interesting phenomenon called sea-breeze and land-breeze which are based on the transfer of heat in air by convection currents. This happens as follows.

During day time, when the sun shines, the solid land gets heated to a higher temperature much more quickly than the liquid sea-water. The hot air over the land rises upwards and cooler air from over the sea moves towards the land in the form of a cool breeze (to take the place of hot rising air) (see Figure 15). The breeze blowing from the sea towards the land is called sea-breeze. The cool sea-breeze blows only during the day time when the land is hotter than the sea. To receive the cool sea-breeze during the day, the windows of houses in coastal areas are made to face the sea.

At night time, the hot land cools much faster than the warm sea-water. Due to this, the land becomes cool very quickly but the sea-water remains warm for a much longer time. So, during night, the hot air over the warm sea rises upwards and cooler air from the land blows in towards the sea in the form of a breeze (to take the place of hot rising air) (see Figure 16). The breeze blowing from the land towards the sea is called land-breeze. Land breeze blows only during the night when the sea-water is hotter than the land.
**RADIATION**

When we switch on an electric bulb, it becomes hot and gives out heat and light. Now, if we keep our hand a short distance below the glowing bulb, we can feel its heat on the hand (see Figure 17). This means that the hot, glowing bulb is transferring some of its heat to our hand held below it. The hot electric bulb cannot transfer its heat to our hand by conduction because air is a poor conductor of heat. The hot bulb also cannot transfer its heat to our hand by convection because the convection currents of air always carry heat in the upward direction (but our hand is held below the bulb). **The hot electric bulb transfers its heat to our hand held below it by the process called ‘radiation’**. Please note that even if there is no air in the room, the hot electric bulb can transfer its heat to our hand by radiation. In fact, all the hot objects (whether solids, liquids or gases) can transfer heat by radiation. This happens as follows.

Every hot object emits (gives out) invisible heat rays in all directions. These heat rays carry heat energy. When these heat rays fall on a cold object, the cold object receives heat energy and gets heated. In this way, heat energy is transferred from hot object to cold object by means of heat rays. This method of transfer of heat energy by heat rays is called radiation. Heat can be transferred from a hot body to a cold body by radiation even if there is no material medium (like solid, liquid or gas) between them. In other words, heat can be transferred by radiation even through vacuum (or empty space). We can now define radiation as follows: **Radiation is the transfer of heat energy from a hot body to a cold body by means of heat rays, without any material medium between them.** The best example of radiation is the transfer of heat energy of the sun to the earth. When we come out in the sunshine, we feel hot. This means that the heat from the sun is being transferred to us which makes us feel hot. We will now describe how heat from the sun reaches us on the earth.

**How Does Heat From the Sun Reach on the Earth**

The sun is very far away from the earth and there is mainly empty space (vacuum) between the sun and the earth (see Figure 18). Even then heat from the sun reaches the earth. Now, heat from the sun cannot reach the earth by conduction or convection because both these processes require a material medium (like solid, liquid or gas) to transfer heat, they cannot take place in empty space (or vacuum). **Heat from the sun reaches on the earth by the process of radiation.** This happens as follows:

The sun is an extremely hot object. The sun emits heat radiations (or heat rays) in all directions. These heat radiations travel through vacuum between the sun and the earth at a very high speed and reach us on the earth. When the sun’s radiations fall on the earth and its objects, they receive heat energy and hence get heated. Thus, **the sun’s heat reaches the earth by the process of radiation**. The invisible heat rays which transfer heat by radiation are called *infra-red rays*.

We have just said that the transfer of heat from a hot object to a cold object by the process of radiation does not require any medium. It can take place whether a medium is present or not. Now, though the heat from the sun reaches us mostly through empty space or vacuum (having no air, etc.) but in our day to day life we have many situations where heat is transferred by radiation through a medium called *air*. In all the following examples, heat is transferred by radiation through air.
1. When we stand next to a burning fire, we can feel the heat of the fire falling on our face. The heat is transferred from the fire to our face by the process of radiation.

2. When we sit in front of a room-heater, we get heat directly by the process of radiation.

3. A hot utensil (say, filled with hot milk) kept away from the flame cools down by transferring its heat to the surroundings by radiation.

4. Depending on the temperature of surroundings, our body too gives heat to the surroundings or receives heat from the surroundings by radiation.

Absorbers of Heat Radiations

The amount of heat which an object can absorb by radiation depends on the colour of the object. **The objects having dark colours absorb more heat radiations than the objects having light colours.** We will now describe an activity to show that objects having dark colour are better absorbers of heat than the objects having light colour on their surfaces. In this activity, we will take a black painted tin can as an example of dark coloured object and a white painted tin can as an example of light coloured object. Let us describe the activity now.

**ACTIVITY**

We take a black painted tin can and a white tin can of the same size and place them on two wooden blocks separately (as shown in Figure 19). Pour equal amounts of water in both the tin cans and fix thermometers in them with the help of rubber corks. The initial temperatures of water in both the tin cans are noted. Their initial temperatures will be exactly equal.

![Diagram](image.png)

\( (a) \) Black tin absorbs more heat from the sun  
\( (b) \) White tin absorbs less heat from the sun

**Figure 19.** The amount of heat absorbed by an object by radiation depends on the colour of the object.

We place both the tin cans in bright sunshine for one hour. The heat radiations of sun will fall equally on both the tin cans. After one hour, we note down the temperatures of water in both the tin cans again. We will find that water in black tin can is at a higher temperature than in white tin can (see Figure 19). Since the temperature of water in black tin can is higher, it shows that the black coloured tin can has absorbed more heat of the sun. And the lower temperature of water in the white tin can shows that the white coloured tin can absorbs less heat from the sun. From this activity we conclude that **a black object absorbs more heat radiations than a white object.** Since a black object is a *good absorber* of heat radiations, it also means that a black object is a *bad reflector* of heat radiations. On the other hand, since a white (or silvery) object is a *poor absorber* of heat radiations, it means that a white (or silvery) object is a *good reflector* of heat radiations.
Emitters of Heat Radiations

The amount of heat which a hot object can emit (give out) by radiation also depends on the colour of the object. The hot objects having dark colours emit more heat radiations than the hot objects having light colours. We will now describe an activity to show that the objects having dark colours are better emitters of heat than objects having light colour on their surfaces.

ACTIVITY

We take a black tin can and a white tin can of the same size. These tin cans are placed on wooden blocks separately and kept in a shady place inside a room (see Figure 20). Both the tin cans are filled with the same hot water. We note the initial temperatures of hot water in both the tin cans. Their initial temperatures are exactly equal.

(\textit{a}) Black tin loses heat faster (\textit{b}) White tin loses heat slowly

Figure 20. The amount of heat lost by an object by radiation depends on the colour of the object.

Allow both the tin cans to stand for ten minutes. After ten minutes, note the temperatures of water in both the tin cans again. We will find that the water in black tin can is at a lower temperature than the water in white tin can (see Figure 20). This means that the black coloured tin can has lost heat faster than the white coloured tin can. Thus, a black object is a better emitter of heat. On the other hand, the higher temperature of water in white tin can shows that the white coloured tin can has lost heat slowly. Thus, a white object is a poor emitter of heat. In other words, a white object loses heat slowly.

From the above two activities we conclude that black objects absorb heat better and also emit heat better than white objects. In general, we can say that dark coloured objects absorb heat better and also emit heat better than light coloured objects. A yet another way of saying this is that dark coloured objects are poor reflectors of heat but light coloured objects are good reflectors of heat.

Importance of Colour of Objects in Everyday Life

We will now describe some everyday situations where colour of the object plays an important role. We use dark coloured objects where we want to absorb more heat and light coloured objects where less heat is desired. This point will become more clear from the following examples.

1. Colour of Clothes. People prefer to wear white clothes (or light coloured clothes) in the hot summer days because white clothes (or light coloured clothes) absorb less heat from the sun. In fact, white clothes (or light coloured clothes) reflect most of the sun’s heat rays which fall on them and keep us cool and comfortable in hot weather. For example, in summer a white shirt reflects the sun’s heat rays and makes us stay cooler. People prefer to wear dark coloured clothes in the cold winter days. This is because dark coloured clothes absorb more heat rays from the sun and keep us warm in winter season. For example, a black shirt worn in winter absorbs the sun’s heat rays more efficiently and keeps us warm.

2. Colour of Houses. The houses in hot, sunny countries (like ours) are usually painted white or with light colours from outside. This is because a house painted white or with light colours absorbs very little sun’s heat rays, it reflects most of the sun’s heat rays. This keeps the house cool in the hot days of summer.
3. Solar Cooker (and Solar Water Heater). The box of solar cooker (and solar water heater) is painted black from inside. This is because a black surface is a very good absorber of heat and it will absorb maximum heat radiations coming from the sun.

We are now in a position to **answer the following questions**:

### Very Short Answer Type Questions

1. State the unit in which temperature is commonly measured.
2. What is the normal temperature of human body on Celsius scale?
3. What is the usual temperature range of a laboratory thermometer?
4. Name the liquid which is commonly used in making thermometers.
5. What prevents the mercury level in the glass tube of a clinical thermometer from falling on its own when its bulb is removed from the mouth of a patient?
6. What is the name of the thermometer which has a temperature range:
   - (a) from –10°C to 110°C?
   - (b) from 35°C to 42°C?
7. A clinical thermometer has usually two temperature scales marked on its glass tube. Name these two temperature scales.
8. What is the range of a clinical thermometer on Fahrenheit scale?
9. What is the normal temperature of human body on Fahrenheit scale?
10. What is the name of those thermometers which do not use mercury?
11. Name the thermometer which can automatically record the highest and lowest temperatures reached during the whole day.
12. Name three ways in which heat can flow (or transferred).
13. When one end of an iron rod is heated, its other end also becomes hot soon. Name the process by which heat flows in the iron rod.
14. Name the process by which a frying pan transfers heat from the gas stove through its bottom to the food kept inside it.
15. When does the flow of heat from a hot object to a cold object stop?
16. What is the other name of poor conductors of heat?
17. Name the process by which heat is transferred within a liquid (or gas).
18. State whether water is a good convector of heat or a good conductor of heat.
19. Name the process in which heat is transferred by the movement of a liquid (or gas) itself.
20. Name the process by which:
   - (a) water in a beaker gets heated by the burner kept below it.
   - (b) air above the candle flame gets heated.
21. Name the two types of breeze which blow in coastal areas.
22. Which of the following method of heat transfer will work in empty space (or vacuum)?
   - Convection, Radiation, Conduction
23. Name a method of heat transfer which does not require a material medium.
24. State the method by which heat is transferred:
   - (a) from the sun to the earth.
   - (b) from a man’s hand when placed on a cold iron vessel.
   - (c) from the bottom of a hot liquid to its upper cooler parts.
25. A person sitting in front of a room heater feels hot. Name the process by which heat is transferred.
26. How does the heat from the sun reach the earth?
27. When we stand next to a burning fire, we can feel the heat on our face. Name the process which transfers this heat from fire.
28. A hot utensil (filled with hot water) kept away from flame cools down by transferring heat to surroundings. Name the process of heat transfer involved.
29. Which of the following is a better reflector of heat and which one is a better absorber of heat?
   - (a) Shiny white surface
   - (b) Dull black surface
30. Fill in the following blanks with suitable words:
   (a) A cold steel spoon is dipped in a cup of hot milk. It transfers heat to its other end by the process of .......... 
   (b) In solids, heat is transferred by .......... 
   (c) The two examples of insulators of heat are .......... and .......... 
   (d) Air is a .......... conductor of heat whereas copper is a .......... conductor of heat. 
   (e) Feathers and furs keep birds and animals warm during cold weather because they have .......... trapped in them. 
   (f) The hotness of an object is determined by its .......... 
   (g) Temperature is measured in degree .......... 
   (h) Temperature of boiling water cannot be measured by a .......... thermometer. 
   (i) No medium is required for the transfer of heat by the process of .......... 
   (j) In liquids and gases, heat is transferred by the process of .......... 

Short Answer Type Questions

31. Why is a frying pan made of metal (like aluminium or stainless steel) but the handle of frying pan is made of plastic (or wood)?
32. Why are cooking utensils provided with handles made of plastic (or wood)?
33. Explain why, a laboratory thermometer is not suitable for measuring human body temperature.
34. Why does the mercury level not fall on its own when the bulb of a clinical thermometer is removed from the mouth?
35. Define conduction. Give one example where heat is transferred by the process of conduction.
36. What is meant by good conductors of heat? Give examples of two materials which are good conductors of heat.
37. What is meant by poor conductors of heat (or insulators of heat)? Give two examples of materials which are poor conductors of heat.
38. Classify the following materials into good conductors of heat and poor conductors of heat (or insulators): Wood, Plastic, Copper, Air, Paper, Glass, Stainless steel, Aluminium, Thermocol, Rubber
39. Name the three ways in which heat is transferred. Which is the most important in: (a) solids (b) liquids (c) gases, and (d) empty space (or vacuum)?
40. Explain why, it is difficult to hold a stainless steel tumbler containing very hot tea in the hand but a thermocol cup containing the same hot tea can be held easily.
41. Explain why, the clinical thermometer has a short temperature range from 35°C to 42°C?
42. What is the function of ‘kink’ in a clinical thermometer?
43. Define temperature. Name the device which is used to measure temperature.
44. Give the similarities and differences between the clinical thermometer and laboratory thermometer.
45. Why can the sun’s heat not reach the earth by conduction or convection?

Long Answer Type Questions

46. Explain how, woollen clothes keep us warm during cold winter days. Discuss why, wearing more layers of clothing during winter keeps us warmer than wearing just one thick piece of clothing.
47. What is a clinical thermometer? What is the range of a clinical thermometer? Explain why, a clinical thermometer cannot be used to measure high temperatures.
48. Explain how, the water in a beaker gets heated when a burner is kept below it. Draw a labelled diagram to illustrate your answer.
49. Explain how all the air in a room gets heated when a room heater kept on the floor in a corner of the room is switched on. Draw a labelled diagram to illustrate your answer.
50. Describe the blowing of sea-breeze and land-breeze in coastal areas with the help of labelled diagrams.
51. (a) Why do people prefer to wear white clothes in summer?
(b) Why is it better to wear dark clothes in winter?
52. (a) What is a thermometer? Name the thermometer used by doctors and nurses to measure the temperature of human body.
(b) Can we use a laboratory thermometer to measure human body temperature? Give reason for your answer.

53. (a) Why is the box of a solar cooker painted black from inside?
(b) In places of hot climate, it is advised that the outer walls of houses be painted white. Why?

54. What is meant by ‘convection’? Explain with the help of an example. Why is it that convection cannot take place in solids?

55. Define radiation. Give any two examples where heat is transferred by radiation. What is the name of invisible heat rays which transfer heat by radiation?

Multiple Choice Questions (MCQs)

56. An iron ball at 40°C is dropped in a mug containing water at 40°C. The heat will:
(a) flow from iron ball to water.
(b) not flow from iron ball to water or from water to iron ball.
(c) flow from water to iron ball.
(d) increase the temperature of both.

57. Some stainless steel frying pans are provided with copper bottoms. The reason for this could be that:
(a) copper bottom makes the pan more durable.
(b) such pans appear colourful.
(c) copper is a better conductor of heat than stainless steel.
(d) copper is easier to clean than stainless steel.

58. A wooden spoon is dipped in a cup of ice cream. Its other end:
(a) becomes cold by the process of conduction.
(b) becomes cold by the process of convection.
(c) becomes cold by the process of radiation.
(d) does not become cold.

59. The device used for measuring temperature is called:
(a) tachometer
(b) odometer
(c) thermometer
(d) barometer

60. The expansion of one of the following liquids is used for measuring the temperature in ordinary thermometers. This liquid is:
(a) alcohol
(b) water
(c) glycerol
(d) mercury

61. Which of the following features are that of a clinical thermometer?
A. Short temperature range
B. Wide temperature range
C. Alcohol filled glass bulb
D. Constriction in glass tube
(a) A and B
(b) B and C
(c) A and D
(d) B and D

62. The normal temperature of a healthy person is thirty seven degrees on:
(a) Kelvin scale
(b) Roemer scale
(c) Fahrenheit scale
(d) Celsius scale

63. Digital thermometers available these days for measuring temperature use:
(a) alcohol
(b) water
(c) mercury
(d) none of these

64. Which of the following is not a method of transfer of heat?
(a) conduction
(b) radiation
(c) convention
(d) convection

65. Which of the following is not an insulator?
(a) brick
(b) bamboo
(c) brass
(d) cardboard

66. A liquid which is a good conductor of heat is:
(a) water
(b) milk
(c) mercury
(d) alcohol

67. The woollen clothes keep us warm during winter because:
A. Wool is an insulator
B. Wool is a conductor
C. Wool traps air
D. Wool has vacuum
(a) A and B
(b) B and C
(c) C and D
(d) A and C

68. The objects made of steel, mica, wood and brass are lying in the same room during winter season. The objects which will feel warmer to touch are:
(a) steel and brass objects
(b) mica and brass objects
(c) wooden and steel objects
(d) mica and wooden objects

69. The transfer of heat by convection can take place in:
(a) solids and liquids
(b) solids and vacuum
(c) gases and liquids
(d) vacuum and gases
70. The convection currents in air transfer heat:
(a) downwards (b) upwards
(c) downwards as well as upwards (d) sideways

71. Which of the following conditions lead to the blowing of sea-breeze in coastal areas?
A. Land cool and sea warm  B. Land hot and sea cool
C. Day time  D. Night time
(a) A and B  (b) A and C  (c) B and C  (d) B and D

72. The hot objects which can transfer heat by radiation are:
(a) solids only  (b) liquids and gases only
(c) gases only  (d) liquids, gases and solids

73. The invisible rays which transfer heat by radiation are called:
(a) ultraviolet rays  (b) ultrasonic rays
(c) infrasonic rays  (d) infrared rays

74. The heat from the sun reaches us on the earth by the process of:
(a) conduction  (b) radiation  (c) convection  (d) none of these

75. The process which can transfer heat through the vacuum as well as air is:
(a) conduction  (b) convection  (c) irradiation  (d) radiation

Questions Based on High Order Thinking Skills (HOTS)

76. The bulb of thermometer A is coated with lampblack and the bulb of thermometer B is coated with silver.
Both the thermometers are placed in sunshine for equal time:
(a) Which thermometer will show a higher rise in temperature?  (b) What conclusion is obtained from the above observation?

77. One end of the objects such as a steel spoon, a plastic scale, a pencil and a divider is put in a beaker of hot water. In which of these objects the other end will get hot?
Why?

78. Which would you prefer to keep you warm on a cold winter night: one thick woollen blanket or two thin woollen blankets joined together? Why?

79. A person has a white shirt and a black shirt. Which shirt will make him more comfortable in: (a) winter, and (b) summer? Give reasons for your answer.

80. Look at the Figure given alongside. Mark where the heat is being transferred by conduction, by convection, and by radiation.

Answers

4. Mercury  5. Kink (or Constriction)  6. (a) Laboratory thermometer (b) Clinical thermometer  10. Digital thermometers  13. Conduction  14. Conduction  15. When temperature of both the objects becomes the same (or equal)  16. Insulators  17. Convection  18. Good convector of heat  19. Convection  (a) Convection (b) Convection  22. Radiation  23. Radiation  24. (a) Radiation (b) Conduction (c) Convection  25. Radiation  26. By radiation  27. Radiation  28. Radiation  29. (a) Shiny white surface: Better reflector of heat (b) Dull black surface: Better absorber of heat  30. (a) conduction (b) conduction (c) plastic; wood (d) poor; good  (e) air (f) temperature (g) Celsius (h) clinical (i) radiation (j) convection  39. (a) Conduction (b) Convection (c) Convection (d) Radiation  56. (b)  57. (c)  58. (d)  59. (c)  60. (d)  61. (c)  62. (d)  63. (d)  64. (c)  65. (c)  66. (c)  67. (d)  68. (d)  69. (c)  70. (b)  71. (c)  72. (d)  73. (d)  74. (b)  75. (d)  76. (a) Thermometer A will show higher temperature (b) Black objects are better absorbers of heat  77. Steel spoon and divider (They are made of metals which are good conductors of heat).  78. I would prefer to use two thin woollen blankets joined together to keep warm on a cold winter night. This is because the two thin blankets joined together will have
a layer of air trapped in-between them. And this extra layer of trapped air (being a very poor conductor of heat) will prevent the body heat from going away more efficiently and hence keep me more warm 79. (a) The black shirt will make the person more comfortable in cold winter season. This is because the black coloured shirt will absorb more heat rays from the sun and keep him warm and comfortable in cold winter season (b) The white shirt will make the person more comfortable in the hot summer season. This is because the white coloured shirt will reflect most of the sun’s heat rays and keep him cool and comfortable in hot summer season.

80.

Temperature Measuring temperature:
Acids, Bases and Salts

Acids, bases and salts are the three important groups of chemical compounds (or chemical substances) which are useful to us in many ways. For example, our stomach makes an acid (hydrochloric acid) which is necessary for the digestion of food; baking soda (sodium hydrogen carbonate) used in baking bread is a base; whereas common salt (sodium chloride) used in cooking food is a salt. Some of the acids, bases and salts occur in nature whereas many acids, bases and salts are made artificially in factories. There are, however, many other chemical compounds (such as water, glucose, cane sugar, urea, etc.) which are neither acids nor bases nor salts. In this Chapter we will study only acids, bases and salts. In order to find out whether a substance is an acid or base, we should first know the meaning of the term ‘acid-base indicator’ or just ‘indicator’. Indicators are special type of chemicals which are used to test whether a given substance is an acid or base. Indicators change their colour when added to a solution containing an acid or a base. We will now discuss the various types of indicators in detail.

**INDICATORS FOR TESTING ACIDS AND BASES**

An indicator is a ‘dye’ that changes colour when it is put into an acid or a base. An indicator gives different colours in acid and base. Thus, an indicator tells us whether the substance we are testing is an acid or a base by change in its colour. A substance which contains an acid is said to be acidic whereas the substance which contains a base is said to be basic. So, we can also say that an indicator tells us whether the substance we are testing is acidic or basic by change in its colour. Acid-base indicators are of two types: Natural indicators and Synthetic indicators.

(i) Litmus, China rose and Turmeric are naturally occurring indicators.
(ii) Phenolphthalein is a synthetic indicator.

We will now describe how these indicators are prepared and how they help us in finding out whether a given substance is an acid or a base (acidic or basic).
1. Litmus

Litmus is a natural indicator. Litmus solution is a purple coloured dye which is extracted from a type of plant called ‘lichen’ (see Figure 1). Litmus has a purple colour (mauve colour) in water. In other words, when litmus solution is neither acidic nor basic (it is neutral), then its colour is purple. **When litmus is added to an acidic solution, it turns red.** And **when litmus is added to a basic solution, it turns blue.** Though the natural colour of litmus is purple, it is made into blue litmus and red litmus for the sake of convenience in detecting colour change when an acid or base is added to it. Thus, litmus is made into two types: Blue litmus and Red litmus. Litmus can be used in the form of litmus solution (like blue litmus solution and red litmus solution) or in the form of strips of litmus paper (blue litmus paper and red litmus paper). The blue litmus paper strip and red litmus paper strip are shown in Figure 2.

![Figure 1. Lichens (from which litmus indicator is extracted).](image)

![Figure 2.](image)

(a) Blue litmus paper
(b) Red litmus paper

Litmus is the most common indicator for testing acids and bases in the laboratory.

(i) **Acids turn blue litmus to red.**
(ii) **Bases turn red litmus to blue.**

So, a convenient way to find out whether a solution is acidic or basic is to test it with blue litmus paper and red litmus paper, turn by turn, and observe the change in colour which takes place.

(a) If a drop of the given solution turns blue litmus paper to red, then the given solution will be acidic in nature (or it will be an acid).

For example, a drop of lemon juice turns blue litmus paper to red, so lemon juice is acidic in nature. That is, lemon juice contains an acid.

(b) If a drop of the given solution turns red litmus to blue, then the given solution will be basic in nature (or it will be a base).

For example, a drop of baking soda solution turns red litmus paper to blue, so baking soda is basic in nature. That is, baking soda is a base.

Please note that in order to test a solid substance with dry litmus paper, it is necessary to make a solution of the solid substance in water (otherwise the colour change will not take place). For example, solid baking soda will not turn dry red litmus paper blue. We have to first make a solution of baking soda in water and then use it for testing with red litmus paper. A drop of baking soda solution will turn red litmus paper to blue.

2. China Rose Indicator

China rose is also a natural indicator. China rose is called ‘Gudhal’ in Hindi. **China rose indicator is a light pink coloured solution which is extracted from the red flowers of China rose plant with water** (see Figure 3).

![Figure 3. China rose flower (from which china rose indicator is extracted).](image)

**ACTIVITY**

We can make the China rose indicator ourselves as follows: Collect some petals of China rose flower and place them in a beaker. Add some warm water. Keep the China rose petals immersed in water for some time till water in the beaker acquires a light pink colour. Remove the petals by filtration. The light pink solution thus obtained is the China rose indicator. This China rose indicator can now be used for testing acids and bases.
(i) Acids turn China rose indicator to magenta (deep pink).
(ii) Bases turn China rose indicator to green.

So, another way to find out whether a solution is acidic or basic is to test it with China rose indicator and observe the change in colour which takes place.

(a) If a drop of the given solution turns China rose indicator from light pink to magenta (deep pink), then the given solution will be acidic in nature (or it will be an acid) (see Figure 4). For example, lemon juice turns China rose indicator to magenta (deep pink), so lemon juice is acidic in nature. That is, lemon juice contains an acid.

(b) If a drop of the given solution turns China rose indicator from light pink to green, then the given solution will be basic in nature (or it will be a base) (see Figure 5). For example, baking soda solution turns China rose indicator green, therefore, baking soda is a base.

3. Turmeric as Indicator

Turmeric is another natural indicator. Turmeric is a bright yellow powder obtained from a plant. Turmeric is called ‘haldi’ in Hindi. Turmeric contains a yellow dye. Turmeric turns red in basic solution. Turmeric is used as indicator in the form of turmeric paper.

**ACTIVITY**

Turmeric paper can be prepared as follows: Take a tablespoonful of turmeric powder, add a little water and make a paste. Deposit the turmeric paste on a blotting paper (or filter paper) and dry it. The yellow paper thus obtained is the turmeric paper. Cut thin strips of turmeric paper. Use these strips of turmeric paper as indicator.

Turmeric paper is used as indicator. Turmeric paper is yellow in colour.

(i) Turmeric paper is yellow in acid solution.
(ii) Bases turn the yellow turmeric paper to red.

If a drop of the given solution turns the yellow turmeric paper to red, then the given solution will be basic in nature (or it will be a base). For example, if a drop of baking soda solution is put on the strip of a turmeric paper, the yellow turmeric paper turns red. This shows that baking soda solution is basic in
nature. That is, baking soda is a base. The yellow turmeric paper, however, remains yellow on adding an acid solution.

We have just learnt that a base turns yellow turmeric paper to red. Now, if we put a drop of an acid on this turmeric paper (which has been turned red by a base), then the turmeric paper will change from red to yellow. This is because acid cancels the effect of base and restores the original yellow colour of turmeric paper.

Many times we have noticed that a yellow stain of curry on a white shirt (which is due to the presence of turmeric in curry), turns red when soap is scrubbed on it. This is due to the fact that soap solution is basic in nature which changes the colour of turmeric in the curry stain to red.

4. Phenolphthalein Indicator

Phenolphthalein is a synthetic (man-made) acid-base indicator.

(i) Phenolphthalein indicator is colourless in acid solution.

(ii) Phenolphthalein indicator gives pink colour in basic solution.

We will be using phenolphthalein indicator when we carry out the neutralisation reaction of an acid and a base. Please note that if we add acid in the solution of a base (which has been turned pink by phenolphthalein indicator), then the solution will change from pink to colourless. This is because acid cancels the effect of base.

There are some substances which have no effect on any indicator. Such substances are neither acidic nor basic. The substances whose solutions do not change the colour of any indicator in any way are called neutral substances. For example, the substances whose solutions do not change the colour of either red litmus or blue litmus are known as neutral substances (they are neither acidic nor basic). Pure water (distilled water), common salt and sugar are neutral substances. So, pure water, common salt solution and sugar solution do not change the colour of any indicator.

ACIDS

If we cut a lemon (neembu) and taste it, the lemon appears to have a sour taste (khatta taste) (see Figure 6). The sour taste of lemon is due to the presence of an acid in it. The acid present in lemon which gives it a sour taste is called citric acid. Raw mango, raw grapes, lemon juice, orange juice, curd, sour milk, vinegar and tamarind (imli), etc., are sour in taste due to the presence of acids in them. The acids present in plant materials and animals are natural acids called organic acids. The acids can be defined as follows.

A substance which reacts with a base to form a salt (and water) is called an acid. Acids have sour taste. Acids turn blue litmus to red. Some of the examples of acids are: Acetic acid, Citric acid, Hydrochloric acid, Sulphuric acid and Nitric acid. Acids are of two types: Organic acids and Mineral acids. These are discussed below.

Organic Acids

Organic acids are the naturally occurring acids. They are found in various types of plants and animals. Some of the important organic acids (which occur in nature) are:

1. Acetic acid 5. Tartaric acid
2. Formic acid 6. Ascorbic acid
3. Citric acid 7. Oxalic acid
4. Lactic acid

(i) Acetic acid is found in vinegar (or sirka). Vinegar is used as a preservative in foods.
(ii) Formic acid is present in ant’s sting. The sharp pain caused by the sting of an ant is due to the formic acid pushed into our skin during the sting.

(iii) Citric acid is present in citrus fruits such as lemons and oranges.

(iv) Lactic acid is present in curd and in sour milk.

(v) Tartaric acid is present in tamarind (imli), unripe grapes and unripe mangoes.

(vi) Ascorbic acid is present in amla and citrus fruits (such as lemons and oranges). Ascorbic acid is commonly known as vitamin C.

(vii) Oxalic acid is present in spinach (palak).

**ACTIVITY**

We can test the presence of an acid in a substance by performing the litmus test. For example, we can perform the litmus test to show the presence of acid in lemon juice (or orange juice) as follows:

(i) Take some lemon juice in a test-tube and add a little water to it.

(ii) Put a drop of the lemon juice solution on a strip of red litmus paper with the help of a dropper. We will find that there is no change in the colour of red litmus paper. This means that lemon juice is not basic in nature (because only basic substances or bases turn red litmus to blue).

(iii) Now put a drop of lemon juice solution on a strip of blue litmus paper. The blue litmus paper turns red. This shows that lemon juice is acidic in nature (or lemon juice contains an acid). This is because only acidic substances or acids turn blue litmus to red.

Organic acids (or naturally occurring acids) are weak acids. It is not harmful to eat or drink substances containing naturally occurring acids in them. For example, we can eat oranges or drink orange juice which contain natural acids. Similarly, we can consume lemon juice because it contains organic acid (or natural acid) which does not harm us.

**Mineral Acids**

The acids prepared from the minerals of the earth are called mineral acids. Mineral acids are the man-made acids. Mineral acids are also known as laboratory acids because they are used in the science laboratory to perform experiments (see Figure 7). The three most common mineral acids are:

1. Hydrochloric acid,
2. Sulphuric acid, and
3. Nitric acid.

We also use mineral acids in our daily life. For example, hydrochloric acid is used in cleaning kitchen sinks and bathroom sanitaryware (like wash basin and toilet seat). Sulphuric acid is used in making storage batteries for cars, buses, trucks and inverters. Nitric acid is used by goldsmiths for cleaning gold and silver ornaments.

Concentrated mineral acids are very dangerous. These acids can burn our hands and clothes. These acids should be handled with great care. In the laboratory, acids are generally mixed with water to dilute them. Such acids are called dilute acids. Dilute acids are less harmful to us.

**Strong Acids and Weak Acids**

All the acids can be divided into two groups : strong acids and weak acids. Hydrochloric acid, sulphuric acid and nitric acid are strong acids. On the other hand, acetic acid, formic acid, citric acid, tartaric acid and carbonic acid are some of the weak acids. This can be written as follows:
**Strong acids**  
- Hydrochloric acid  
- Sulphuric acid  
- Nitric acid

**Weak acids**  
- Acetic acid  
- Formic acid  
- Citric acid  
- Tartaric acid  
- Carbonic acid

It is obvious that the mineral acids are strong acids. Only one mineral acid, carbonic acid, is a weak acid. Strong acids are very dangerous to drink. Even the dilute solutions of strong acids are extremely harmful to drink. The organic acids are weak acids. The dilute solutions of weak acids are quite safe to drink. Being weak, the organic acids like acetic acid, citric acid and tartaric acid are used as food ingredients. Many foods like pickle and tomato ketchup contain acetic acid in the form of vinegar. Vinegar preserves fruits and vegetables. Baking powder used in making cakes and biscuits contains tartaric acid. Though carbonic acid is not an organic acid, but it is a weak acid. Carbonic acid is used in fizzy soft drinks and soda water. It gives them a pleasant taste.

**Acid Rain**

The rain which contains a higher level of acid than normal is called acid rain. Acid rain is caused by the acidic gases like sulphur dioxide, nitrogen dioxide and carbon dioxide which are released into the air as pollutants during the burning of various types of fuels. Sulphur dioxide gas dissolves in falling rain drops to form sulphuric acid; nitrogen dioxide gas dissolves in rain drops to form nitric acid whereas carbon dioxide gas dissolves in rain drops to form carbonic acid. The presence of sulphuric acid, nitric acid and carbonic acid in rain water makes the rain water acidic. And when this acidic rain water falls on the earth, we call it acid rain. Acid rain causes damage to aquatic animals (like fish), trees, crop plants, metal structures and stone buildings and monuments. This happens as follows:

(i) Acid rain makes the water of lakes, ponds and rivers too acidic due to which fish and other aquatic animals get killed.

(ii) Acid rain eats up the leaves of the trees gradually. By losing leaves, the trees die. Acid rain also damages crop plants in the fields.

(iii) Acid rain damages the metal structures like steel bridges, etc., when it falls on them.

(iv) Acid rain damages the surfaces of buildings and monuments made of stone.

**BASES**

If we take some baking soda and taste it, the baking soda appears to have a bitter taste (kadwa taste). And if we rub a solution of baking soda between our fingers, it feels soapy to touch (or slippery to touch). The substances (such as baking soda) which are bitter in taste and feel soapy to touch are known as bases. Bases are the chemical opposites of acids. When bases are added to acids, they neutralise (or cancel) the effect of acids. We can now define bases as follows:

A substance which can neutralise an acid to form a salt (and water) is called a base. Bases have bitter taste. Bases turn red litmus to blue. Some of the examples of bases are:

1. Sodium hydroxide  
2. Potassium hydroxide  
3. Calcium hydroxide  
4. Magnesium hydroxide  
5. Ammonium hydroxide (Ammonia solution)  
6. Sodium carbonate  
7. Sodium hydrosyngencarbonate

A base which is soluble in water is called an alkali. All the bases which we have given above are soluble in water so all of them are alakalis (see Figure 8).
(i) Sodium hydroxide and potassium hydroxide are found in soap.

(ii) Calcium hydroxide is found in lime water.

(iii) Magnesium hydroxide is found in milk of magnesia.

(iv) Ammonium hydroxide (also called ammonia solution) is found in window cleaners.

(v) Sodium carbonate is found in washing soda.

(vi) Sodium hydrogencarbonate is found in baking soda.

**Strong Bases and Weak Bases**

Like acids, bases can also be strong or weak. Some of the strong bases and weak bases are given below:

<table>
<thead>
<tr>
<th>Strong Bases</th>
<th>Weak Bases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium hydroxide</td>
<td>Calcium hydroxide</td>
</tr>
<tr>
<td>Potassium hydroxide</td>
<td>Ammonium hydroxide</td>
</tr>
<tr>
<td>Sodium carbonate</td>
<td>Sodium carbonate</td>
</tr>
<tr>
<td>Magnesium hydroxide</td>
<td>Sodium hydrogencarbonate</td>
</tr>
</tbody>
</table>

As we can see above, sodium hydroxide and potassium hydroxide are strong bases. Sodium hydroxide is commonly known as ‘caustic soda’ and potassium hydroxide is commonly known as ‘caustic potash’ (‘caustic’ means ‘corrosive’ or ‘burning’). Sodium hydroxide and potassium hydroxide are dangerous bases which can burn our skin. They must be handled very carefully. Calcium hydroxide, ammonium hydroxide and sodium carbonate are weak bases but their solutions are unsafe to drink. Magnesium hydroxide is, however, a very weak base which is safe to drink. It is used in milk of magnesia and other indigestion mixtures. Similarly, sodium hydrogencarbonate is a very weak base which is used as an antacid to cure indigestion.

We know that some of the sugary food eaten by us is converted into acid by the bacteria present in our mouth. And this acid causes tooth decay. The toothpaste which we use for brushing and cleaning our teeth is basic in nature. Since toothpaste is basic, it neutralises the acid in our mouth and hence prevents tooth decay. We will now give the main points of difference between acids and bases.

**Main Differences Between Acids and Bases**

<table>
<thead>
<tr>
<th>Acids</th>
<th>Bases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Acids have sour taste.</td>
<td>1. Bases have bitter taste.</td>
</tr>
<tr>
<td>2. Acids are not soapy to touch.</td>
<td>2. Bases feel soapy to touch.</td>
</tr>
<tr>
<td>3. Acids turn blue litmus to red.</td>
<td>3. Bases turn red litmus to blue.</td>
</tr>
</tbody>
</table>

Great care should be taken in handling laboratory acids and bases because they are corrosive in nature, irritating and harmful to skin.

**Neutral Substances**

Those substances which are neither acidic nor basic in nature are called neutral substances. Being neither acidic nor basic, neutral substances do not change the colour of any indicator. Thus, if the solution of a substance in water does not change the colour of either blue litmus or red litmus, then it will be a neutral substance. Some of the neutral substances are: Pure water (or Distilled water), Glucose, Canesugar and Common salt.
ACTIVITY

We can confirm the neutral nature of substances by performing the litmus test. For example, let us put one drop of distilled water on blue litmus paper and another drop of distilled water on red litmus paper. We will find that there is no change in the colour of blue litmus paper or red litmus paper. This shows that distilled water is neither acidic nor basic in nature. So, distilled water is neutral. We can show the neutral nature of glucose, canesugar and common salt in a similar way by testing their water solutions (aqueous solutions) with blue litmus paper and red litmus paper, turn by turn.

We will now answer some questions based on acids and bases.

Sample Problem 1. You have been provided with three test-tubes. One of them contains distilled water and the other two contain an acidic solution and a basic solution, respectively. If you are given only red litmus paper, how will you identify the contents of each test-tube?

Solution. (i) Put the red litmus paper in all the test-tubes, turn by turn. The solution which turns red litmus to blue will be a basic solution. The blue litmus paper formed here can now be used to test the acidic solution.

(ii) Put the blue litmus paper (obtained above) in the remaining two test-tubes, one by one. The solution which turns the blue litmus paper to red will be the acidic solution.

(iii) The solution which has no effect on any litmus paper will be neutral and hence it will be distilled water.

Sample Problem 2. Three liquids are given to you. One is hydrochloric acid, another is sodium hydroxide and the third is a sugar solution. How will you identify them? You have only turmeric paper indicator.

Solution. (i) Put one drop of each liquid on turmeric paper, turn by turn. The liquid which turns the yellow turmeric paper red will be sodium hydroxide (base). The red turmeric paper formed here can now be used to test hydrochloric acid.

(ii) Put one drop each of the remaining two liquids on red turmeric paper. The liquid which makes the red turmeric paper yellow again will be hydrochloric acid (This is because hydrochloric acid cancels the effect of sodium hydroxide base on turmeric paper).

(iii) The liquid which has no effect on the red turned turmeric paper will be sugar solution (because it is neutral).

Note. Though we have not studied elements and compounds so far but we should remember the following elements and their symbols as well as the following compounds and their formulae because they will be used in the discussion of our next topics on ‘neutralisation’ and ‘salts’.

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
<th>Element</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>H</td>
<td>Sulphur</td>
<td>S</td>
</tr>
<tr>
<td>Carbon</td>
<td>C</td>
<td>Chlorine</td>
<td>Cl</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>N</td>
<td>Sodium</td>
<td>Na</td>
</tr>
<tr>
<td>Oxygen</td>
<td>O</td>
<td>Potassium</td>
<td>K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compound</th>
<th>Formula</th>
<th>Compound</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>H₂O</td>
<td>Sodium chloride</td>
<td>NaCl</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>HCl</td>
<td>Ammonium chloride</td>
<td>NH₄Cl</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>H₂SO₄</td>
<td>Sodium sulphate</td>
<td>Na₂SO₄</td>
</tr>
<tr>
<td>Nitric acid</td>
<td>HNO₃</td>
<td>Ammonium sulphate</td>
<td>(NH₄)₂SO₄</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>H₂CO₃</td>
<td>Potassium nitrate</td>
<td>KNO₃</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>NaOH</td>
<td>Sodium carbonate</td>
<td>Na₂CO₃</td>
</tr>
<tr>
<td>Potassium hydroxide</td>
<td>KOH</td>
<td>Sodium hydrogen carbonate</td>
<td>NaHCO₃</td>
</tr>
<tr>
<td>Ammonium hydroxide</td>
<td>NH₄OH</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NEUTRALISATION

The acids and bases are chemically opposite substances. So, when an acid is mixed with a base, they neutralise (or cancel) the effect of each other. The products formed on mixing an acid and a base are salt and water. The reaction in which an acid reacts with a base to form salt and water is called neutralisation. A neutralisation reaction can be represented as:

\[
\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}
\]

Some heat is always evolved (or produced) in a neutralisation reaction. This heat raises the temperature of reaction mixture due to which the reaction mixture becomes hot.

In a neutralisation reaction, two new substances, salt and water, are formed. The salt formed during a neutralisation reaction depends on which acid and which base are reacted with each other. An example of neutralisation reaction is given below.

Sodium hydroxide is a base and hydrochloric acid is an acid. So, when sodium hydroxide is treated with hydrochloric acid, then a neutralisation reaction takes place to form sodium chloride (salt) and water. This can be written as:

\[
\text{Sodium hydroxide} + \text{Hydrochloric acid} \rightarrow \text{Sodium chloride} + \text{Water}
\]

\[
(\text{NaOH}) + (\text{HCl}) \rightarrow (\text{NaCl}) + (\text{H}_2\text{O})
\]

The salt formed in this neutralisation reaction of sodium hydroxide and hydrochloric acid is sodium chloride (NaCl). It is known as common salt. Some heat is also evolved during this neutralisation reaction. This neutralisation reaction can be performed as follows.

**ACTIVITY**

We take 5 mL of dilute hydrochloric acid solution in a test-tube. The hydrochloric acid solution is colourless. Add 2 or 3 drops of phenolphthalein indicator to the acid in the test-tube. Shake the test-tube gently. Phenolphthalein indicator is colourless. There is no change in the colour of phenolphthalein indicator on adding it to hydrochloric acid solution [see Figure 9(a)].

![Figure 9. The process of neutralisation.](image)

Take sodium hydroxide solution (base) in a dropper. Add this sodium hydroxide solution to hydrochloric acid in the test-tube drop wise (stirring the test-tube gently after each addition). Continue to add sodium hydroxide solution drop by drop (while stirring) till a light pink colour just appears in the solution in the test-tube [see Figure 9(b)]. We then stop adding more of sodium hydroxide solution.

At this stage, all the hydrochloric acid taken in the test-tube has been completely neutralised by sodium hydroxide base. Thus, a neutralisation reaction has taken place in the test-tube. The completion of neutralisation reaction is indicated by the fact that when all the acid has been neutralised, then a little excess of the base changes the colour of phenolphthalein indicator to pink. This makes the solution in the test-tube light pink.

If we touch the test-tube immediately after the neutralisation reaction is over, we will find the test-tube to be somewhat hot. This is because some heat is evolved during the neutralisation reaction. This heat raises the temperature of reaction mixture and makes the test-tube feel hot.
Neutralisation in Everyday Life

The neutralisation reactions involving acids and bases play a very important role in our everyday life. The remedy for indigestion (caused by acidity), treatment of an ant’s sting, reducing the too acidic or too basic nature of soil and the treatment of factory wastes, all involve neutralisation reactions. Let us discuss this in detail.

1. Indigestion

Our stomach produces hydrochloric acid. This hydrochloric acid helps in digesting our food without harming the stomach. Sometimes, excess of hydrochloric acid is produced in the stomach due to various reasons (one being over-eating). The excess of acid in the stomach causes indigestion which produces pain and irritation (The person who has excess acid in the stomach is also said to suffer from acidity). In order to cure indigestion and get rid of pain, we can take bases called ‘antacids’ (‘antacid’ means ‘anti-acid’). Antacids are a group of mild bases which have no toxic effects on the body. Being basic in nature, antacids react with excess acid in the stomach and neutralise it. This gives relief to the person concerned. A common antacid used for curing indigestion due to acidity is milk of magnesia (see Figure 10). Milk of magnesia contains a base called magnesium hydroxide. Magnesium hydroxide neutralises the excess acid present in the stomach and cures indigestion. Another antacid is baking soda. Baking soda contains a base called sodium hydrogencarbonate. Antacids are available in the market in the form of liquid mixtures or tablets.

2. Ant’s Sting

The sting of an ant contains an acid called formic acid. So, when an ant stings (or bites) a person, it injects an acidic liquid into the skin of the person which causes burning pain. If an ant stings a person, then rubbing a mild base like baking soda solution (or calamine solution) on the stung area of the skin gives relief. This is because, being a base, baking soda solution (or calamine solution) neutralises the acidic liquid injected by the ant and cancels its effect. Please note that calamine solution contains a base called zinc carbonate.

3. Soil Treatment

The soil may be acidic or basic naturally. The plants do not grow well if the soil at a place is too acidic or too basic. The excessive use of chemical fertilisers in the fields also makes the soil too acidic. When the soil is too acidic, it is treated with bases such as quicklime (calcium oxide) or slaked lime (calcium hydroxide). The bases such as quicklime (or slaked lime) neutralise the excess acid present in the soil and reduce its acidic nature. Thus, a farmer should add quicklime (or slaked lime) in the fields if the soil is too acidic. Sometimes, however, the soil is too basic. If the soil is too basic, then decaying organic matter (called manure or compost) is added to it. The decaying organic matter releases acids which neutralise the excess bases present in the soil and reduce its basic nature. Thus, a farmer should add decaying organic matter (manure or compost) in his fields if the soil is too basic.

4. Factory Wastes

The waste substances discharged by many factories contain acids. If these untreated factory wastes are discharged into water bodies (like lakes, ponds, and rivers, etc.), then the acids present in them will kill the fish and other aquatic organisms which live in the water bodies. The acidic factory wastes should be treated with basic substances to neutralise them before discharging them into water bodies (such as lakes, ponds and rivers, etc.).
SALTS

A salt is a substance formed by the reaction of an acid with a base. An example of salt is sodium chloride. It is formed by the reaction of hydrochloric acid with sodium hydroxide base. In a way we can say that a salt has two parents: an acid and a base. So, the name of a salt consists of two parts: the first part of the salt’s name is derived from the name of the base and the second part of the salt’s name is derived from the name of the acid. For example, the name of the salt called ‘sodium chloride’ comes from the ‘sodium hydroxide’ base and ‘hydrochloric acid’. Please note that:

(i) The salts of hydrochloric acid are called chlorides.
(ii) The salts of sulphuric acid are called sulphates.
(iii) The salts of nitric acid are called nitrates.
(iv) The salts of carbonic acid are called carbonates.
(v) The salts of acetic acid are called acetates, and so on.

The names and formulae of some of the bases and acids, and the salts formed from them are given below:

<table>
<thead>
<tr>
<th>Base</th>
<th>Acid</th>
<th>Salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sodium hydroxide (NaOH)</td>
<td>Hydrochloric acid (HCl)</td>
<td>Sodium chloride (NaCl)</td>
</tr>
<tr>
<td>2. Sodium hydroxide (NaOH)</td>
<td>Sulphuric acid (H₂SO₄)</td>
<td>Sodium sulphate (Na₂SO₄)</td>
</tr>
<tr>
<td>3. Potassium hydroxide (KOH)</td>
<td>Nitric acid (HNO₃)</td>
<td>Potassium nitrate (KNO₃)</td>
</tr>
<tr>
<td>4. Ammonium hydroxide (NH₄OH)</td>
<td>Hydrochloric acid (HCl)</td>
<td>Ammonium chloride (NH₄Cl)</td>
</tr>
<tr>
<td>5. Sodium hydroxide (NaOH)</td>
<td>Carbonic acid (H₂CO₃)</td>
<td>Sodium carbonate (Na₂CO₃)</td>
</tr>
</tbody>
</table>

Salts can be of three types: (i) Neutral salts (ii) Acidic salts, and (iii) Basic salts.

Those salts which form a neutral solution on dissolving in water are called neutral salts. The salts formed by the neutralisation of a strong acid by a strong base are neutral salts. The two examples of neutral salts are sodium chloride (NaCl) and sodium sulphate (Na₂SO₄). The solution of a neutral salt has no effect on any litmus. For example, a solution of sodium chloride salt in water does not change the colour of any litmus paper.

Those salts which form an acidic solution on dissolving in water are called acidic salts. The salts formed by the neutralisation of a strong acid with a weak base are acidic salts. The two examples of acidic salts are ammonium chloride (NH₄Cl) and ammonium sulphate [(NH₄)₂SO₄]. The solution of an acidic salt in water turns blue litmus to red. For example, the solution of ammonium chloride salt in water turns blue litmus paper to red.

Those salts which form basic solutions on dissolving in water are called basic salts. The salts formed by the neutralisation of weak acids with strong bases are basic salts. The two examples of basic salts are sodium carbonate (Na₂CO₃) and sodium hydrogen carbonate (NaHCO₃). The solutions of basic salts in water turn red litmus to blue. For example, the solution of sodium carbonate in water turns red litmus paper to blue. We are now in a position to answer the following questions:

Very Short Answer Type Questions

1. Name one natural indicator and one synthetic indicator.
2. Name the acid-base indicator extracted from lichens.
3. What colour do the following indicators turn when added to an acid?
   (a) Litmus solution  
   (b) China rose indicator

4. What colour do the following indicators turn when added to a base?
   (a) Litmus solution  
   (b) China rose indicator  
   (c) Phenolphthalein  
   (d) Turmeric paper

5. (a) Name one indicator which turns red on adding an acid.
    (b) Name one indicator which turns red on adding a base.

6. State whether the following statements are true or false:
   (a) Nitric acid turns red litmus blue.
   (b) Sodium hydroxide turns blue litmus red.
   (c) Tooth decay is caused by the presence of a base.
   (d) Change of colour in an acid or base depends on the type of indicator used.
   (e) Indicator is a substance which shows different colours in acidic and basic solutions.

7. Is sodium hydroxide an acid or a base?

8. What can you say about the nature of a solution which turns blue litmus paper red?

9. Ammonia is found in many household products such as window cleaners. It turns red litmus blue. What is its nature?

10. Name any two gaseous pollutants which cause acid rain.

11. Name two strong acids and two weak acids.

12. Name two strong bases and two weak bases.

13. Name the chemical which is injected into the skin of a person when an ant bites.

14. What does calamine solution contain?

15. What name is given to the reaction in which an acid reacts with a base to form salt and water?

16. Which indicator is used to carry out the neutralisation reaction of hydrochloric acid with sodium hydroxide solution?

17. Name the salt formed when hydrochloric acid neutralises sodium hydroxide solution.

18. (a) Name two organic acids (naturally occurring acids).
    (b) Name two mineral acids.

19. (a) Give one characteristic property of all acids.
    (b) Write one characteristic property of all bases.

20. Fill in the following blanks with suitable words:
   (a) Excessive use of chemical fertilisers make the soil .........
   (b) When an acid is mixed with a base, a ..........reaction takes place.
   (c) The products formed in a neutralisation reaction of an acid and a base are .........and ...........
   (d) Acid      +     Base   $\rightarrow$ ............... + Water
   (e) Hydrochloric acid + Sodium hydroxide $\rightarrow$ ............... + Water
   (f) The acidic or basic nature of a substance is tested by using an ...............  
   (g) The substances which show different colours in acidic, basic and neutral solutions are called .............

Short Answer Type Questions

21. What is an indicator? Name three indicators.

22. Name the source from which litmus solution is obtained. What is the use of this solution?

23. Why does a yellow curry stain on a white shirt turn red when it is washed with soap?

24. Which of the following are acidic and which are basic?
    Lime water, Vinegar, Toothpaste, Stomach juices, Lemon juice,
    Baking soda solution, Milk of magnesia, Ammonia solution

25. What is a salt? Name any two salts.

26. What are the three types of salts? Give one example of each type of salt.

27. Choose the acidic, basic and neutral salts from the following:
    Sodium chloride, Ammonium chloride, Sodium carbonate, Sodium sulphate,
    Ammonium sulphate.

28. Explain why, if we touch the test-tube immediately after carrying out the neutralisation reaction of an acid and a base in it, it is found to be somewhat hot.
29. A student adds dilute sulphuric acid to lime water. Will the reaction mixture become hot or cold? Why?
30. Explain why, an antacid tablet is taken when you suffer from acidity.
31. Explain why, calamine solution is applied on the skin where an ant bites.
32. The soil in a field is highly acidic. Name two materials which can be added to this soil to reduce the acidity. Give reason for your choice.
33. What material should be added to a soil which is too basic? How does this material help in reducing the basic nature of the soil?
34. What is an antacid? How does an antacid work? Name any one antacid.
35. (a) Which acid is produced in our stomach?
   (b) What happens if there is an excess of acid in the stomach?
   (c) How can its effect be cured?
36. Give one important use of milk of magnesia (magnesium hydroxide) in our everyday life.
37. What happens when an ant stings? What is its remedy?
38. A shopkeeper has a few bottles of soft drinks in his restaurant which are not labelled. One customer wants acidic drink, another wants basic drink and the third one wants neutral drink. How will the shopkeeper decide which drink is to be served to whom?
39. State the main differences between acids and bases.
40. State whether distilled water is acidic, basic or neutral. How will you confirm it?

Long Answer Type Questions

41. What is meant by acid rain? How is acid rain caused? What damage is caused by acid rain?
42. What are neutral salts, acidic salts and basic salts. Give two examples each of neutral, acidic and basic salts.
43. What is an acid? Name any two acids. How can you test the presence of an acid in a substance?
44. What is a base? Name any two bases. How can you test the presence of a base in a substance?
45. (a) What is neutralisation? Describe the process of neutralisation with the help of an example.
   (b) Write a word equation for the neutralisation reaction between sodium hydroxide and hydrochloric acid. Also write the chemical formulae of all the substances involved.

Multiple Choice Questions (MCQs)

46. Which of the following type of medicine is used for treating indigestion caused by overeating?
   (a) antibiotic (b) analgesic (c) antacid (d) antiseptic
47. One of the following is not an organic acid. This is:
   (a) acetic acid (b) formic acid (c) citric acid (d) carbonic acid
48. The discomfort caused by indigestion due to overeating can be cured by taking:
   (a) baking soda (b) vinegar (c) lemon juice (d) caustic soda
49. The property which is common between vinegar and curd is that they:
   (a) have sweet taste (b) have bitter taste (c) are tasteless (d) have sour taste
50. One of the following is a medicine for indigestion. This is:
   (a) sodium hydroxide (b) manganese hydroxide (c) magnesium hydroxide (d) potassium hydroxide
51. The acid produced naturally in our stomach is:
   (a) acetic acid (b) citric acid (c) hydrochloric acid (d) sulphuric acid
52. Which of the following contains lactic acid?
   (a) ant’s sting (b) unripe grapes (c) lemons (d) sour milk
53. The salt which will give an acidic solution on dissolving in water is:
   (a) sodium sulphate (b) ammonium sulphate (c) sodium carbonate (d) sodium chloride
54. Which one of the following salts will give a basic solution on dissolving in water?
   (a) sodium carbonate (b) sodium chloride (c) sodium sulphate (d) ammonium chloride
55. The aqueous solution of one of the following will turn China rose indicator from light pink to green. This solution is of:
   (a) vinegar  (b) baking soda  (c) lemon juice  (d) carbonic acid

56. Which of the following is a strong base?
   (a) calcium hydroxide  (b) sodium hydroxide  (c) sodium carbonate  (d) ammonium hydroxide

57. When a basic solution is added to an indicator, a green colour is produced. The indicator should be:
   (a) red litmus indicator  (b) china rose indicator  (c) phenolphthalein indicator  (d) turmeric paper indicator

58. Which of the following bases cannot be used as antacids?
   A. Sodium carbonate  B. Sodium hydrogen carbonate  C. Magnesium hydroxide  D. Sodium hydroxide
   (a) A and B  (b) B and C  (c) A and D  (d) B and D

59. The reaction between an acid and a base to form salt and water is called:
   (a) carbonation  (b) hydrogenation  (c) neutralisation  (d) titration

60. The dilute solutions of which of the following are not harmful to drink?
   A. Magnesium hydroxide  B. Potassium hydroxide  C. Sodium hydrogen carbonate  D. Sodium carbonate
   (a) A and B  (b) B and C  (c) A and D  (d) B and D

61. With which of the following ‘milk of Magnesia’ be reacted so as to have a neutralisation reaction?
   (a) baking soda  (b) vinegar  (c) ammonia solution  (d) quicklime

62. When an ant stings a person, it injects a liquid into the skin of the person which contains:
   (a) acetic acid  (b) calcium hydroxide  (c) formic acid  (d) potassium hydroxide

63. The two indicators which give red or pink colour on adding a basic solution are:
   A. China rose indicator  B. Turmeric paper indicator  C. Phenolphthalein indicator  D. Blue litmus indicator
   (a) A and B  (b) B and C  (c) C and D  (d) A and D

64. When an ant stings a person, it causes a burning pain. Which of the following should be rubbed on the stung area of skin to get relief?
   (a) lemon juice  (b) baking soda solution  (c) vinegar solution  (d) formic acid solution

65. The substance which can turn blue litmus to red is:
   (a) baking soda  (b) milk of magnesia  (c) lemon juice  (d) calamine solution

66. A yellow stain of turmeric containing curry on a white shirt turns red when soap solution is scrubbed on it. This shows that soap solution is:
   (a) basic  (b) acidic  (c) neutral  (d) sour

67. A certain solution does not change the colour of any indicator. This solution is most likely to be:
   (a) vinegar solution  (b) baking soda solution  (c) common salt solution  (d) washing soda solution

68. Which of the following does not cause acid rain?
   (a) sulphur dioxide  (b) carbon monoxide  (c) carbon dioxide  (d) nitrogen dioxide

69. Which of the following is a mineral acid?
   (a) citric acid  (b) acetic acid  (c) carbonic acid  (d) oxalic acid

70. Which indicator will produce a pink colour on adding a few drops of sodium hydroxide solution?
   (a) blue litmus  (b) phenolphthalein  (c) turmeric paper  (d) china rose indicator
Questions Based on High Order Thinking Skills (HOTS)

71. Consider the following salts:
   Sodium sulphate, Sodium carbonate, Ammonium sulphate
   The aqueous solution of which of these salts will:
   (a) turn blue litmus to red?
   (b) turn phenolphthalein to pink?
   (c) turn China rose indicator to green?
   (d) have no effect on any indicator?
   Give reasons for your answer in each case.

72. Blue litmus paper is dipped in a solution. It remains blue. What is the nature of the solution? Explain.

73. If someone is suffering from the problem of acidity after overeating, which of the following would you suggest as a remedy?
   Lemon juice, Vinegar, Baking soda solution
   Give reason for your choice.

74. A white shirt has a yellow stain of curry. When soap is rubbed on this shirt during washing, the yellow stain turns red. On rinsing the shirt with plenty of water, the red stain turns yellow again.
   (a) Name the natural indicator present in curry stain.
   (b) What is the nature of soap (acidic or basic) as shown by the indicator present in curry stain?
   (c) Name a synthetic indicator which will give pink colour with soap solution.

75. You have been provided with three test-tubes. One of these test-tubes contains distilled water and the other two contain an acidic and a basic solution respectively. If you are given only blue litmus paper, how will you identify the contents of each test-tube?

ANSWERS

3. (a) Red (b) Magenta (Deep pink)  4. (a) Blue (b) Green (c) Pink (d) Red  5. (a) Litmus (b) Turmeric paper
6. (a) False (b) False (c) False (d) True (e) True  8. Acidic 9. Basic 17. Sodium chloride 20. (a) acidic
(b) neutralisation (c) salt; water (d) Salt (e) Sodium chloride (f) indicator (g) indicators 29. The reaction mixture will become hot. This is because a neutralisation reaction takes place.
46. (c) 47. (d) 48. (a) 49. (d) 50. (c) 51. (c) 52. (d) 53. (b) 54. (a) 55. (b) 56. (b) 57. (b) 58. (c) 59. (c) 60. (c) 61. (b) 62. (c) 63. (b) 64. (b) 65. (c) 66. (a) 67. (c) 68. (b) 69. (c) 70. (b) 71. (a) Ammonium sulphate solution. Because it is acidic in nature (b) Sodium carbonate solution. Because it is basic in nature (c) Sodium carbonate solution. Because it is basic in nature (d) Sodium sulphate solution. Because it is neutral in nature. 72. The solution is either basic or neutral. This is because basic and neutral solutions do not change the colour of blue litmus paper (Only acids turn blue litmus paper to red) 73. Baking soda solution; Being basic, it neutralises excess acid in the stomach.
74. (a) Turmeric (b) Basic (c) Phenolphthalein 75. Acidic solution will turn blue litmus red; This red litmus will turn blue in basic solution; Distilled water will have no effect on any type of litmus paper.

Indicators for testing acids and bases
Neutralisation
We have many substances around us. All these substances have certain properties such as state (solid, liquid or gas), size, shape, colour, smell, temperature, composition and structure, etc. When one or more properties of a substance become different, we say that a change has taken place in it. Here is an example. We know that ice melts to form water. Melting of ice is a common change around us. Now, ice is a solid whereas water is a liquid. So, the melting of ice involves a change in state: from solid state to liquid state. Changes are taking place all around us. Some of the changes observed by us in our everyday life are:

(i) Formation of curd from milk  (iv) Drying of clothes
(ii) Cooking of food  (v) Ripening of fruits, and
(iii) Burning of fuels  (vi) Rusting of iron

Some changes are beneficial to us whereas some are harmful to us. For example, ripening of fruits is a beneficial change. So, we try to make the ripening of fruits faster by artificial methods. On the other hand, rusting of iron is a harmful change. So, we try to prevent rusting of iron objects by various methods (such as painting the iron object, etc.). The change in a substance does not occur on its own. There is always a ‘cause’ which brings about a change in a substance. For example, ice does not melt on its own to form water. Ice must be given some heat to melt and change into water. Thus, ‘heat’ is the cause of the change of state of ice from solid to liquid.

Types of Changes

Changes can be of two types:
1. Physical changes, and
2. Chemical changes

We will now discuss physical changes and chemical changes in detail, one by one. Let us start with the physical changes.
PHYSICAL CHANGES

Those changes in which no new substances are formed, are called physical changes. The changes in state, size, shape and colour of a substance are physical changes. The properties such as state, size, shape and colour of a substance are called its physical properties. So, we can also say that: Those changes in which a substance undergoes a change in its physical properties are called physical changes. The physical changes are temporary changes which can be easily reversed to form the original substance. Very little energy (in the form of heat, etc.) is either absorbed or evolved in physical changes. Thus, the important characteristics of a physical change are as follows:

(i) No new substance is formed in a physical change.
(ii) A physical change is a temporary change. A physical change can be easily reversed.
(iii) Very little energy (heat, etc.) is either absorbed or evolved in a physical change.
(iv) A temporary change in colour may take place in a physical change.

We will now take an example to understand a physical change clearly. Let us take a sheet of paper and cut it into a number of pieces. Now, we cannot join the cut pieces of paper to make the original sheet of paper. But each small piece of paper is still paper, it has not changed into something else. So, during the cutting of a sheet of paper into pieces of paper, only the size and shape of paper has changed but no new substance has been formed. So, the cutting of paper (or tearing of paper) is a physical change.

Some more examples of physical changes are: Melting of ice (to form water); Freezing of water (to form ice); Boiling of water (to form steam); Condensation of steam (to form water); Evaporation of water (to form water vapour); Condensation of water vapour (to form liquid water); Cutting of cloth; Breaking of a chalk stick; Conversion of chalk stick into chalk dust; Breaking of a glass tumbler; Breaking of a wooden stick; Cutting of a log of wood (into pieces of wood); Melting of wax; Formation of clouds; Drying of wet clothes; Dissolving salt in water (to make salt solution); Dissolving sugar in water (to make sugar solution); Making soda water by dissolving carbon dioxide; Glowing of an electric bulb (or tube-light); Stretching of a rubber band; Grinding of a substance; Hammering of metals to form thin sheets (like beating aluminium metal to form aluminium foil); Stretching metals to form wires; and Conversion of liquefied petroleum gas (LPG) from liquid form in cylinder to gaseous form when it comes out of cylinder into gas stove. We will now describe some of these physical changes in detail.

Melting of Ice and Freezing of Water

Take some ice in a beaker and keep it aside for some time. We will see that ice melts to form water (see Figure 1). Actually, the ice kept in beaker receives heat from the surrounding air to melt and form water. Though ice and water look different, they are both made of water molecules. This means that no new substance is formed during the melting of ice, only a change of state (from solid to liquid) takes place during the melting of ice. So, the melting of ice (to form water) is a physical change. The change which occurs during the melting of ice to form water can be reversed easily by freezing the water to form ice again. This can be done as follows.

Let us keep the beaker containing water in the freezer compartment of a refrigerator. After a few hours, the water kept in the freezer of a refrigerator gets cooled too much, freezes (or solidifies) to form ice. In this case, the liquid water changes into solid water called ice. Only a change in state (from liquid to solid) takes place during the freezing of water to form ice, but no new substance is formed. So, the freezing of water (to form ice) is a physical change.
Boiling of Water and Condensation of Steam

Take some water in a hard glass beaker and heat it by using a burner till it starts boiling. When the water starts boiling, we can see the steam rising from the surface of hot water (see Figure 2). Now, water is a liquid whereas steam is a gas. So, during the boiling of water, only a change in state (from liquid to gas) has taken place. Though water and steam look different, they are both made of water molecules. This means that no new substance is formed during the boiling of water. So, the boiling of water (to form steam) is a physical change. The change which occurs during the boiling of water (to form steam) can be reversed easily by condensing the steam to form water again. This can be done as follows.

Hold an inverted frying pan by its handle over the rising steam at some distance above the beaker of boiling water. Now, if we look at the inner surface of the frying pan, we will see drops of water sticking to it. Actually, when hot, rising steam comes in contact with the inverted frying pan, then some of the steam gets cooled and condenses to form drops of liquid water. During the condensation of steam, there is only a change in state from gaseous state to liquid state but no new substance is formed. So, the condensation of steam (to form water) is a physical change.

Steam is very hot water vapour. So, we can also say that the conversion of water into water vapour is a physical change. In other words, evaporation of water is a physical change. The conversion of water vapour into liquid water (on cooling) is also a physical change. In other words, condensation of water vapour is a physical change.

The Case of Chalk Stick and Chalk Dust

Let us take a chalk stick and go on writing on the blackboard. Soon the whole chalk stick will be converted into small chalk particles called chalk dust. The conversion of chalk stick into chalk dust is a physical change because both the chalk stick and the chalk dust are just the same substance, only their size is different. No new substance is formed during the conversion of chalk stick into chalk dust. The change which occurs during the conversion of chalk stick into chalk dust can be reversed easily as follows.

We take the chalk dust (or chalk powder) and add a little water to it to make a thick paste of chalk dust. This thick paste of chalk dust can be moulded into a chalk stick and then dried. In this way, we can get back the original chalk stick from the chalk dust. Thus, the physical change from chalk stick to chalk dust is a temporary change. It can be easily reversed by converting chalk dust back into chalk stick.

Making of a Solution

We take some water in a porcelain dish and dissolve some common salt in it. The salt disappears in water and forms a salt solution. So, a change has taken place in making salt solution. Let us now heat this porcelain dish containing salt solution on a burner till all the water evaporates. A white powder is left behind in the porcelain dish. If we taste this white powder, we will find that it is common salt. It is the same common salt which we had dissolved in water earlier. This means that no new chemical substance has been formed by dissolving common salt in water to make salt solution. So, the dissolving of salt in water (to make salt solution) is a physical change. Similarly, dissolving sugar in water (to make sugar solution) is also a physical change.

Breaking of a Glass Tumbler

When a glass tumbler breaks, it forms many pieces. Each broken piece of glass tumbler is still glass. So, during the breaking of a glass tumbler, only the size and shape of glass has changed but no new substance has been formed. So, the breaking of a glass tumbler is a physical change.
Heating a Hacksaw Blade

Hacksaw blade is a long, toothed blade which is used to cut metal objects. Take a used hacksaw blade and hold its one end with a pair of tongs. Keep the other end of hacksaw blade over the flame of a gas burner to heat it. After some time, we will see that the tip of hacksaw blade gets heated too much and turns red in colour (it is said to become red-hot). Now, remove the tip of hacksaw blade from the burner and allow it to cool. On cooling, the tip of hacksaw blade gets back to its original grey colour. Now, only a temporary change in colour of hacksaw blade takes place during heating; no new substance is formed in this process. So, the heating of hacksaw blade to the red-hot stage is a physical change (which can be easily reversed on cooling). (Caution: Heating the tip of hacksaw blade to red-hot stage is a very dangerous activity. It should be demonstrated only by the teachers).

CHEMICAL CHANGES

Those changes in which new substances are formed, are called chemical changes. The properties of new substances formed in chemical changes are entirely different from those of the original substances. During chemical change, a substance undergoes a change in its chemical composition (or change in chemical properties). Chemical changes are also called chemical reactions. The chemical changes are permanent changes which can usually not be reversed to form the original substance. A lot of energy (in the form of heat, light, sound, etc.) is either absorbed or given out in chemical changes. Thus, the various characteristics of a chemical change are as follows:

(i) One or more new substances are formed in a chemical change.
(ii) A chemical change is a permanent change. A chemical change usually cannot be reversed.
(iii) A lot of energy (in the form of heat, light, etc.) is either absorbed or given out in a chemical change.
(iv) Sound may be produced in a chemical change.
(v) A change in smell may take place or a new smell may be given off in a chemical change.
(vi) A permanent change in colour may take place in a chemical change.
(vii) A gas may be formed in a chemical change.

Let us take an example to understand a chemical change clearly. If we burn a piece of paper with a lighted match stick, then entirely new substances such as carbon dioxide, water vapour, smoke and ash are produced. So, the burning of paper is a chemical change (see Figure 3). Heat and light are also given out during the burning of paper. The burning of paper is a permanent change which cannot be reversed. For example, we cannot combine the products of burning of paper to form the original paper again. In fact, the burning of any substance is a chemical change. Burning is always accompanied by the production of heat. Some light is also produced during burning.

Some more examples of chemical changes are: Souring of milk; Formation of curd from milk; Cooking of food (like rice and chapatis); Spoilage of food; Change in colour of cut apple (cut brinjal or cut potato) on keeping in air; Photosynthesis; Digestion of food; Neutralisation reaction; Explosion of a firework (or cracker); Burning of magnesium ribbon; Burning of fuels (like burning of wood, coal, kerosene, LPG and biogas); Burning of dry leaves; Burning of candle wax; Burning of incense stick (agarbatti); Rusting of iron; Ripening of fruits; Reaction between vinegar and baking soda (which produces carbon dioxide gas); Passing carbon dioxide gas through lime water (which produces calcium carbonate precipitate); Reaction between copper sulphate solution and iron (to form iron sulphate and copper); Formation of manure (or compost) from leaves; Formation of biogas from animal wastes (like cow-dung). All these changes are chemical changes because new substances are formed in them. Moreover, these changes cannot be reversed. We will discuss some of these changes in a little more detail.
When food gets spoiled, it produces a foul smell. This shows that new substances have been formed in the spoiled food which have foul smell. So, the spoilage of food is a chemical change. If we cut an apple into slices and keep it aside for some time, we will find that the cut surface of apple acquires a brown colour. The cut surface of an apple slice acquires a brown colour due to the formation of new substances by the action of oxygen (of air). So, the change in colour of a cut apple slice on keeping in air is due to a chemical change. Similarly, the cut surface of a brinjal (or potato) turns black on keeping in air for sometime due to chemical change. This is because new substances are formed which impart black colour to their cut surfaces.

During photosynthesis, the plants combine carbon dioxide and water in the presence of chlorophyll and sunlight to form two new substances: glucose (food) and oxygen gas. So, photosynthesis is a chemical change. In the process of digestion, the various food materials break down to form new substances which can be absorbed by the body. So, the process of digestion is a chemical change. When an acid reacts with a base, then a neutralisation reaction takes place in which two new substances, salt and water, are formed. So, neutralisation is a chemical change. The explosion of a firework (like a cracker) is a chemical change because many new substances are formed in this process. The explosion of a firework also produces heat, light, sound and unpleasant gases. These unpleasant gases pollute the air around us.

In a biogas plant, anaerobic bacteria digest (break down) the animal wastes (like cow-dung) and produce biogas whose major component is methane gas. The formation of biogas from animal wastes is a chemical change. This is because new substances like methane are produced from animal waste. Biogas is burnt as a fuel. The burning of biogas is also a chemical change. This is because burning of biogas produces new substances like carbon dioxide and water vapour along with the evolution of heat (and some light). Similarly, the burning of liquefied petroleum gas (LPG) in a gas stove is also a chemical change.

Note. We have already given the symbols of some elements and formulae of some compounds in the previous Chapter. In addition to those, we should also remember the following elements and their symbols as well as compounds and their formulae:

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
<th>Element</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>Mg</td>
<td>Oxygen (gas)</td>
<td>O₂</td>
</tr>
<tr>
<td>Iron</td>
<td>Fe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>Cu</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compound</th>
<th>Formula</th>
<th>Compound</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium oxide</td>
<td>MgO</td>
<td>Acetic acid</td>
<td>CH₃COOH</td>
</tr>
<tr>
<td>Magnesium hydroxide</td>
<td>Mg(OH)₂</td>
<td>Sodium acetate</td>
<td>CH₂COONa</td>
</tr>
<tr>
<td>Calcium hydroxide</td>
<td>Ca(OH)₂</td>
<td>Copper sulphate</td>
<td>CuSO₄</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>CO₂</td>
<td>Iron sulphate</td>
<td>FeSO₄</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>CaCO₃</td>
<td>Iron oxide</td>
<td>Fe₂O₃</td>
</tr>
</tbody>
</table>

We will now study some of the chemical changes by performing activities.

1. **Burning of Magnesium Ribbon**

Magnesium is a metal which burns easily on heating. A long and thin strip of magnesium metal is called magnesium ribbon. We usually use magnesium metal in the form of a magnesium ribbon to perform activities.

When a magnesium ribbon is heated, it burns in air with a brilliant white light to form a powdery ash called magnesium oxide. This magnesium oxide is an entirely new substance. Thus, a new substance is formed during the burning of magnesium ribbon. So, the burning of magnesium ribbon is a chemical change (see Figure 4). We can perform the magnesium ribbon burning activity as follows.

![Figure 4. The burning of magnesium ribbon is a chemical change.](image-url)
**ACTIVITY**

Take a small piece of magnesium ribbon and clean it by rubbing its surface with a sand paper. Hold the magnesium ribbon at one end with a pair of tongs and bring its other end over the flame of a burner [see Figure 5(a)]. The magnesium ribbon starts burning with a dazzling white light. Hold the burning magnesium ribbon over a watch glass so that the powdery ash being formed by the burning of magnesium collects in the watch glass [see Figure 5(b)]. Actually, when magnesium ribbon burns in air, then the magnesium metal combines with the oxygen (of air) to form a new substance called magnesium oxide. This change can be written in the form of a word equation as follows:

\[
\text{Magnesium} + \text{Oxygen} \rightarrow \text{Magnesium oxide}
\]

\[
\text{(Mg)} \quad \text{(O}_2\text{)} \quad \text{(MgO)}
\]

It is the magnesium oxide compound which appears as a white, powdery ash. So, magnesium oxide (ash) is the new substance formed when magnesium burns in air. **The burning of magnesium ribbon is a chemical change** because a new substance, magnesium oxide, is formed during this change.

We can carry out another chemical change by using the magnesium oxide ash formed by the burning of magnesium ribbon. This can be done as follows.

**ACTIVITY**

Take magnesium oxide (ash) in a hard glass test-tube and add a small amount of water to it. Stir the magnesium oxide and water mixture carefully with a glass rod to obtain an aqueous solution of magnesium oxide. Test the magnesium oxide solution with blue litmus paper and red litmus paper respectively, as follows:

(i) Take a strip of blue litmus paper and put a drop of magnesium oxide solution on it. The blue colour of litmus paper does not turn to red showing that magnesium oxide solution is **not acidic**.

(ii) Now take a strip of red litmus paper and put a drop of magnesium oxide solution on it. The red litmus paper turns blue showing that magnesium oxide solution is **basic** in nature.

Actually, when we dissolve magnesium oxide in water, then magnesium oxide combines with water to form a new substance called magnesium hydroxide. This change can be written in the form of a word equation as follows:

\[
\text{Magnesium oxide} + \text{Water} \rightarrow \text{Magnesium hydroxide}
\]

\[
\text{(MgO)} \quad \text{(H}_2\text{O)} \quad \text{Mg(OH)}_2
\]

The new substance ‘magnesium hydroxide’ formed during this change is a base which turns red litmus paper to blue. **The dissolving of magnesium oxide in water is a chemical change** because a new substance magnesium hydroxide is produced during this change.
2. Reaction Between Baking Soda and Vinegar

When baking soda and vinegar are mixed together, then bubbles of carbon dioxide gas are formed (alongwith some other substances). This carbon dioxide is an entirely new substance. **The reaction between baking soda and vinegar is a chemical change** because it forms carbon dioxide as one of the new substances. We can carry out the chemical change between baking soda and vinegar as follows: Take about 10 mL vinegar in a test-tube and add a pinch of baking soda to it. We will hear a hissing sound and see the bubbles of carbon dioxide gas coming out and rising in the test-tube (see Figure 6).

Baking soda is sodium hydrogen carbonate and vinegar contains acetic acid. So, when baking soda and vinegar are mixed together, then a chemical change takes place between sodium hydrogen carbonate and acetic acid to form three new substances: sodium acetate, carbon dioxide and water. This chemical change can be written in the form of a word equation as follows:

\[
\text{Sodium hydrogen carbonate} + \text{Acetic acid} \rightarrow \text{Sodium acetate} + \text{Carbon dioxide} + \text{Water}
\]

We can carry out another chemical change by using the carbon dioxide gas produced in the above chemical reaction between baking soda and vinegar. This can be done as follows.

Prepare carbon dioxide gas by adding baking soda to vinegar in a test-tube. Take some freshly prepared lime water in another test-tube. Pass carbon dioxide gas through lime water by using a glass delivery tube as shown in Figure 7. We will see that lime water turns milky. This happens as follows.

Lime water is calcium hydroxide solution. When carbon dioxide gas is passed through lime water, then calcium hydroxide combines with carbon dioxide to form a white solid substance ‘calcium carbonate’ (which makes lime water appear milky). This chemical change can be written in the form of a word equation as follows:

\[
\text{Calcium hydroxide} + \text{Carbon dioxide} \rightarrow \text{Calcium carbonate} + \text{Water}
\]

The reaction between lime water and carbon dioxide gas is a chemical change because a new substance ‘calcium carbonate’ is formed during this change. **The turning of lime water milky is used as a standard test for carbon dioxide gas.** This is because only carbon dioxide gas can turn lime water milky (by forming a white precipitate of calcium carbonate). No other gas can turn lime water milky.

**Note:** To prepare lime water, dissolve some lime (choona) in water in a bottle. Stir the solution and keep it for some time. Pour a little clear solution from the top. This is lime water.

3. Reaction Between Copper Sulphate Solution and Iron

When an iron object (like an iron nail, etc.) is kept immersed in the blue coloured solution of copper sulphate, then a chemical change takes place to form green coloured iron sulphate solution and a brown deposit of copper on the iron object (like nail). This change can be written in the form of a word equation as follows:
Copper sulphate solution + Iron \[\rightarrow\] Iron sulphate solution + Copper

(Blue) (Grey) (Green) (Brown)

The reaction between copper sulphate (CuSO\(_4\)) solution and iron (Fe) is a chemical change because it produces two new substances: iron sulphate (FeSO\(_4\)) solution and copper (Cu). We can perform the reaction between copper sulphate solution and an iron nail as follows. Please note that the common name of copper sulphate is ‘blue vitriol’. It is called ‘neela thotha’ in Hindi.

**ACTIVITY**

Dissolve a little of copper sulphate in half test-tube of water. Add a few drops of dilute sulphuric acid to obtain a clear solution. This will give us a blue-coloured copper sulphate solution. Take a big iron nail and place it carefully in the test-tube containing copper sulphate solution [see Figure 8(a)]. Keep the test-tube containing copper sulphate solution and iron nail aside for a few hours. We will see that the blue colour of copper sulphate solution fades gradually and ultimately changes to light green colour and a brown deposit (or layer) is formed on the iron nail [see Figure 8(b)]. We can take out the iron nail from the test-tube to see the brown deposit on it clearly. These changes are due to a chemical reaction between copper sulphate solution and iron nail which produces two new substances: iron sulphate and copper. The formation of green coloured substance ‘iron sulphate’ makes the solution green. And the formation of ‘copper metal’ deposits a brown layer on the iron nail.

![Figure 8. Chemical reaction between copper sulphate solution and iron (nail).](image)

**Importance of Chemical Changes**

Chemical changes are very important in our lives. All the new substances which we use in various fields of our life are produced as a result of chemical changes (or chemical reactions). Some of the examples of the importance of chemical changes are given below:

(i) Metals are extracted from their naturally occurring compounds called ‘ores’ by a series of chemical changes. For example, iron metal is extracted from the iron ore by chemical changes.

(ii) Medicines are prepared by carrying out a chain of chemical changes.

(iii) The materials such as plastics, soaps, detergents, perfumes, acids, bases, salts, etc., are all made by carrying out various types of chemical changes.

(iv) Every new material is discovered by studying different types of chemical changes.

**Differences Between Physical and Chemical Changes**

The main differences between physical and chemical changes are given below:

<table>
<thead>
<tr>
<th>Physical change</th>
<th>Chemical change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No new substance is formed in a physical change.</td>
<td>1. A new substance is formed in a chemical change.</td>
</tr>
<tr>
<td>2. A physical change is a temporary change.</td>
<td>2. A chemical change is a permanent change.</td>
</tr>
<tr>
<td>3. A physical change is easily reversible.</td>
<td>3. A chemical change is usually irreversible.</td>
</tr>
<tr>
<td>4. Very little energy (in the form of heat, etc.) is absorbed or given out in a physical change.</td>
<td>4. A lot of energy (in the form of heat, light, sound, etc.) is absorbed or given out in a chemical change.</td>
</tr>
</tbody>
</table>
Please note that the same substance can undergo a physical change or a chemical change depending upon the conditions. For example:

(i) The tearing of a sheet of paper into pieces of paper is a physical change but the burning of a sheet of paper is a chemical change.

(ii) The melting of wax is a physical change but the burning of wax is a chemical change. So, when a candle burns, then both physical and chemical changes take place. This is because when a candle burns, then some of the wax melts (physical change) and some of the wax burns (chemical change) (see picture on page 79).

A Protective Shield of Ozone

Ozone is a gas. There is a layer of ozone gas high up in the atmosphere. The ozone layer in the upper atmosphere is very useful. The ozone layer protects us from the harmful ultraviolet radiations which come from the sun. This happens as follows: Ozone absorbs ultraviolet radiations coming from the sun and breaks down to form oxygen. In this way, ozone layer absorbs harmful ultraviolet radiations coming from the sun and prevents them from reaching the earth. The breaking down of ozone into oxygen is a chemical change. If ultraviolet radiations were not absorbed by ozone layer, they would reach the earth’s surface and cause harm to us and other living things. Ultraviolet radiations can cause skin cancer, damage our eyes and plants (including crops). The ozone layer in the atmosphere acts as a natural, protective shield against the harmful ultraviolet radiations coming from the sun.

**Rusting of Iron**

When an iron object is left in damp air (or water) for a considerable time, it gets covered with a red-brown flaky substance called rust. This is called rusting of iron. During the rusting of iron, iron metal combines with the oxygen (of air) in the presence of water (moisture) to form a compound ‘iron oxide’. This iron oxide is rust. The process of rusting can be represented by the following word equation:

\[
\text{Iron (Fe)} + \text{Oxygen (O}_2\text{)} + \text{Water (H}_2\text{O)} \rightarrow \text{Iron oxide (Fe}_2\text{O}_3\text{)}
\]

Rust is iron oxide (Fe₂O₃). Thus, rust and iron are not the same substance. Rust is different from iron on which it gets deposited. **Rusting of iron is a chemical change** (because a new substance ‘iron oxide’ is formed in this process).

Almost every iron (or steel) object kept in the open gets rusted slowly. We can usually see the rusted iron gates of parks and iron benches kept in the gardens which always remain in the open (see Figure 9). The agricultural tools such as spades and shovels also get rusted when exposed to the atmosphere for a considerable time. In the kitchen, the iron pan (tawa) often gets rusted if kept in wet state for some time. We can also usually see the formation of some rust on iron grills, iron railings, iron pipes, iron nails, old cars, bicycles and steel bridges, etc.

**Conditions Necessary for Rusting**

Both, oxygen and water (or moisture) must be present for the rusting of iron to occur. So, two conditions are necessary for the rusting of iron to take place:

(i) presence of oxygen (of air), and

(ii) presence of water or water vapour (called moisture).

Figure 9. This picture shows a part of the rusted iron gate.
Iron rusts when placed in damp air (or moist air), or when placed in water. Now, damp air (or moist air), also contains water vapour. Thus, **damp air alone provides both the things, oxygen and water, required for the rusting of iron to occur.** Again, ordinary water always has some dissolved oxygen in it. So, **ordinary water also supplies both the things, oxygen and water, needed for the rusting of iron.**

(i) If the air at a place has a high moisture content (more water vapour), that is, if the air at a place is more humid, then the rusting of iron becomes *faster.* The rusting of iron is faster in coastal areas (sea-side areas) because the air at those places contains more water vapour (or more moisture).

(ii) The presence of salt in water makes the process of rusting of iron *faster.* Thus, an iron object will rust much faster when kept in sea-water (which is salty water) than when kept in fresh water (having no salts dissolved in it).

**Rusting Damages Iron Objects**

Rust is soft and porous, and it gradually falls off from the surface of a rusted iron object, and then the iron below starts rusting. Thus, **rusting of iron is a continuous process which slowly eats up the iron objects and makes them useless.** Since iron is used in making a large number of objects or articles such as bridges, grills, railings, gates, and bodies of cars, buses, trucks and ships, etc., rusting of iron causes a great loss over a period of time. It is obvious that we should have some ways of preventing the rusting of iron.

**How Do We Prevent Rusting of Iron**

Rusting takes place when an iron object comes in contact with air (containing oxygen) and water. So, if air and water are prevented from coming in contact with iron objects, then rusting will not take place. Thus, most of the methods of preventing rusting of iron involve coating the iron object with ‘something’ to keep out air and water (which cause rusting). Some of the **methods of preventing rusting of iron** are given below:

(i) **Rusting of iron can be prevented by painting.** When a coat of paint is applied to the surface of an iron object, then air and moisture cannot come in contact with the iron object and hence no rusting takes place. The window grills, railings, steel furniture, iron bridges, railway coaches, and bodies of cars, buses and trucks, etc., are all painted regularly to protect them from rusting.

(ii) **Rusting of iron can be prevented by applying grease or oil.** When some grease or oil is applied to the surface of an iron object, then air and moisture cannot come in contact with it and hence rusting is prevented. For example, the tools and machine parts made of iron and steel are smeared with grease or oil to prevent their rusting.

(iii) **Rusting of iron can be prevented by galvanisation.** The process of depositing a thin layer (or coating) of zinc metal on iron objects is called galvanisation. Galvanisation is done by dipping an iron object in molten zinc metal. A thin layer of zinc metal formed on the surface of an iron object protects it from rusting (because zinc metal remains unaffected by air and moisture). The iron sheets used for making buckets, drums, dust-bins and sheds (roofs) are galvanised to prevent their rusting (see Figure 10). The iron pipes used in our homes to carry water are also galvanised to prevent rusting.

(iv) **Iron is coated with chromium to prevent rusting.** This is called chrome-plating. Chromium metal is resistant to the action of air and moisture. So, when a layer of chromium is deposited on an iron object, then the iron object is protected from rusting. Chromium-plating is done on steel furniture, taps, bicycle handle bars and car bumpers, etc., made of iron and steel to prevent them from rusting.

(v) **Rusting of iron can be prevented by alloying it to make stainless steel.** When iron is mixed (or alloyed) with carbon, chromium and nickel, then stainless steel is obtained. Stainless steel is an alloy of iron.

Figure 10. This bucket is made of galvanised iron sheet (to prevent its rusting).
Stainless steel does not rust at all. Cooking utensils, knives, scissors and surgical instruments are made of stainless steel and do not rust at all.

**The Case of Ships**

Ships are made of iron (and steel) and a part of the ship always remains under sea-water. Even on the part of ships which remain above sea-water, water drops keep clinging to their outer surface. Moreover, the sea-water contains many salts. The presence of salts in sea-water makes the process of rust formation on ships faster. So, inspite of being painted regularly, the ships suffer a lot of damage from rusting. In fact, the damage caused by rusting is so much that a fraction of ship’s iron has to be replaced every year. This causes a lot of monetary loss (money loss) to the world.

**The Iron Pillar at Delhi**

There is an iron pillar near the Qutub Minar in Delhi which is more than 7 metres high and weighs more than 6000 kg (see Figure 11). It was built more than 1600 years ago. Even after such a long period, the iron pillar has not rusted at all. This shows that Indian scientists had made great advances in metal making technology as back as 1600 years which enabled them to make this iron pillar having the quality of great rust resistance.

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**CRYSTALLISATION**

Sea-water contains salts dissolved in it (which make it salty). We have learnt in Class VI that salt can be separated from sea-water by the process of evaporation. The process of evaporation (to dryness) is not a good technique of separation because:

1. The soluble impurities do not get removed in the process of evaporation of a salt solution. So, the salt obtained by evaporation is not pure.
2. The crystals of salts obtained by the process of evaporation are small. And the shape of crystals cannot be seen clearly.

Large crystals of pure substances can, however, be obtained from their solutions by the process of crystallisation. So, the solid substances are usually purified by the process of crystallisation. **Crystallisation is an example of a physical change.** This is described below.

The solid particles having flat surfaces, straight edges and regular shapes are called crystals. Many substances form crystals. **The process of cooling a hot, concentrated solution of a substance to obtain crystals is called crystallisation.** The process of crystallisation is used to obtain large crystals of a pure solid substance from the impure solid substance. An impure solid substance usually contains two types of impurities: **insoluble** impurities and **soluble** impurities. The insoluble impurities are removed by filtering its solution whereas soluble impurities get removed during crystallisation. As an example, we will now describe how large crystals of pure copper sulphate can be obtained from an impure sample of copper sulphate powder by the process of crystallisation.

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**ACTIVITY TO OBTAIN PURE COPPER SULPHATE CRYSTALS FROM AN IMPURE SAMPLE**

Impure copper sulphate powder can be purified by the process of crystallisation to obtain large crystals of pure copper sulphate. This is done as follows: Take about 100 mL of water in a beaker and add a few drops of dilute sulphuric acid to it. Heat the water over a burner till it boils. Add copper sulphate powder slowly to the hot water with constant stirring [see Figure 12(a)]. Continue to add copper sulphate till no
more copper sulphate can be dissolved. This will give us a saturated solution of copper sulphate. Filter the hot saturated solution of copper sulphate to remove insoluble impurities. Allow the hot and concentrated solution of copper sulphate to cool slowly. Do not disturb the solution when it is cooling. After some time, we will see large copper sulphate crystals at the bottom of the beaker [see Figure 12(b)]. Separate the copper sulphate crystals from solution by filtration and dry. The soluble impurities present in copper sulphate do not crystallise and hence remain behind in the solution.

The crystals of other substances like alum (phitkari) can also be prepared in a similar way. Impure common salt obtained by the evaporation of sea-water is also purified by the process of crystallisation. We are now in a position to answer the following questions:

**Very Short Answer Type Questions**

1. Name the metal which is used for galvanising iron.
2. Name the substances which are mixed (alloyed) with iron to make stainless steel.
3. Name the process which can be used to obtain pure copper sulphate from an impure sample.
4. (a) Name the process by which common salt is obtained from sea-water.
   (b) Name the process by which common salt is purified.
5. Name a substance which can be purified by crystallisation.
6. Name the gas which can turn lime water milky.
7. State whether the following statements are true or false:
   (a) Cutting a log of wood into pieces is a chemical change.
   (b) Formation of manure from leaves is a physical change.
   (c) Condensation of steam is not a chemical change.
   (d) Iron and rust are the same substance.
   (e) Iron pipes coated with zinc do not get rusted easily.
8. Classify the changes involved in the following processes as physical or chemical changes:
   (a) Photosynthesis
   (b) Burning of coal
   (c) Digestion of food
   (d) Dissolving sugar in water
   (e) Melting of wax
   (f) Beating aluminium to make aluminium foil
9. Which of the following are physical changes and which are chemical changes?
   (i) A glass bottle breaking
   (ii) Making a cake
   (iii) Wool being knitted into a sweater
   (iv) Burning of incense stick
   (v) Tearing of paper
   (vi) Cooking of food
   (vii) Formation of clouds
   (viii) Drying of clothes
   (ix) Burning of paper
   (x) Formation of rust
20. Fill in the following blanks with suitable words:
    (a) Changes in which new substances are formed are called ............ changes.
    (b) Melting of wax is a ............ change but burning of wax is a ........change.
(c) Souring of milk is a ........ change.
(d) The chemical name of baking soda is....
(e) When carbon dioxide is passed through lime water, it turns milky due to the formation of .......... 
(f) The two methods by which rusting of iron can be prevented are ..........and ........
(g) The process of depositing a thin layer of zinc on iron objects is called .........
(h) The presence of ...........in sea water makes the process of rust formation on ships faster.
(i) Some substances can be obtained in pure state from their solutions by..........

Short Answer Type Questions

11. Why is an iron grill painted frequently ?
12. Explain why, iron pipes for carrying water are coated with zinc.
13. Why are the tools and machine parts made of iron smeared with grease or oil ?
14. Explain how, painting of an iron gate prevents it from rusting.
15. Explain why, rusting of iron is faster in coastal areas than in deserts.
16. What is meant by galvanisation ? Why is it done ?
17. Give two methods of preventing the rusting of iron.
18. What is stainless steel ? How is stainless steel made ? State an important property of stainless steel.
19. State three differences between a physical change and a chemical change.
20. Write a word equation to represent the process of rusting of iron. Also write the chemical symbols and formulae of all the substances involved.
21. Explain why, explosion of a firework (such as cracker) is said to be a chemical change.
22. Explain why, melting of ice to form water is said to be a physical change.
23. What is meant by crystallisation ? State its one use.
24. Describe how, crystals of copper sulphate are prepared.
25. (a) Give example of a chemical change which occurs by the action of heat.
(b) Give example of a physical change which occurs by the action of heat.

Long Answer Type Questions

26. What is a (a) physical change, and (b) chemical change ? Give two examples of physical changes and two examples of chemical changes.
27. What is meant by the rusting of iron ? State two conditions necessary for the rusting of iron to occur.
28. Explain how, rusting damages iron objects.
29. What happens when an iron nail is kept immersed in copper sulphate solution ? Write a word equation for this process. Name the type of change involved.
30. What happens when baking soda is added to vinegar ? Write a word equation for this reaction. Name the type of change which takes place.
31. What happens when carbon dioxide gas is passed through lime water ? Write a word equation for this process. Name the type of change which takes place.
32. When a candle burns, both physical and chemical changes take place. Identify these changes.
33. Explain why, burning of wood and cutting of wood into small pieces are considered as two different types of changes.
34. What happens when magnesium ribbon is burned in air ? Write a word equation for this process. Name the type of change which takes place.
35. What happens when magnesium oxide is dissolved in water ? Write a word equation for this process. Name the type of change which takes place.

Multiple Choice Questions (MCQs)

36. Which one of the following is not a chemical change ?
   (a) formation of curd (b) ripening of banana
   (c) sublimation of naphthalene (d) corrosion of photo frame
37. Which of the following are physical changes?
   A. Melting of iron metal  
   B. Rusting of iron metal  
   C. Burning of iron filings  
   D. Drawing a wire of iron metal  
   (a) A and B  
   (b) B and C  
   (c) A and D  
   (d) B and D

38. Which of the following are chemical changes?
   A. Decaying of wood  
   B. Burning of wood  
   C. Sawing of wood  
   D. Hammering of nail into wood  
   (a) A and B  
   (b) B and C  
   (c) A and C  
   (d) B and D

39. Which one of the following change can be reversed?
   (a) water changing into ice  
   (b) nails becoming rusty  
   (c) bread turning mouldy  
   (d) paper burning into ash

40. Which of the following is not a physical change?
   (a) salt is added to water  
   (b) charcoal burns  
   (c) ice melts  
   (d) iron nail is magnetised

41. When ice-cream melts:
   A. Heat is lost from the ice-cream  
   B. Heat is gained by the ice-cream  
   C. Heat is lost from the surroundings  
   D. Heat is gained by the surroundings  
   (a) A and B  
   (b) B and C  
   (c) A and C  
   (d) C and D

42. Which of the following is a chemical change?
   (a) Lifting up a chair  
   (b) Filling a glass with orange juice  
   (c) Cooking a pot of rice  
   (d) Bursting a balloon

43. One of the following is not a chemical change. This one is:
   (a) ripening of bananas  
   (b) souring of milk  
   (c) decaying of jute bag  
   (d) drying of cotton cloth

44. Which of the following is not a characteristic of a physical change?
   (a) no new substance formed  
   (b) can be reversed  
   (c) temporary change  
   (d) permanent change

45. The gas which turns lime water milky is:
   (a) sulphur dioxide  
   (b) nitrogen dioxide  
   (c) hydrogen chloride  
   (d) carbon dioxide

46. The ozone layer in the upper atmosphere of earth absorbs most of the:
   (a) infrared radiations  
   (b) infrasonic radiations  
   (c) ultraviolet radiations  
   (d) ultrasonic radiations

47. The rusting of iron can be prevented by coating it with a layer of:
   A. Zinc  
   B. Sodium  
   C. Chromium  
   D. Carbon  
   (a) A and B  
   (b) B and C  
   (c) A and C  
   (d) B and D

48. Impure copper sulphate powder can be purified by the process of:
   (a) galvanisation  
   (b) crystallisation  
   (c) evaporation  
   (d) sublimation

49. The gas we use in the kitchen is called liquefied petroleum gas (LPG). In the cylinder it exists as liquid. When it comes out from the cylinder, it becomes a gas (change - A), then it burns (change - B). The following statements pertain to these changes. Choose the correct one:
   (a) Process A is a chemical change.  
   (b) Process B is a physical change.  
   (c) Process A is a physical change but B is a chemical change.  
   (d) Process A is a chemical change but B is a physical change.

50. Anaerobic bacteria digest animal waste and produce biogas (change A). The biogas is then burnt as fuel (change B). The following statements pertain to these changes. Choose the correct one:
   (a) A is a chemical change whereas B is a physical change.  
   (b) B is a chemical change whereas A is a physical change.  
   (c) Both A and B are physical changes.  
   (d) Both A and B are chemical changes.
Questions Based on High Order Thinking Skills (HOTS)

51. When magnesium is burned in air, a powdery ash X is formed. X on dissolving in water forms Y.
   (a) What are (i) X, and (ii) Y?
   (b) What is the action of Y on litmus paper?
   (c) What conclusion do you get about the nature of Y from its action on litmus paper?
   (d) What is the common name of the indigestion-relieving medicine which contains Y?

52. When a grey coloured object made of metal A is left exposed to damp air for a considerable time, it gets covered with a red-brown flaky coating by the process called B which eats up the whole object gradually. It is said that the presence of C and D is necessary for this process to take place. If this object is galvanised by metal E, then the process B does not occur.
   (a) Name the metal A of which the object is made.
   (b) Name the process B.
   (c) What are (i) C, and (ii) D?
   (d) Name the metal E.

53. When electricity is passed through water, then a change V occurs which leads to the formation of two gases W and X. On the other hand, when water is heated strongly, then a change Y takes place leading to the formation of gas Z.
   (a) What are gases (i) W (ii) X, and (iii) Z?
   (b) What type of change is (i) V, and (ii) Y?

54. When an ant stings a person, the solution of substance A is rubbed on the stung area of the skin to get relief from pain. The substance A is also used in kitchen for cooking purposes. Another substance B is sour in taste and contains an organic acid C. It is used in making pickles. When a solution of A is mixed with B, then a change D takes place to produce bubbles of gas E.
   (a) What are substances (i) A, and (ii) B?
   (b) Name the acid C.
   (c) What type of change is D?
   (d) Name the gas E.

55. When an object made of material P is kept immersed in the blue coloured solution Q, then a chemical change takes place to form a green coloured solution R and a brown layer of substance S is deposited on the object. P is used for making nails and S is used for making electric wires.
   (a) What could the material P be?
   (b) Name the blue coloured solution Q.
   (c) Name the green coloured solution R.
   (d) What could the substance S be?

ANSWERS

4. (a) Evaporation  (b) Crystallisation  6. Carbon dioxide  7. (a) False  (b) False  (c) True  (d) False  (e) True
10. (a) chemical  (b) physical  ; chemical  (c) chemical  (d) sodium hydrogen carbonate  (e) calcium carbonate
(f) painting ; galvanisation  (g) galvanisation  (h) salt  (i) crystallisation  25. (a) Burning of magnesium ribbon in air to form magnesium oxide  (b) Melting of ice to form water  36. (c)  37. (c)  38. (a)  39. (a)  40. (b)  41. (b)
42. (c)  43. (d)  44. (d)  45. (d)  46. (c)  47. (c)  48. (b)  49. (c)  50. (d)  51. (a) (i) Magnesium oxide
(ii) Magnesium hydroxide  (b) Y turns red litmus paper blue  (c) Y is basic in nature  (d) Milk of magnesia
52. (a) Iron  (b) Rusting  (c) (i) Oxygen (of air)  (ii) Water (or Water vapour)  (d) Zinc  53. (a) (i) Hydrogen
(ii) Oxygen  (iii) Steam  (b) (i) Chemical change  (ii) Physical change  54. (a) (i) Baking soda  (ii) Vinegar
(b) Acetic acid  (c) Chemical change  (d) Carbon dioxide  55. (a) Iron  (b) Copper sulphate solution
(c) Iron sulphate solution  (d) Copper
During the summer days, we wear light coloured clothes because the weather is hot. In winter, we prefer to wear dark coloured clothes because the weather is cold. And if there are clouds in the sky on a particular day, we usually take an umbrella (or raincoat) with us because the weather is cloudy and it may rain any time. If there is going to be a religious function or a wedding in our family, then our elders discuss the weather which is likely to be at that point of time and plan accordingly (by putting up tents only or making a water-proof pandal). Many times we have heard the experts discussing weather on radio or television before the start of a game such as a cricket match. This is because, say, a cloudy weather can change the course of a cricket match or spoil it altogether by bringing showers of rain. Thus, weather has a great effect on our lives. In fact, many of our activities are planned by taking into account the weather predicted for that day. It is for this reason that there are daily reports of impending weather (coming weather) in newspapers, radio and television.

If, however, we are planning to go to a hill station for holidays, then we always take along woollen clothes with us because the climate on the hill stations is always cold. On the other hand, if we are going to a coastal area (sea-side area), then we do not need woollen clothes because the climate there is not cold. As we will study after a while, weather and climate are two different things. In this Chapter, we will first discuss weather and climate, and then describe how different types of animals are adapted to the climates of their habitats. Before we do that, we should know the meaning of the terms ‘humidity’ and ‘rain gauge’. These are discussed below.

We know that air (or atmosphere) always contains some water vapour (or moisture) in it. Humidity is a measure of water vapour (or moisture) in air. When the amount of water vapour in the air is high, we say humidity is high and the air feels moist (or damp). Under these conditions, the sweat (pasina) from our
body does not evaporate readily and we feel hot and uncomfortable. If the humidity in an area is generally high, the climate there is said to be humid. On the other hand, if the amount of water vapour in the air is low, we say the humidity is low. When the humidity is low, the air feels dry. Under these conditions, the sweat from our body evaporates readily and we feel cool and comfortable.

Humidity of air is expressed as a percentage (%). A humidity of 100 per cent (100%) at a particular temperature means that the air is saturated with water vapour at that temperature (which means the air is holding the maximum amount of water vapour for that temperature). A humidity of 50 per cent (50%) means that the air contains half the amount of water vapour required for saturation at that temperature. **Rainfall is measured by an instrument called ‘rain gauge’**. Rain gauge is basically a measuring cylinder with a funnel at the top to collect rainwater. Rain gauge measures the rainfall at a place in the unit of ‘millimetres’ (mm).

**WEATHER**

If the temperature of air (or atmosphere) around us on a particular day is high, we say that the weather is ‘hot’ today. If the temperature on a day is low, we say that the weather is ‘cold’. If there is lot of water vapour (or moisture) in the air, we say that the weather is too ‘humid’. If there is rain, we say the weather is ‘rainy’ today (see Figure 1). And if a lot of wind starts blowing on a day, then we say that the weather is very ‘windy’ today. So, when we talk of weather, we are actually describing the condition of the atmosphere (or air) around us at a particular time. We can now define weather as follows: **The day-to-day condition of the atmosphere at a place and time with respect to the temperature, pressure, humidity, wind speed and wind direction, sunshine, clouds, rainfall (or snowfall), etc., is called weather at that place at that time.** The various factors which decide weather at a place are called ‘elements’ of weather. The **major elements of weather at a place are temperature, pressure, humidity, wind speed and wind direction, sunshine, clouds, and rainfall (or snowfall).** Weather is called ‘mausam’ in Hindi.

There are many different types of weather. Some types of weather are: hot, cold, sunny, cloudy, foggy, dry, humid, windy and rainy. The weather at a place is generally not the same on any two days. The weather at a place changes day after day and week after week. Actually, weather is such a complex phenomenon that it can change even over very short periods of time. For example, it can be sunny weather in the morning but suddenly clouds may appear from nowhere and it can become cloudy. And if it starts raining, then it becomes rainy weather. It is also possible that a heavy rain may vanish in a matter of minutes and give way to bright sunshine. **Weather is never constant anywhere.** So, it is not easy to predict weather. The weather plays a big part in our lives today. Weather affects many of the things we do. For example, we wear the clothes according to the prevailing weather; we eat food depending on weather; and we make our travel plans keeping the weather in mind. We will now discuss the source of weather and why weather changes so frequently.

**What Produces Weather**

Weather is produced by the heat of the sun and the effect it has on the atmosphere. This happens as follows: The sun is a huge sphere of hot gases at a very high temperature. Though the distance of the sun from the earth is very large, even then it is the source of all heat and light on the earth (see Figure 2). **The heat energy of the sun absorbed and reflected by the earth’s surface, oceans and atmosphere, plays an**
important role in determining the weather at any place. For example, the sun’s heat causes water from the oceans and land to evaporate. These water vapour rise high up in the atmosphere, get cooled, condense and form clouds in the atmosphere which produce rain leading to ‘rainy’ weather. Similarly, heat from the sun heats the earth’s surface. The hot surface of earth heats the air near it. This hot air (being lighter) rises up creating an area of low pressure. Air from high pressure area moves towards the low pressure area. The air moving from high pressure area to low pressure area is called wind. So, it is the sun’s heat which causes wind to blow and gives us ‘windy’ weather.

From the above discussion we conclude that the ‘rainy weather’ and ‘windy weather’ are produced by the sun. In fact, all types of weather (and all changes in weather) are caused by the sun. Thus, the sun is the primary source of energy which causes changes in the weather. The weather changes so frequently because the condition of the earth’s atmosphere keeps changing frequently due to the various effects produced by the sun’s heat.

**Maximum and Minimum Temperatures**

The ‘highest temperature’ reached during a day is called the ‘maximum temperature’ and the ‘lowest temperature’ during the day is called the ‘minimum temperature’. In order to prepare weather reports, the maximum and minimum temperatures are recorded at a place every day. The maximum and minimum temperatures reached during a whole day are recorded automatically by a special thermometer called ‘Maximum-and-Minimum thermometer’ (see Figure 3). Please remember that:

(i) The maximum temperature of the day generally occurs in the afternoon, and
(ii) The minimum temperature of the day generally occurs in the early morning.

During summers, we feel miserable in the afternoon because the maximum temperature of the day is reached in the afternoon (making the surroundings very hot and unbearable). On the other hand, we feel comparatively cool and comfortable in the early morning during summers because the minimum temperature of the day is reached in the early morning (making the surroundings somewhat cooler).

In any month of a year, all the seven days of the week do not have the same maximum and minimum temperatures at a place. The maximum and minimum temperatures keep on changing day by day. The maximum and minimum temperatures recorded at Delhi for a week from 01 November 2008 to 07 November, 2008 are given in the following table. A graph showing the variation of maximum temperature during this week is given in Figure 4.

<table>
<thead>
<tr>
<th>Date</th>
<th>Maximum temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.11.08</td>
<td>33.1°C</td>
</tr>
<tr>
<td>02.11.08</td>
<td>32.8°C</td>
</tr>
<tr>
<td>03.11.08</td>
<td>32.1°C</td>
</tr>
<tr>
<td>04.11.08</td>
<td>33.0°C</td>
</tr>
<tr>
<td>05.11.08</td>
<td>33.5°C</td>
</tr>
<tr>
<td>06.11.08</td>
<td>31.8°C</td>
</tr>
<tr>
<td>07.11.08</td>
<td>31.0°C</td>
</tr>
</tbody>
</table>

**Figure 3.** A maximum-and-minimum thermometer.

**Figure 4.** Graph showing the variation of maximum temperature at Delhi during the week 01 to 07 November, 2008.
By carefully monitoring the atmospheric conditions such as temperature, pressure, humidity, wind speed and wind direction, sunshine, cloud formations, rainfall (or snowfall), etc., it is possible to predict the coming weather in advance. Prediction of weather in advance is called weather forecasting. Weather experts use the various types of data collected by Earth Stations in different parts of the country as well as by the Satellites orbiting high up in the sky to predict weather (or forecast weather) well in advance. The scientific study of weather is called meteorology. The scientists who study and forecast weather are called meteorologists.

Weather Reports

We can see the daily weather reports in newspapers. The weather reports are also read on radio and shown on TV. The daily weather report carries information about the temperatures, humidity and rainfall during the past 24 hours. It also gives the timings of sunrise, sunset, moonrise and moonset. The weather report also predicts the weather for the day. A sample of the weather report which appeared in a newspaper on a Monday morning in the month of November 2008 in Delhi is given in Figure 5.

(i) The weather report given in Figure 5 tells us that the maximum temperature during the past 24 hours was 33°C (The figure +3 in brackets means that this maximum temperature is 3°C above normal). The minimum temperature during the past 24 hours is shown to be 16°C (The figure +2 in brackets means that this minimum temperature is 2°C above normal).

(ii) The weather report tells us that the moon will set on Monday at 9.30 pm and moon will rise on Tuesday at 11.55 pm. It also informs us that the sun will set on Monday at 5.34 pm and the sun will rise on Tuesday at 6.36 am.

(iii) The forecast of weather for the day given in the weather report tells us that: Sky will remain clear (which means no clouds, etc.) but there will be mist in the morning. The maximum and minimum temperatures predicted for the day are around 33°C and 17°C respectively.

(iv) The weather report given in Figure 5 also tells us that the maximum humidity recorded in the past 24 hours was 82 per cent and the minimum humidity was 29 per cent.

(v) Since rainfall does not occur every day, so no rainfall has been recorded in the above weather report during the past 24 hours.

Weather reports are prepared by the scientists (called meteorologists) of the Meteorology Department of the Government. Meteorological Department collects all the data on the condition of atmosphere (like temperature, pressure, wind speed, wind direction, humidity, sunshine, cloud formations, rainfall or snowfall, etc.) from various sources and prepares the weather report.

The times of sunrise and sunset also change during the year. During summer, sunrise is early and the sunset is late. Due to this, days are longer in summers and nights are shorter. On the other hand, during winter the sunrise is late but the sunset is early. Due to this, days are shorter in winter but nights are longer. From this discussion we conclude that **days are shorter in winter than in summer**.

Weather Over a Week

Let us cut out the weather reports of the last one week from any newspaper. We now record the information regarding temperatures, humidity, and rainfall given in these weather reports in the form of a table. As an example, the weather data for a full week at Delhi is given in the following table.
Weather Data of a Week (at Delhi)

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>01.11.08</td>
<td>33.1°C</td>
<td>17.4°C</td>
<td>75%</td>
</tr>
<tr>
<td>02.11.08</td>
<td>32.8°C</td>
<td>17.2°C</td>
<td>88%</td>
</tr>
<tr>
<td>03.11.08</td>
<td>32.1°C</td>
<td>17.5°C</td>
<td>73%</td>
</tr>
<tr>
<td>04.11.08</td>
<td>33.0°C</td>
<td>16.0°C</td>
<td>82%</td>
</tr>
<tr>
<td>05.11.08</td>
<td>33.5°C</td>
<td>15.0°C</td>
<td>86%</td>
</tr>
<tr>
<td>06.11.08</td>
<td>31.8°C</td>
<td>16.3°C</td>
<td>96%</td>
</tr>
<tr>
<td>07.11.08</td>
<td>31.0°C</td>
<td>14.2°C</td>
<td>84%</td>
</tr>
</tbody>
</table>

From the above table we can see that all the seven days of the week do not have the same maximum and minimum temperatures. Similarly, the maximum and minimum humidity values are also not the same on all the seven days of a week. It is possible that the maximum and minimum temperatures (or maximum and minimum humidity values) may be the same on some of the days of a week but all the parameters are not the same on any two days. There is a considerable variation in the weather data (such as temperature, humidity, rainfall, etc.) over a whole week.

CLIMATE

The scientists called ‘meteorologists’ record the weather at various places everyday. The records of the weather over the past several decades have been preserved. These records help the meteorologists to determine the weather pattern at a place. The average weather pattern at a place taken over a long period of time (say, 25 years) is called the climate of that place. For example, if the temperature at a place is high most of the time, then we say that the climate of that place is hot. And if there is also heavy rainfall on most of the days at that place, then we say that the climate of that place is hot and wet (or hot and humid). Climate is called ‘jalvayu’ in Hindi.

There are four major types of climates in the world: polar climate, temperate climate, tropical climate and desert climate. A brief description of all these climates is given below:

(i) Polar Climate. Polar climate is always very cold. In fact, polar regions have the coldest climate in the world. The air is so cold in polar regions of the earth that water falls there as snow (and not as rain). So, the air contains very little water vapour (or moisture) at the poles. Thus, the polar climate is extremely cold and dry.

(ii) Temperate Climate. A climate which is neither very hot in summer nor very cold in winter is called temperate climate. In temperate climate, there is moderate rain and snowfall.

(iii) Tropical Climate. A climate having very high temperatures and high humidity is called tropical climate. Thus, tropical climate is very hot and humid. There is usually a lot of rain in tropical climate.

(iv) Desert Climate. Desert climate is very hot during the day. There is little rain in desert areas so the desert climate is also dry. Thus, desert climate is very hot and dry.

Every place on the earth has its own climate. Our climate depends on our position on the earth and our distance from the sun. The climate is different at different places around the world because these are not heated equally by the sun. The equator of earth is at the minimum distance from the sun. The regions around the equator of earth called tropical regions (where the sun shines directly overhead) get the maximum heat from the sun and have a very hot climate (see Figure 6). As a region gets more and more distant from the equator, it becomes cooler and cooler. So, the climate becomes cooler and cooler as we move away from the equator.

Figure 6. Regions of earth near the equator (where the sun shines directly overhead) have a hotter climate than the regions farther away from the equator.
more away from the equator (towards the poles), the amount of sun’s heat received by the region goes on
decreasing, leading to gradually cooler climates. The poles of the earth are at the maximum distance from
the sun. Due to this, the sun’s rays have to travel much more to reach the polar regions of earth which
makes them lose much of their heat. **The polar regions of earth (near north pole and south pole of earth)**
receive the minimum amount of sun’s heat, so the polar regions of earth have an extremely cold climate.
We have just said that the climate in tropical regions is very hot whereas that in polar regions is extremely
cold. Thus, **the tropical regions and polar regions are the two regions of the earth which have extreme
climatic conditions.**

**Factors Which Affect Climate**

(i) **Temperature** and rainfall are the two most important factors which determine the climate at a
place.

(ii) Another factor which affects the climate of a place is its altitude: whether it is located on high
mountains or on plains (flat ground). A place at higher altitude will have a cooler climate than another
place on plains (flat ground). This is why hill stations always have a cool climate.

(iii) A yet another factor which affects the climate at a place is its location with respect to the sea:
whether it is located near the sea or far away from the sea. Sea-water heats up slowly and also cools down
slowly. This has a moderating effect on the climate of coastal areas. The temperatures in coastal areas are
neither very high nor very low.

We will now compare the climates of two places in India which are very far apart from each other.
These two places are **Srinagar** (in Jammu and Kashmir) and **Thiruvananthapuram** (in Kerala). Before we
do that, we should know how to find the **mean temperature** for a month. The mean temperature for a given
month is found in two steps: First we find the average of temperatures recorded during the month. Second,
we calculate the ‘average’ of such ‘average temperatures’ over many years. This gives us the mean
temperature for that month. The mean temperatures are found for the ‘maximum’ as well as the ‘minimum’
temperatures for the month.

Srinagar is situated at high altitude on a mountain in the Northern part of India whereas
Thiruvananthapuram is situated on plains (flat ground) at sea-level in the South-West part of India. Srinagar
is located very far away from the sea whereas Thiruvananthapuram is located near the sea. Srinagar is located
quite far away from the equator whereas Thiruvananthapuram is comparatively nearer to the equator. So, due to
their totally different positions on earth, Srinagar and Thiruvananthapuram have entirely different climates.
Some of the information about the climates (mean temperatures and mean rainfall) of Srinagar and
Thiruvananthapuram during the whole year is given in the following tables:

<table>
<thead>
<tr>
<th>Information About Climate of Srinagar (Jammu and Kashmir)</th>
<th>Information About Climate of Thiruvananthapuram (Kerala)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td>Mean temperature</td>
</tr>
<tr>
<td></td>
<td>Daily Min</td>
</tr>
<tr>
<td>Jan</td>
<td>–2.3°C</td>
</tr>
<tr>
<td>Feb</td>
<td>–0.6°C</td>
</tr>
<tr>
<td>Mar</td>
<td>3.8°C</td>
</tr>
<tr>
<td>Apr</td>
<td>7.7°C</td>
</tr>
<tr>
<td>May</td>
<td>10.7°C</td>
</tr>
<tr>
<td>June</td>
<td>14.7°C</td>
</tr>
<tr>
<td>July</td>
<td>8.2°C</td>
</tr>
<tr>
<td>Aug</td>
<td>17.5°C</td>
</tr>
<tr>
<td>Sept</td>
<td>12.9°C</td>
</tr>
<tr>
<td>Oct</td>
<td>6.1°C</td>
</tr>
<tr>
<td>Nov</td>
<td>0.9°C</td>
</tr>
<tr>
<td>Dec</td>
<td>–1.6°C</td>
</tr>
</tbody>
</table>
If we look at the data given in the above tables carefully, we can easily see the difference in the climates of Srinagar and Thiruvananthapuram.

(i) In Srinagar, the temperatures round the year are neither very low nor very high. Also, the rainfall is neither very low nor very high. Thus, *Srinagar has a moderately hot and wet climate*. In general we can say that **Jammu and Kashmir has a moderately hot and wet climate**. It is like a *temperate climate*.

(ii) In Thiruvananthapuram, the temperatures round the year are quite high. Also, the rainfall is very high. Thus, *Thiruvananthapuram has a very hot and wet climate*. In general we can say that **Kerala state has a very hot and wet climate**. Actually, Kerala has a typical *tropical climate*.

Rajasthan state lies in the Western region of India. In Rajasthan, the temperature is very high during most part of the year, so it is very hot (But during winter, which lasts only for a few months, the temperature is quite low). Rajasthan receives very little rainfall, so it is dry. Thus, **the climate of Rajasthan is hot and dry**. This is the typical *desert climate*. The North–East India (like Assam) receives rain for a major part of the year, therefore, we can say that **the climate of North–East India is wet**.

Please note that **climate is not the same as weather**. Weather is the day-to-day condition of the atmosphere at a place whereas climate is the average weather pattern at a place taken over a long period of time.

**CLIMATE AND ADAPTATIONS**

Climate has a great effect on all the living organisms (animals as well as plants). A living organism can survive in a particular habitat only if its body is suited (or adapted) to the climate of that habitat. Animals and plants develop special features in their body or develop certain habits to survive in their habitats (or surroundings). **The presence of specific body features (or certain habits) which enable an animal or a plant to live in a particular habitat (or surroundings) is called adaptation.** The body features and habits that help animals (and plants) to adapt to their particular habitats or surroundings are a result of the process of evolution. Adaptation is called ‘*anukulān*’ in Hindi.

Animals (and plants) are adapted to survive in climates in which they live. Adaptation can help animals to survive in their environment by enabling them to withstand climate (such as extreme cold or hot climate), to obtain food, to hide to keep safe or catch prey, or to breathe, etc. For example, **polar bears have two thick layers of fur and a thick layer of fat under their skin. Both these body features of polar bears are the adaptations to make them withstand the extremely cold climate of polar region** so that they may survive in their habitat.

We will now study the adaptations of some animals to the climates in which they live. As examples of adaptations of animals to climatic conditions, we will discuss only the animals living in two types of habitats:

(i) **Polar regions**, and

(ii) **Tropical rainforests**.

Our earth has two poles : north pole and south pole. **The areas situated near the poles of the earth are called polar regions.** Some of the well known countries that belong to the polar regions of the earth are Canada, Greenland (Denmark), Iceland, Norway, Sweden, Finland, Alaska in USA and Siberian region of Russia. All these countries actually belong to the north polar region (which is also called Arctic region). The south polar region of the earth is called Antarctic region (or just Antarctica). The polar regions of the earth have an extremely cold climate.

**Tropical rainforests** are thick forests which grow near both the sides of the equator of earth where the climate is very hot and humid, and rainfall is high. Some of the countries where tropical rainforests are found are India, Malaysia, Indonesia, Brazil, Republic of Congo, Kenya, Uganda and Nigeria.

The polar regions and the tropical regions are the two regions of the earth which have severe climatic conditions. We will now describe the climatic conditions in both these habitats and how animals are adapted to live in these climates. Let us describe the polar region first.
THE POLAR REGIONS

The polar regions of the earth have an extremely cold climate. The polar regions are covered with ice and snow, and it is extremely cold for most part of the year. For six months, the sun does not set at the poles while for the next six months, the sun does not rise (above the horizon). During winter in polar regions, the temperature can be as low as, \(-37^\circ\text{C}\) (minus 37°C). The animals living in the polar regions have adapted to the extremely cold climate by having some special features such as white colour, thick layer of fur, thick skin, a layer of fat under the skin, strong sense of smell, and big feet (big paws) for walking on soft snow and swimming, etc. The two animals which live in polar regions are polar bears and penguins. Polar bears live in north pole region whereas penguins live in the south pole region of the earth. We will now understand how animals of the polar regions have adapted to live in the severely cold climate by taking the examples of polar bear and penguins.

Adaptations in Polar Bear

The polar bear is a large, white bear which lives in north polar regions of the earth (see Figure 7). The polar bear feeds mainly on fish and seal (seal is an aquatic mammal). The polar bear lives in extremely cold climate of polar regions due to the following adaptations:

1. **Polar bear has white colour which matches with its surroundings.** Due to white colour, polar bear is not visible easily in the snowy white background and hence its prey is unable to see it. This adaptation of white colour helps the polar bear to catch its prey. The white colour of polar bear also protects it from its predators (who kill and eat it) because it mixes well with the snowy white surroundings due to which the predators cannot see it easily.

2. **Polar bear has two thick layers of fur on its body.** This fur protects the polar bear from extreme cold by preventing the loss of heat from its body. Thus, the two thick layers of fur keep the polar bear warm in extremely cold climate (by keeping its body heat in). The polar bear has also fur on its feet and toes. This protects it from cold when it walks on snow and ice.

3. **Polar bear has a thick layer of fat under its skin.** This layer of fat insulates the body of polar bear against heat loss and keeps it warm in cold climate. Thus, the thick layer of fat also protects the polar bear from extreme cold.

4. **Polar bear has a rounded body and small ears** to keep the body surface area to a minimum (compared to the body weight). This reduces the heat loss from the body of polar bear.

5. **Polar bear has big feet (or big paws) to spread the weight of its body on snow which prevent it from sinking into snow and make it walk on snow easily.** Polar bear has long, curved and sharp claws which help it to walk and run on slippery ice.

6. **Polar bear is a good swimmer.** The big feet (or big paws) help the polar bear to swim well. Being a fast swimmer helps the polar bear to catch its prey (like seal) in water very easily. While swimming under water, polar bear can close its nostrils and remain under water for long durations.

7. **Polar bear has a very strong sense of smell.** The very strong sense of smell helps the polar bear in locating and catching its prey for food.

Adaptations in Penguins

Penguin is an animal which lives in extremely cold south polar region of the earth. Penguin is a seabird which cannot fly (see Figure 8). Penguins hunt for fish which they eat as food. Penguins can live in the extremely cold climate of the polar region due to the following adaptations:
1. Penguin is black and white in colour but still it merges well with the white background of ice and snow.
2. Penguin has thick skin and a layer of fat below its skin which protect it from extreme cold.
3. Penguins live together in large numbers. Penguins huddle together to keep themselves warm.
4. Penguin has streamlined body, flipper-like wings and webbed feet which make it a good swimmer. Being a good swimmer helps penguin in catching fish as prey.

In addition to polar bears and penguins, some other animals which live in polar regions are Musk oxen, Reindeers, Arctic foxes, Seals, Whales, many kinds of Fish and Birds.

**MIGRATION**

The process in which a bird (or other animal) moves from one place to another in one season and returns again in a different season is called migration. **Migration of birds (or other animals) is an adaptation to escape the harsh and cold conditions of their normal habitat in winter so as to survive.** This point will become more clear from the following discussion. The birds must remain warm to survive. When the winter sets in cold regions of the earth, the climate becomes extremely cold. The birds which normally live in these regions migrate (fly off) to far flung warmer places to escape the extremely cold winter climate and survive (see Figure 9). And when the winter season is over, these birds fly back to their original habitats in the cold regions.

The birds which migrate from very cold regions to warmer regions in winter and go back after the winter is over, are called **migratory birds.** India is one of the destinations of many of the migratory birds coming from the very cold regions of the earth. **One of the most common migratory bird which comes to India every year for a few months is the Siberian crane** (see Figure 10). The normal habitat of Siberian crane is Siberia (which is a very cold place). When winter sets in Siberia, and it gets extremely cold, the Siberian crane flies thousands of kilometres and comes to warmer places in India such as Bharatpur in Rajasthan, Sultanpur in
Haryana, some wetlands of North-East, and some other parts of India. The Siberian cranes stay in the warmer places in India for a few months. The Siberian cranes fly back to Siberia when the winter ends there and climate becomes favourable. Thus, the adaptation of “migration” in Siberian crane is to escape the extremely cold winter conditions in Siberia and survive by moving to warmer regions.

Some migratory birds travel as much as 15,000 kilometres to escape the extremely cold climatic conditions at home to reach warmer places where there is plenty of food. The migratory birds usually fly high up in the sky where the wind flow is helpful and low temperature aids in dispersing the heat generated by the constant working of their flight muscles in flapping the wings. An important question now arises: How do migratory birds travel to the same place year after year? An exact answer to this question is still not available. Some of the probable reasons for how the migratory birds travel to the same place year after year are as follows:

(i) It seems that the migratory birds have a built-in sense of direction which tells them in which direction to fly to reach the same place.

(ii) Some migratory birds probably use landmarks to guide them to reach the same place.

(iii) Many migratory birds may be guided by the position of the sun during the day and by the position of stars at night to reach the same place.

(iv) There is also some evidence that the migratory birds may be using the magnetic field of earth to find the direction so as to reach the same place.

It is not only the birds which migrate. Even mammals, many types of fish, and insects (such as butterflies) are known to migrate seasonally in search of favourable climatic conditions and food. For example, reindeer is a mammal which migrates. Reindeers live in herds in the cold, northern regions of North America where they feed on grass and shrubs in the summer. During winter, when the snowfall occurs, all the grass and shrubs get buried in snow and reindeers do not get any food. Due to this, reindeers migrate to the warmer regions in the south where they get sufficient food. They return to the original habitat in the north after a few months when the snow starts melting.

**THE TROPICAL RAINFORESTS**

The area of earth near both sides of the equator is called tropical region. The tropical region has generally a hot climate because of its location around the equator. During hot summer days, the temperature in this region may go above 40°C. Even in the coldest months, the temperature is generally higher than about 15°C. The tropical regions get plenty of rainfall. This makes the region humid. Thus, the tropical regions have hot and humid climate. In tropical regions, days and nights are almost equal in length throughout the year. An important feature of the tropical regions of earth is the tropical rainforests (see Figure 11). Tropical rainforests are found in India, South-east Asia, Central America and Central Africa. In India, tropical rainforests are found in Western Ghats and Assam (Western Ghats is a mountain range parallel to the West coast of India. Western Ghats run through Maharashtra, Karnataka, Tamil Nadu and Kerala states). Because of highly favourable climatic conditions in tropical rainforests (such as continuous warmth and rain), a large variety of plants and animals are found in tropical rainforests. The major types of animals living in the tropical rainforests are Lions, Tigers, Leopards, Elephants, Monkeys, Apes, Lion-tailed macaque, Gorillas, Birds, Snakes, Lizards, Frogs and Insects, etc.
Since the number of animals living in the tropical rainforests is very large, they are adapted such that they eat different kinds of food (to overcome competition for food) and live in different kinds of places (to overcome competition for shelter). **Some of the adaptations in animals living in tropical rainforests are:**

- A skin colour which helps them to camouflage (mix up with the surroundings and hide) in order to catch prey or protect themselves from predators;
- Running very fast (to catch prey or escape from predators);
- Development of trunk, tusks, and large ears and feet;
- Sharp eyesight, Sensitive hearing and Thick skin;
- Living on trees;
- Development of strong, gripping tails;
- Long and large beaks;
- Bright colours and Loud voice;
- Living on diet of fruits, etc.

We will now describe the adaptations of some of the animals which help them to live and survive in the tropical rainforest habitats.

**Adaptations in Big Cats**

The wild animals such as lions and tigers, etc., are called big cats (see Figure 12). The big cats are carnivores which eat only the meat (or flesh) of other animals. The big cats hunt and kill animals (such as deer) to obtain food. The big cats can live and survive in the tropical rainforests due to the following adaptations:

1. **The big cats (lion and tiger) have a highly developed sense of smell** which helps them to locate their prey (and kill for obtaining food). Big cats also have **sensitive hearing**. This also helps to find their prey.

2. The ‘yellow-brown colour’ of lion and the ‘yellow-brown colour with black stripes’ of tiger helps them to hide in the forest (without being seen easily). This camouflage (or blending with the surroundings) helps the big cats in catching their prey.

3. **The big cats (lion and tiger) have eyes in front of their head which enable them to have a correct idea of the location of their prey.** This helps in catching the prey. The big cats also have **good eyesight** for hunting at night.

4. **The big cats (lion and tiger) can run very fast.** The high speed of running helps the big cats in catching their prey.
5. The big cats (lion and tiger) have long, strong and sharp claws in their front legs to catch their prey. The big cats can withdraw (pull in) the claws inside the toes so that they do not get worn out and blunt when they walk. Big cats also have powerful teeth and jaws to kill large prey.

Adaptations in Elephants

Elephant is a very large animal of Indian tropical rainforest (see Figure 13). Elephants are plant eaters. Elephant has adapted to the conditions of rainforests in many remarkable ways. The various adaptations in elephant which help it live and survive in tropical rainforest habitat are as follows:

1. One of the most important adaptation in an elephant is its trunk (which we can see in the front) (see Figure 13). The trunk of an elephant is basically an elongated nose (which is also capable of grasping things). The trunk helps the elephant in many ways. The elephant uses the trunk to smell. Because of the trunk, elephant has a strong sense of smell. It is also used for breathing. The elephant uses its long trunk to pick up food (like grass and plants, etc.) and put into its mouth. The trunk of elephant can reach up to the branches of trees and help it eat tree leaves as food. The elephant uses trunk for drinking water (by sucking up water and putting it into the mouth). The elephant also uses the trunk to bathe itself.

2. Another good adaptation of the elephant are its tusks. Tusks are the big and long pointed teeth which come out from the closed mouth of the elephant (see Figure 13). Tusks are the modified teeth of elephant. Tusks are actually the incisor teeth of elephant. Elephant uses the tusks to obtain food as follows: Elephant uses the tusks to tear off the bark of trees which it eats as food. An elephant has two tusks and four teeth. The elephant’s four teeth are inside the mouth. The elephant’s four teeth are molars (for chewing and grinding food). Elephants also use the tusks for fighting their enemies and protecting themselves.

3. The elephant has large ears. The large ears of elephant help it to hear even very soft sounds. Due to large ears, an elephant can hear even the slightest sound made by its predator behind him so that it can sense the danger and run away to safety. When the temperature rises, the elephants flap their large ears and use them as fans to cool themselves. So, the large ears also help the elephant to keep cool in the hot and humid climate of the tropical rainforest.

4. An elephant is very heavy. The elephant is adapted to support its great weight and prevent it from sinking into soft ground. The elephant’s feet are large and round. The large and round feet give good stability to the elephant and also prevent it from sinking into soft ground (by spreading its weight over a larger area).

We have just studied that big cats (lions and tigers) and elephants live on ground but they have different eating habits. Big cats eat flesh of animals whereas elephants eat grass and other plants. Due to their different food habits, big cats and elephants do not compete for food. There are, however, many other animals in the tropical rainforests (deer, etc.) which compete with elephants for grass and other plant food. In order to overcome the competition for food and shelter on the ground, many animals live on the trees in the tropical rainforests. Some of the animals which are adapted to live on the trees are: Red-eyed frogs, Toucans, Monkeys, and Lion-tailed macaques. We will now describe the important adaptations in these animals which help them live and survive on the trees.

Adaptations in Red-Eyed Frog

Red-eyed frog lives on the trees in the tropical rainforests, so it is also called red-eyed tree frog. It does not live in water. The red-eyed frog has a green back and a creamy underside. It has big and bulging bright-red eyes (see Figure 14). Red-eyed frog is nocturnal. It sleeps during the day and becomes active and...
feeds mainly at night. Red-eyed frog spends most of the day hidden on the underside of tree leaves. The various adaptations which help the red-eyed frog to live and survive on the trees in the rainforest habitat are as follows:

1. **Red-eyed frog has developed sticky pads on its feet which help it to climb easily on the trees on which it lives.** The sticky pads on feet also allow the red-eyed frog to attach itself to the branches and leaves of the trees.

2. **The big and bulging bright-red eyes of this frog are an adaptation for protection.** This can be explained as follows: If a predator (enemy) wakes up the sleeping red-eyed frog during daytime, its big and bright red eyes ‘pop open’ suddenly. The sudden opening of big and bright-red eyes frightens the predator for a while and the frog gets time to jump to a safe place.

3. **The green colour of red-eyed frog helps it to hide within the green leaves of the tree unnoticed by its prey.** This helps it in catching its prey (like insects, etc.). The hiding of red-eyed frog by mixing up with leaves due to its green colour also protects it from its predators (because they cannot see it easily).

4. **Red-eyed frog has very good eye-sight** which helps it to see very clearly at night.

5. **Red-eyed frog is a carnivore** and eats any type of insects as food.

**Adaptations in Toucan**

As there is competition for food even on the trees, some animals are adapted to get food from trees which is not reachable easily (like the fruits at the ends of very thin branches). **An example of the animal which is adapted to get food from the fruits attached at the ends of even very thin branches is ‘toucan’**. Toucan is a colourful bird with a strange looking beak (see Figure 15). Toucan’s beak is long and large. It has brightly coloured feathers. Toucan lives on the trees in tropical rainforests. It spends most of the time in the holes of big trees. Toucan eats fruits of the trees. The various adaptations which help the toucan to live and survive in its habitat on the trees in rainforests are as follows:

1. **Toucan has a long and large beak.** The long and large beak helps a toucan to reach the fruits attached to the ends of even thin branches of trees which are too weak to support its weight. Thus, **long and large beak is an adaptation in toucan for getting the otherwise unreachable fruits at the ends of very thin branches of trees**. The large beak also helps in the temporary storage of fruits being collected by toucan.

2. **The feet of toucan are adapted for grasping the branches of trees firmly.** This happens as follows. The toucan has four toes (with claws) on each foot: two toes pointing forward and two toes pointing backward. This arrangement of toes helps the toucan to get a firm grip on the branches of trees (without falling down).

3. **Toucan has the ability to change the colour of its feathers in order to blend (or mix up) with the surroundings.** Due to this adaptation, toucan is not noticed easily by the predators and hence remains safe.

**Adaptations in Monkey**

The monkey is a small to medium sized animal usually having a long tail which normally lives on trees in tropical rainforests (see Figure 16). Monkeys
simply sleep on convenient tree branches without making nests. The main adaptations in monkeys which help them live and survive on the trees in tropical rainforests are as follows:

1. **Monkeys are expert climbers.** The hands and feet of monkeys are adapted in such a way that they can easily hold on to the branches of trees.

2. **Monkeys have long and strong gripping tails which they use for grasping branches of trees.** Actually, monkeys use their long and strong tail like an extra hand to hold on to the branches of trees.

3. **Monkeys have very good eyesight.** The very good eyesight helps the monkeys in leaping between the branches to escape from their predators.

4. In the rainforest habitat, monkeys eat fruits, seeds, leaves, roots and insects as food.

**Adaptations in Lion-Tailed Macaque**

The lion-tailed macaque is a kind of medium sized monkey with a long face and cheek pouches for holding food while it is being collected. It is called lion-tailed because its tail is like that of a lion having ‘tufts of hair’ (bunch of hair) at the end. **The most outstanding feature of lion-tailed macaque is its silver-white ‘mane’ which surrounds its head from the cheeks down to its chin** (see Figure 17) (A growth of long hair on the neck of macaque is called ‘mane’). The mane of lion-tailed macaque appears to be like a beard, so the lion-tailed macaque is also called ‘beard ape’. Lion-tailed macaques are unique to India. **The lion-tailed macaques live in the rainforests of Western Ghats in India.** The lion-tailed macaques spend most of the time feeding in the upper canopy of trees in the rainforests. The various adaptations in lion-tailed macaques which help them live and survive on the trees in tropical rainforests are as follows:

1. **The lion-tailed macaque is a good climber and spends most of its time high up in trees.** The hand and feet of lion-tailed macaque are adapted to hold on to the branches of trees firmly.

2. **The lion-tailed macaque has very good eyesight which helps it in leaping between the branches.** This adaptation is useful in moving from one tree to another in search of food and also to escape from predators.

3. **The lion-tailed macaque feeds mainly on fruits on the trees.** It also eats seeds, leaves, stems, flowers, and buds. The lion-tailed macaque also searches for insects under the bark of trees and eats them. Since lion-tailed macaque gets sufficient food on the trees, it rarely comes down on the ground.

We are now in a position to **answer the following questions:**

<table>
<thead>
<tr>
<th>Very Short Answer Type Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is the primary source of energy which causes changes in the weather?</td>
</tr>
<tr>
<td>2. Name any two activities of our daily life which are planned according to the weather on a day.</td>
</tr>
<tr>
<td>3. What term is used to denote the amount of water vapour (or moisture) in air?</td>
</tr>
<tr>
<td>4. Name the instrument used to measure the rainfall at a place.</td>
</tr>
<tr>
<td>5. Name the unit in which rainfall is measured.</td>
</tr>
<tr>
<td>6. Which of two changes frequently: weather or climate?</td>
</tr>
</tbody>
</table>
| 7. Name one state (or region) each in India having the following climates:  
  (a) Very hot and wet  
  (b) Hot and dry  
  (c) Moderately hot and wet  
  (d) Wet |
| 8. Name one state in India which has a typical tropical climate. |
| 9. Name one state in India which has a typical desert climate. |
| 10. Name two animals which live in the polar regions of the earth. |
| 11. Name two animals (other than polar bears and penguins) which live in the polar regions of the earth. |
| 12. Name a sea-bird which cannot fly. |
13. Name two places in India where the migratory bird called ‘Siberian crane’ comes every year from Siberia.

14. Name any five types of animals which live in tropical rainforests.

15. Name two big cats.

16. Name the colourful bird having a long and large beak which lives in tropical rainforests.

17. What is the most outstanding feature of lion-tailed macaque?

18. State whether the following statements are true or false:
   (a) Weather and climate are just the same.
   (b) Red-eyed frog lives in the water of a pond.

19. The temperature at a place is high most of the time and there is also heavy rainfall on most of the days in the same place. What type of climate does this place have?

20. Fill in the following blanks with suitable words:
   (a) The average weather taken over a long time is called .............
   (b) The state of the atmosphere at a given place and time is called ............
   (c) A place receives very little rainfall and the temperature is high throughout the year, the climate of that place will be .............and .............
   (d) The two regions of the earth with extreme climatic conditions are .............and .............
   (e) The days are ................ in winter than in summer.
   (f) Tropical rainforests are found in ...........Ghats and .............in India.

Short Answers Type Questions

21. When are the maximum and minimum temperatures likely to occur during the day?

22. Explain why, in summers we feel so miserable in the afternoon and comparatively comfortable in the early morning.

23. What are the various types of information usually carried by the daily weather report in a newspaper?

24. What is a rain gauge? For what purpose is it used?

25. How have the animals living in polar regions adapted to the extremely cold climate?

26. A polar bear is white. How does the white colour help in the survival of polar bear in polar region?

27. State two important features of a polar bear which protect it from the extreme cold in snowy surroundings.

28. A polar bear has two thick layers of fur and a layer of fat under the skin. How do these adaptations help the polar bear in its survival?

29. A polar bear has a very strong sense of smell. How does this help the polar bear in its survival?

30. A polar bear has big feet (or big paws). What might be the advantages of this?

31. A polar bear is a good swimmer. How does this feature help the polar bear in its survival?

32. How does elephant living in the tropical rainforest adapt itself?

33. What are tusks? How does an elephant make use of tusks for its survival?

34. An elephant has large ears. How do large ears help the elephant?

35. State the adaptation in red-eyed frog which helps it to climb on trees on which it lives.

36. A toucan has a long and large beak. How does this adaptation help toucan in its survival on trees?

37. How are monkeys adapted to live on trees?

38. What is the other name of lion-tailed macaque? Where does lion-tailed macaque live?

39. State the adaptations in lion-tailed macaque which help it to live and survive on trees in the tropical rainforests.

40. How is penguin adapted to live and survive in polar regions?

41. State two features of a penguin which protect it from extreme cold in polar regions.

42. Why do penguins huddle together?

43. What are the various body features which make penguin a good swimmer? How does being a good swimmer help a penguin?

44. What is meant by the migration of birds? Why do birds migrate?

45. What are migratory birds? Name one migratory bird which visits warmer regions of India every year.

46. Describe the climate in tropical regions. Also name an important feature of the tropical regions.

47. Where are tropical rainforests found in India?

48. State two conditions due to which tropical rainforests support a wide variety of plants and animals.
49. Why does Siberian crane come from Siberia to places like Bharatpur in Rajasthan every year for a few months?
50. State any two adaptations in big cats which help in their survival.

Long Answer Type Questions

51. What is meant by ‘weather’? Name the elements which determine the weather of a place.
52. What produces weather? Why does weather change so frequently?
53. What is meant by ‘climate’? Explain with the help of an example. Name the four major types of climate.
54. State the factors which affect the climate of a place. What is the difference in the locations of Srinagar and Thiruvananthapuram? How do their climates differ?
55. What are polar regions? Describe the climate in the polar regions of the earth. Name any five countries that belong to polar regions.
56. What is meant by “adaptation”? Explain with the help of an example. How is polar bear adapted to live in extremely cold polar regions having snow all around?
57. (a) What are tropical rainforests? Name any five countries where tropical rainforests are found.
   (b) Name some of the adaptations which help the animals live and survive in tropical rainforests.
58. (a) Why do we find animals of certain kinds living in particular climatic conditions? Explain with examples.
   (b) Which of the following normally live in polar regions and which in tropical rainforests?
   Elephant, Musk oxen, Reindeer, Lion-tailed macaque, Penguin, Toucan, Seal, Red-eyed frog, Siberian crane, Arctic fox
59. What is the difference between the weather and climate? Indicate the type of climate in the following areas:
   (a) Jammu and Kashmir (b) Kerala
   (c) North-East India (d) Rajasthan
60. (a) How does the adaptation called ‘migration’ help the birds in their survival? Name one bird and one mammal which migrate seasonally.
   (b) An elephant has a long trunk. How does this adaptation help the elephant to live and survive in the tropical rainforest?

Multiple Choice Questions (MCQs)

61. Which of the following option best describes a tropical region?
   (a) hot and humid (b) moderate temperature, heavy rainfall
   (c) cold and humid (d) hot and dry
62. A carnivore with stripes on its body moves very fast while catching its prey. It is likely to be found in:
   (a) polar regions (b) deserts (c) oceans (d) tropical rainforests
63. Which of the following features adapt polar bears to live in extremely cold climate?
   (a) A white fur, Fat below skin, Keen sense of smell.
   (b) Thin skin, Large eyes, A white fur
   (c) A long tail, Strong claws, White large paws
   (d) White body, Paws for swimming, Gills for respiration
64. Which of the following has a tropical climate?
   (a) Kashmir (b) Kerala (c) Rajasthan (d) Assam
65. Which of the following is not a type of climate?
   (a) polar climate (b) equator climate (c) desert climate (d) tropical climate
66. If the ‘minimum’ and ‘maximum’ humidity values on four different days are as given below, which one is most likely to be a rainy day?
   (a) 30 %; 75 % (b) 43 %; 96 % (c) 29 %; 82 % (d) 26 %; 84 %
67. The most outstanding feature of a lion-tailed macaque is its:
   (a) silver-white mane (b) sticky pads on feet
   (c) long and large beak (d) ability to change colour
68. A climate which is neither very hot in summer nor very cold in winter is called:
   (a) polar climate (b) desert climate (c) temperate climate (d) tropical climate
69. An animal which is adapted to get food from the fruits attached at the end of even very thin branches is:
(a) red-eyed frog (b) monkey (c) lion-tailed macaque (d) toucan

70. Tropical climate is the one which is:
(a) neither very hot nor very cold (b) very hot and humid (c) very hot and dry (d) very cold and dry

71. The animal having sticky pads on its feet which help it to climb easily on trees is:
(a) toucan (b) red-eyed frog (c) siberian crane (d) reindeer

72. If the region of a country is nearer to the equator, it will have a:
(a) temperate climate (b) polar climate (c) desert climate (d) tropical climate

73. The red-eyed frog lives:
(a) in ponds (b) on trees (c) in lakes (d) on mountains

74. The climate of an Indian State is said to be hot and humid. This state is likely to be:
(a) Rajasthan (b) Kerala (c) Kashmir (d) Haryana

75. Which of the following does not live in tropical rainforests?
(a) leopard (b) gorilla (c) reindeer (d) lizard

76. Which of the following country does not have tropical rainforests?
(a) India (b) Brazil (c) Malaysia (d) Canada

77. One of the most common migratory bird which comes from Siberia is:
(a) crow (b) crane (c) toucan (d) parakeet

78. Which of the following have a thick layer of fat under the skin?
A. Parrot B. Polar bear C. Elephant D. Penguin
(a) A and B (b) B and C (c) A and D (d) B and D

79. Which of the following does not live in polar regions?
(a) reindeers (b) seals (c) toucans (d) penguins

80. The mammal which is known to migrate seasonally in search of favourable climatic conditions and food is:
(a) Siberian crane (b) Reindeer (c) African elephant (d) Toucan

Questions Based on High Order Thinking Skills (HOTS)

81. Some of the adaptations in animals are given below:
(a) White fur (b) Diet heavy on fruits (c) Strong tails (d) Layer of fat under skin
(e) Big feet (f) Sticky pads on feet (g) Thick skin (h) Strong sense of smell
(i) Need to migrate (j) Long and large beak
Which of these adaptations are:
(i) for polar regions?
(ii) for tropical rainforests?
(iii) for polar regions as well as for tropical rainforests?

82. The bird X moves from Siberia to places like Y in Rajasthan and Z in Haryana in India during a particular season. It stays in India for a few months and then goes back.
(a) Name the bird X.
(b) What are the places (i) Y, and (ii) Z?
(c) What general name is given to birds like X?
(d) Name the season during which bird X moves from Siberia to India.

83. The animal P having white colour lives in Arctic region whereas another animal Q having black and white colour lives in Antarctic region. Both these animals have thick layer of fat under the skin.
(a) What could animals (i) P, and (ii) Q be?
(b) In what type of surroundings do these animals live?
(c) What is the function of thick layer of fat under the skin of these animals?
(d) Which of these animals could be called a bird?
84. The two animals A and B are called big cats. The animal A has yellow-brown colour with black stripes whereas animal B has just yellow-brown colour.

(a) What could animals (i), A and (ii) B be?
(b) Name the type of habitat where these animals usually live.
(c) Where are the eyes of these animals located and what advantage do they confer to the animals?
(d) State whether these animals are carnivores or herbivores.

85. The two animals X and Y live in tropical rainforests. The animal X is a kind of bird which is adapted to obtain even those fruits from trees which are attached at the end of very thin branches. On the other hand, animal Y is a kind of frog which lives on trees. It has sticky pads on feet so as to climb the trees.

(a) What could X be?
(b) Name the adaptation in X which helps it to obtain fruits even from the ends of very thin branches.
(c) What could Y be?
(d) Name an adaptation in Y which helps in its protection.

ANSWERS

1. Sun 3. Humidity 6. Weather 7. (a) Kerala (b) Rajasthan (c) Jammu and Kashmir (d) North-East India 11. Musk oxen and Reindeers 12. Penguin 18. (a) False (b) False 19. Hot and wet 20. (a) climate (b) weather (c) hot; dry (d) polar regions; tropical regions (e) shorter (f) Western; Assam 61. (a) 62. (d) 63. (a) 64. (b)
65. (b) 66. (b) 67. (a) 68. (c) 69. (d) 70. (b) 71. (b) 72. (d) 73. (b) 74. (b) 75. (c) 76. (d) 77. (b) 78. (d)
79. (c) 80. (b) 81. (i) a, d, e, g, h, i (ii) b, c, f, j (iii) e, g, h 82. (a) Siberian crane (b) (i) Bharatpur (ii) Sultanpur (c) Migratory birds (d) Winter season 83. (a) (i) Polar bear (ii) Penguin (b) Surroundings covered with ice and snow (c) The thick layer of fat insulates the body of these animals against heat loss and keeps them warm in extremely cold climate (d) Animal Q (It is a penguin) 84. (a) (i) Tiger (ii) Lion (b) Tropical rainforest (c) These animals have eyes in front of their head. Having eyes in front of the head enables these animals to have a correct idea of the location of their prey. This helps in catching the prey (d) Carnivores 85. (a) Toucan (b) Long and large beak (c) Red-eyed frog (d) Big and bulging bright-red eyes (which ‘pop-up’ suddenly and frighten the predator)
We live on the earth and there is a lot of air around us. Air is a mixture of colourless gases, so we cannot see air. The layer of air above the earth is called atmosphere. The atmosphere contains a tremendous amount of air. About 99 per cent of atmosphere is made up of just two gases: nitrogen and oxygen. The amount of water vapour in the atmosphere depends on temperature and humidity. The earth’s atmosphere extends to a height of several hundred kilometres above the earth but most of the air lies within about 10 kilometres of the earth’s surface. The atmosphere exerts a pressure called atmospheric pressure due to the weight of air contained in it. The atmospheric pressure decreases with height. Even the small changes in atmospheric pressure can bring about considerable changes in the weather on earth. All the phenomena such as winds, storms, and cyclones, etc., occur in the earth’s atmosphere. In this Chapter we will study the formation of winds, storms and cyclones, and their effects. Before we go further, we will discuss the two important properties of air which are: air exerts pressure, and air expands on heating (and becomes lighter).

AIR EXERTS PRESSURE

The continuous physical force exerted on an object (or against an object) by something in contact with it, is called pressure. Air exerts pressure. Actually, air exerts pressure in different ways under different situations. For example:

(i) Air enclosed in a container (like a balloon or bicycle tube) exerts pressure,
(ii) Air in the atmosphere around us exerts pressure, and
(iii) Moving air (called wind) exerts pressure.

We will now describe the pressure exerted by air under different conditions in detail, one by one. Air is a mixture of gases. Air is made up of tiny particles called ‘molecules’ which move around quickly in all directions. The moving air molecules (or gas molecules) are so small that we cannot see them.
If we put air in a closed container (say, a balloon), then the fast moving air molecules ‘collide’ with the walls of the container and exert a force on the walls of the container from inside. This force produces pressure. Now, if we put more air into the container, then the container will have more air molecules in it. Due to more air molecules, the number of collisions of air molecules with the walls of the container will increase and hence the pressure exerted by air will also increase. The fact that air exerts pressure can be demonstrated by the following activity.

**ACTIVITY**

Take a rubber balloon and fill air into it with mouth. We will find that on filling air, the balloon gets inflated (it expands and becomes bigger in size) (see Figure 1). This can be explained as follows: When we put air in the balloon, then the number of air molecules in the balloon increases. These air molecules cause collisions with the rubber walls of balloon and create an ‘air pressure’. The air pressure acting on the thin rubber walls of the balloon from inside causes the balloon to expand and get inflated. Just like balloon, a football also gets inflated when air is filled in it. The football gets inflated because the air filled in it exerts pressure.

Let us take the example of bicycle tube now. The bicycle tube is a rubber tube (which is enclosed inside the tyre of the bicycle). We have to fill air in the bicycle tube to inflate it. This air is filled by using an ‘air pump’ called ‘bicycle pump’. When we fill air into the bicycle tube, then the air molecules inside the tube collide with the walls of the tube and exert air pressure. This air pressure exerted from inside, inflates the bicycle tube. So, it is the pressure exerted by air filled in a bicycle tube which keeps the tube ‘tight’ and makes the bicycle tyre feel ‘hard’. If we go on filling more and more air into bicycle tube with a pump, then ultimately the air pressure in the bicycle tube will increase too much due to which the bicycle tube may even burst! Thus, the two observations (or experiences) which tell us that air exerts pressure are as follows:

(i) When air is filled into a balloon with our mouth, the balloon gets inflated. This observation shows that air exerts pressure.

(ii) When air is filled into a bicycle tube with a pump, the bicycle tube gets inflated and makes the bicycle tyre feel hard. This observation also shows that air exerts pressure.

From the above discussion we conclude that when air is filled in a closed container (like a balloon or a bicycle tube), it exerts pressure. This air pressure is due to the motion of the molecules of gases present in air which is enclosed in the container. We will now describe another type of air pressure called ‘atmospheric pressure’ which is due to the weight of air present in the atmosphere above the surface of earth.

The atmosphere contains a tremendous amount of air. Air has weight, so the atmosphere consisting of tremendous amount of air has enormous weight. The weight of atmosphere (or air) above us exerts a pressure on the surface of earth and on all the objects on the earth. This pressure is known as atmospheric pressure. We can now say that atmospheric pressure is the air pressure which is exerted by the weight of air present in the atmosphere above us. The magnitude of atmospheric pressure is very large. As we go to higher altitudes, the atmospheric pressure goes on decreasing (because the weight of air above us goes on decreasing). Atmospheric pressure acts in all directions: downwards, sideways and even upwards!

We will now describe the ‘crushing a tin can’ activity to show the existence of air pressure (or atmospheric pressure) around us. This activity will also show that the magnitude of atmospheric pressure is very large. Tin can is a vessel made of a thin and flexible metal sheet. An empty tin can has air inside it
as well as outside it. So, the air pressure (or atmospheric pressure) acting on the walls of an empty tin can from inside and outside is equal and opposite, and balance each other. Due to this, an empty tin can (which contains air) does not get crushed by the large atmospheric pressure exerted by the air around us. We will now perform an activity to show what happens when air from inside the tin can is removed.

**ACTIVITY TO SHOW THAT AIR AROUND US EXERTS PRESSURE**

Take a tin can and put some water in it [see Figure 2(a)]. Heat the tin can by using a burner to boil the water so that steam is formed. This steam expels all the air from inside the tin can so that when water is boiling, there is no air inside the can, the whole can is filled with steam [see Figure 2(a)]. A tight cork is now fitted in the mouth of the tin can and heating is stopped. We now pour cold water from a tap on the hot tin can. On pouring cold water, the tin can collapses inwards as if a large force acting on it from outside has crushed it [see Figure 2(b)]. These observations can be explained as follows:

(i) When the water is boiling, steam is formed in the tin can [see Figure 2(a)]. Steam has pressure. The steam pressure acting from inside the tin can balances the air pressure (or atmospheric pressure) acting on all the sides of the tin can and hence the tin can does not get crushed.

(ii) When a tight cork is put on the mouth of the tin can containing steam and then cold water is poured over it, then the hot steam inside the tin can gets cooled, condenses and forms water and water vapour at very low pressure. Thus, on cooling, the pressure inside the tin can decreases too much and it cannot balance the large air pressure (or atmospheric pressure) acting on the tin can from outside. So, the large air pressure (or atmospheric pressure) outside the tin can crushes the tin can inwards [see Figure 2(b)]. The crushing of tin can having very low pressure inside it shows the existence of a large air pressure (or large atmospheric pressure) around it. So, this activity confirms that air around us exerts pressure.

A yet another type of force (or pressure) is exerted by air when it starts moving. Moving air is called wind. **Moving air (or wind) exerts a force or pressure on the objects on which it strikes.** An object which is moving is said to possess kinetic energy. The force (or pressure) exerted by the moving air (or wind) is due to the kinetic energy possessed by it. Some of the observations from our daily life which tell us that moving air (or wind) exerts pressure are as follows:

(i) If the air around us is not blowing, we will find that the leaves of trees, flags and banners, etc., do not move at all, they remain standstill. But when the air blows, then the leaves of trees, flags and banners start fluttering (moving with irregular motion). **It is due to the pressure exerted by moving air (or wind)**
that the leaves of trees, flags and banners flutter when the wind is blowing (see Figure 3). A long strip of cloth used to display advertisements is called a banner and a large board used to display advertisements is called a hoarding. Holes are usually made in hanging banners and hoardings so that high speed wind may pass through them easily without damaging them or bringing them down with its huge force or pressure.

(ii) While riding a bicycle, we find that it is easier to move the bicycle forward if the wind is coming from our back side. It is easier to ride a bicycle in the direction of blowing wind because the blowing wind exerts a force (or pressure) on us in the same direction in which our bicycle is moving and makes our bicycle move faster. On the other hand, we find it very difficult to ride a bicycle against the direction of wind (see Figure 4). This is because in this case the blowing wind exerts a force on us in the direction opposite to the motion of our bicycle. And since the wind opposes our motion, we have to pedal very hard to keep the bicycle moving against the wind.

(iii) While rowing a boat in the lake, we find it easier to row the boat forward if the wind is coming from behind us. This is because the blowing wind exerts pressure on the boat (and on the persons sitting in it) in the direction of their motion and helps it move forward. On the other hand, it becomes much more difficult to row a boat against the direction of blowing wind because in this case the wind exerts a pressure opposite to the direction of motion of boat. And since the wind opposes the motion of boat, we have to apply much more force to row the boat against the direction of wind.

(iv) When we are flying a kite, then the wind coming from our back side helps. This is because the wind coming from our back side, strikes the kite and exerts pressure on the kite to make it fly higher and higher. We can, however, not fly the kite against the direction of wind. This is because in this case the pressure of blowing wind will make the kite fall to the ground.

All the above observations (or experiences) show that moving air or wind exerts a force (or pressure) on all the objects which come in its way. If the wind blows in the same direction in which the object is moving, it makes the movement of object easier. On the other hand, if the wind blows in opposite direction to the motion of the object, it makes the movement of the object difficult.

Before we go further, we should know the meaning of the terms ‘expansion of air’ and ‘contraction of air’. The term ‘expansion of air’ means ‘increase in the volume of air’, and the term ‘contraction of air’ means ‘decrease in the volume of air’. Air expands on heating and contracts on cooling. In other words, when air is heated, its volume increases and it occupies a bigger space. And when air gets cooled, then its
volume decreases and it occupies a smaller space. We will now discuss the expansion of air on heating in detail.

**AIR EXPANDS ON HEATING**

When air is heated, its volume increases and it occupies a bigger space. We say that air expands on heating. The fact that air expands on heating can be demonstrated by performing an activity as follows.

**ACTIVITY**

(i) Take a boiling tube. The empty boiling tube contains air (though we cannot see this air). Take a balloon, stretch the mouth of the balloon and fix it tightly over the neck of the boiling tube [as shown in Figure 5(a)]. Make the joint of balloon with the neck of boiling tube air-tight by wrapping some adhesive tape over it.

![Figure 5(a)](image)

(a) A balloon tied over the neck of a boiling tube which contains air

![Figure 5(b)](image)

(b) When boiling tube is placed in hot water, the air present in boiling tube gets heated, expands and inflates the balloon

Figure 5. Air expands on heating.

(ii) Take some hot water in a beaker. Place the boiling tube (having rubber balloon fixed to its neck) in the hot water in the beaker. After 2–3 minutes we will see that the balloon gets inflated (as if someone has filled air in it) [see Figure 5(b)]. This can be explained as follows: When the boiling tube is placed in hot water, the air present in boiling tube gets heated, expands and its volume increases. The increased volume of air fills the balloon due to which the balloon gets inflated. So, **it is the ‘expansion of air on heating’ which inflates the balloon when the boiling tube is placed in hot water.** From this activity we conclude that **air expands on heating.**

If we take out the boiling tube from hot water and allow it to cool, then after some time, the balloon will get deflated (and come back to its original size). This is because the air present in boiling tube and balloon contracts on cooling due to which its volume decreases and balloon gets deflated.

**Hot Air (or Warm Air) is Lighter Than Cold Air**

We have just studied that air expands on heating and occupies more space. Now, when the same air occupies more space, it becomes lighter (or less heavy). This means that **hot air is lighter than cold air.** Now, when air gets heated at a place, it expands, becomes lighter and rises up in the sky. In other words, **hot air (or warm air) rises up.** We will now describe an activity to show that hot air is lighter (less dense) than cold air and, being lighter, hot air rises upwards.

**ACTIVITY**

(i) Take two paper bags (or paper cups) of exactly the same size. Hang the two paper bags in the inverted position (with their open faces pointing downwards) on the two sides of a light wooden stick with the help of short threads [see Figure 6(a)]. Tie a piece of thread in the middle of the stick. The other end of this thread
is tied to a hook in the roof of a verandah. The wooden stick with two paper bags tied to its two ends will hang like a common beam balance. Initially, the wooden stick is perfectly horizontal showing that the two paper bags contain an equal mass of the same air (cold air) [see Figure 6(a)].

![Figure 6](image)

**Figure 6.** Hot air is lighter (than cold air) and rises up.

(ii) Put a burning candle below the open mouth of the left side paper bag [see Figure 6(b)]. We will see that after some time, the left side of the wooden stick goes up showing that it has become lighter than the right side [see Figure 6(b)]. This observation can be explained as follows: When a burning candle is placed below the left side paper bag, the air above the candle flame gets heated. The hot air, being lighter, rises up and fills the left side paper bag (by displacing the heavier, cold air from it). Since the left side paper bag now contains hot air (which is lighter than cold air present in right side paper bag), therefore, the left end of wooden stick becomes lighter and moves up [see Figure 6(b)].

The above activity gives us two conclusions about the nature of hot air:

(i) hot air is lighter (than cold air), and
(ii) being lighter, hot air rises up.

The fact that **hot air is lighter (than cold air) and rises up, is utilised in launching hot air balloons** (see Figure 7). A white, grey or black substance (formed of small particles) emitted from a burning substance is called smoke. **Smoke always rises up.** This can be explained as follows: Smoke is produced by the burning of a substance, therefore, smoke is always accompanied by hot air (or warm air). *Since warm air is lighter (than cold air), therefore, smoke contained in warm air always rises up.* The air inside a house gets warmed by the body heat of all the persons living in the house and also by the burning of fuels (LPG, etc.) in the kitchen. If we want to buy a house, then we should buy a house having windows as well as *ventilators.* The windows are for bringing in fresh air from outside into the house. *The ventilators (located near the roof of house) take out the warm and stale air from inside the house.* The presence of ventilators in the house increases our comfort.

In nature there are several situations when air at a place gets heated, becomes lighter and rises up. When air at a place gets heated and rises up, then the pressure at that place is lowered (or reduced). The cold air from the surrounding areas (being at higher pressure)
rushes in to fill the space vacated by hot rising air. This leads to blowing of winds. We will now describe the formation of winds in detail.

**HOW WIND IS PRODUCED**

Wind is the movement of air which depends on the difference in air pressures (or atmospheric pressures) in the two regions. Air moves (or flows) from the regions of high air pressure to regions of low air pressure in the atmosphere. The greater the difference in air pressure, the faster the air moves. Thus, the speed of wind depends on the difference in air pressures between the two regions. The greater the difference in air pressures between two regions, the faster the wind blows. The differences in air pressures (or atmospheric pressures) in different regions of the earth which cause wind to blow are created in nature due to the uneven heating (or unequal heating) on the earth in these regions. Thus, **uneven heating on the earth in different regions is the main cause of wind movements**. So, in order to understand how winds are produced, we should first know which regions (or areas) of earth get more heat from the sun and which regions of earth receive less heat from the sun leading to an unequal heating on the earth. This is discussed below.

The equator of earth is at the minimum distance from the sun (see Figure 8), so the region around the equator of earth (called equatorial region) gets the maximum heat from the sun and hence it is very hot. As a region gets more and more away from the equator (towards the poles), the amount of sun’s heat received by the region goes on decreasing gradually leading to less hot climates (or cooler climates). The poles of the earth (north pole and south pole) are at the maximum distance from the sun and hence get the minimum heat from the sun. So, the polar regions of the earth are very cold.

The angular distance of a place (or region) north or south of the earth’s equator is represented by ‘latitude’ (which is measured in degrees). Equator of earth has 0° latitude (zero degree latitude); North pole of earth has 90°N latitude (90 degrees North latitude); whereas South pole of earth has 90°S latitude (90 degrees South latitude) (see Figure 8). A latitude of 30°N (30 degrees North) means a place on the earth’s surface which is 30 degrees North of equator. A latitude of 60°N (60 degrees North) means a place which is 60 degrees North of equator. A latitude of 30°S (30 degrees South) means a place which is 30 degrees South of equator. Similarly, a latitude of 60°S (60 degrees South) means a place which is 60 degrees South of the equator. Keeping these points in mind, we will now describe how winds are produced (or generated) in nature.

**WIND IS PRODUCED DUE TO UNEVEN HEATING ON THE EARTH BY THE SUN**

Wind blows due to the difference in the air pressures (or atmospheric pressures) in the two regions. These differences in air pressures are created by the uneven heating (unequal heating) on the earth in the two regions. So, we can now say that: **Wind is produced due to uneven heating on the earth by the sun.** The uneven heating on the earth (which produces winds) can take place under two situations:

(i) Uneven heating between the equator and poles of the earth, and
(ii) Uneven heating of land and water of oceans.

We will now describe how wind is produced in both these situations, one by one.

1. **Wind is Produced by the Uneven Heating Between Equator and Poles of Earth**

The regions close to the equator of earth get the maximum heat from the sun, so the air in equatorial regions gets heated and becomes warm (see Figure 8). The warm air rises in the equatorial regions of earth creating an area of low air pressure. The cooler air from the regions of up to 30 degrees latitude belt on both the sides of the equator (being at higher pressure), rushes towards the equator to take the place of warm, rising air. This makes the wind to blow from the north and south directions towards the equator (see Figure 8). Again, the air at latitudes of about 60 degrees on both sides of the equator is warmer than at the poles (which is very cold). So, the warmer air at about 60 degrees latitudes rises up creating regions of low air pressure.
pressure and cold air from the polar regions (being at higher pressure) rushes in to take its place. This makes the winds blow from the poles of the earth towards the warmer regions up to about 60 degrees latitudes. These winds also blow from the north and south directions towards the warmer latitude regions (see Figure 8).

Please note that the winds shown in Figure 8 (by the arrows) are not blowing in the exact north-south direction. The winds produced by the uneven heating on the earth between the equator and the poles would have blown in the exactly north-south direction (from ‘north to south’ or from ‘south to north’) if the earth did not rotate on its axis. The winds produced by the uneven heating of the earth between the equator and the poles do not blow in the exact north-south direction because a change in the direction of winds is caused by the rotation of the earth on its axis (see Figure 8).

2. Wind is Produced by the Uneven Heating of Land and Water in Oceans

In summer, land near the equator of earth heats up faster than the water in oceans, so most of the time, the temperature of land is higher than that of water in oceans. The air over the land gets heated and rises creating a low pressure area. The cooler air from over the oceans (being at higher pressure), rushes towards the land. This causes the wind to blow from the oceans towards the land. The winds blowing from the oceans towards the land in summer are called monsoon winds. The monsoon winds carry a lot of water from the oceans (in the form of water vapour) and bring large amount of rains on land. The process in which the winds coming from the oceans carry a lot of water vapour and bring rains is a part of the ‘water cycle’ in nature.

In India, the land (especially the Rajasthan desert) gets heated much more in summer than the water in the Indian ocean. This uneven heating of ‘land’ and ‘water in Indian ocean’ during summer, generates monsoon winds from the Indian ocean. The monsoon winds coming from the south-west direction in summer carry a lot of water vapour from the Indian ocean and bring heavy rains (known as ‘monsoon’ or ‘rainy season’) [see Figure 9(a)]. The summer monsoon is very important to the farmers in our country because most of the annual rainfall occurs at this time and helps in growing crops. Many farmers in our country depend mainly on rains for the irrigation of their crops.

Figure 8. The wind flow pattern due to uneven heating between the equator and poles of the earth.

Figure 9. Winds generated by the uneven heating of land and water in oceans.

(a) Winds blowing from south-west direction in summer (when the land is hotter than water in ocean) 
(b) Winds blowing from north-west direction in winter (when the land is colder than water in ocean)
We have just learnt that during summer, wind blows from the oceans towards land. In winter, the direction of wind flow gets reversed. During winter, wind blows from the land towards the ocean. This happens as follows: During winter, land cools down faster than the water in oceans. So, the temperature of water in oceans is higher than that of land. The warm air over the oceans rises up creating a region of low pressure and cooler air from the land rushes towards the ocean. This causes wind to blow from land towards the oceans. The winds coming from colder land regions (or colder winds) carry only a little of water vapour and hence bring only a small amount of rain in winter season.

In India, the land (especially the north-west region) gets cooled much more in winter than the water in Indian ocean. This uneven heating of land and water in Indian ocean during winter generates winds from the north-west colder land going towards the Indian ocean (see Figure 9(b)). The colder winds coming from the north-west direction in winter carry only a small amount of water vapour and hence bring only a small amount of rain in winter season.

**HIGH SPEED WINDS ARE ACCOMPANIED BY REDUCED AIR PRESSURE**

Fast moving air creates a region of low pressure. Since moving air is called wind, therefore, we can also say that fast blowing wind creates a region of low pressure. Now, ‘fast wind’ means ‘high speed wind’ and ‘low pressure’ means ‘reduced air pressure’. So, a yet another way of saying this is that high speed winds are accompanied by reduced air pressure. We will now describe some activities which will show that fast moving wind creates a region of low air pressure (or reduced air pressure).

**ACTIVITY 1**

Take two balloons of equal size. Fill a little water into both the balloons (to make them slightly heavier). Inflate both the balloons by filling air into them with mouth (or pump) and tie their mouths properly with strong threads. Hang the two inflated balloons about 10 cm apart on a stick with the help of threads tied to their mouths (see Figure 10(a)).

![Figure 10(a)](image)

(a) Two inflated balloons (containing a little water each) hanging from a stick

When air (or wind) is blown in the space between the two balloons, they come closer (see Figure 10(b)). This can be explained as follows: When we blow air (or wind) between the balloons, then the fast moving air (or fast moving wind) creates a region of low air pressure in the space between the two balloons. The air pressure on the outside of the balloons being higher, pushes the two balloons towards each other and makes them come closer. So, this activity shows that the fast moving air (or fast moving wind) creates a region of low air pressure (or reduced air pressure).

**ACTIVITY 2**

Take a piece of paper and crumple it to make a small ‘paper ball’. Hold an empty glass bottle on its side (horizontally) and place the small paper ball in the neck of the bottle just inside its mouth (see Figure 11). Let us now blow air into the bottle from our mouth. When we blow air into the bottle, the paper ball kept in
the neck of the bottle remains unaffected, the paper ball does not go inside the bottle (see Figure 11). This can be explained as follows: When we blow air into the mouth of the bottle, then the air in the neck of bottle has high speed. This fast moving air reduces the air pressure in the neck of the bottle. The air pressure inside the bottle being higher, constantly pushes the paper ball out and does not allow it to go inside the bottle. So, this activity also shows that increased wind speed is accompanied by a reduced air pressure.

The fast moving air (or high speed wind) blowing over an object can also lift the object up by producing a region of low pressure above it. This will become clear from the following activity.

**ACTIVITY 3**

Hold a strip of paper about 20 cm long and 3 cm wide just below your lips and blow air over its surface from your mouth. We will find that the strip of paper lifts up (see Figure 12). This can be explained as follows: When we blow air over the surface of paper strip, the fast moving air creates a region of low air pressure above the paper strip. The air pressure below the paper strip, being higher, pushes the paper strip upwards and lifts it up. This activity shows that fast moving air is accompanied by low air pressure (or reduced air pressure). In other words, increased wind speed is accompanied by a reduced air pressure.

We have just learnt that when air is blown over a strip of paper, then the strip of paper is ‘lifted up’ (because the fast moving air reduces the pressure above the paper strip and higher air pressure acting from below the paper strip lifts it up). **If high speed winds blow over the roofs of houses, they will reduce the air pressure above the roofs. And if the roofs of houses are weak, then higher air pressure from below will lift up the roofs which can then be blown away by the fast winds.** Thus, weak roofs of houses (like the tin roofs or thatched roofs) can be lifted and blown away by high speed winds during a wind-storm.

**Wind Speed and Wind Direction**

Wind speed and wind direction play an important role in the formation of storms (such as thunderstorms, cyclones and tornadoes). It is, therefore, necessary to measure wind speed and wind direction at a place. **The wind speed is measured by an instrument called anemometer** (see Figure 13). The most common type of anemometer consists of 3 or 4 cups mounted on a rod which can rotate freely. The cups catch the wind and rotate. The greater the speed of wind, the faster the cups rotate. At the base of the anemometer is a scale. The speed of wind (in kilometres per hour) is read from this scale. The anemometer is installed on a tall mast where the wind blows freely around it.

The wind can blow from different directions. **The direction of wind at a place is found by using an instrument called wind vane** (see Figure 14). We can find the direction from which wind is blowing by looking at the wind vane. The arrow of wind vane rotates freely. The arrow of wind vane moves until it points to the direction from which the wind is blowing. If the arrow points to the south, it shows that the wind is blowing from the south direction (see Figure 14).
High Speed Winds Can be Destructive

We have just studied that winds bring us rains. This is a useful part played by winds. But high speed winds (called strong winds) can also be destructive sometimes. High speed winds create certain situations in nature which create disasters and pose a threat to the life of human beings and other animals. Houses, other buildings and standing crops are also destroyed in these disasters. Wind plays an important role in the formation of thunderstorms, cyclones and tornadoes which can cause disasters. We will now discuss the formation of thunderstorms, cyclones and tornadoes, and their effects. Before we do that, we should know the meaning of the terms: storm, lightning and thunder. These are discussed below.

(i) Storm. A period of violent weather with strong winds, and usually rain (or snow), is called a storm. A storm is the disturbed state of the earth’s atmosphere which affects the surface of earth and all the objects on it. Storm is called ‘toofan’ in Hindi.

(ii) Lightning. A natural flow of high voltage electricity within a cloud (or between a cloud and the earth) which appears as a bright flash of light in the sky, is called lightning. Please note that for a cloud to become electrically charged and produce lightning, its temperature must be close to the freezing point of water (which is 0°C). We will explain it further when we discuss the formation of a thunderstorm after a while. Lightning is usually accompanied by thunder.

(iii) Thunder. The loud sound which is heard a little after a lightning flash is seen in the sky is called thunder. Thunder is produced by lightning as follows: The high voltage electric spark of lightning heats the air in the atmosphere to a very high temperature. This extreme heating causes the air to expand at an ‘explosive rate’ producing a loud sound called thunder. Thus, it is lightning which causes thunder. As we will study after a while, lightning and thunder are the two characteristic features of a thunderstorm.

THUNDERSTORM

Many times during a storm which brings heavy rain, we also hear loud sound called ‘thunder’ coming from the clouds and see the bright flashes of ‘lightning’ as well. A storm with thunder and lightning is called thunderstorm. A thunderstorm is accompanied by heavy rains or hail (The pellets of frozen rain or ice falling in showers from clouds is called hail). Thunderstorm is produced by the dark clouds which form at fairly low altitude in the
atmosphere. Thunderstorm is called ‘garajwala toofan’ in Hindi. **Thunderstorms develop in hot and humid tropical areas (like India) very frequently.** This is because the heat of tropical area warms up the air and makes it rise up, whereas humidity provides the water vapour for the formation of clouds. **A thunderstorm is formed as follows.**

The sun heats the surface of earth. The hot surface of earth warms the air in contact with it. The warm air (being lighter) rises up creating a low pressure area. And cool air rushes in to take its place in the form of strong winds. As the warm air rises, it transfers heat to the upper levels of atmosphere and begins to cool. The water vapour present in the rising air cool and condense to form a cloud. The cloud grows upwards into areas where the temperature is close to the freezing point of water (0°C). Some of the water vapour of cloud forms tiny water droplets and some of it turns into ice particles. The water droplets are carried upwards in the cloud (by convection currents) but the ice particles drift downwards. The friction between fast rising ‘water droplets’ in the cloud and falling ‘ice particles’ produces opposite electric charges on them (the water droplets getting positive electric charge and ice particles acquiring negative electric charge). Due to this, the top of cloud becomes positively charged and the bottom of cloud becomes negatively charged. When a large amount of opposite electric charges build up in the cloud, a tremendous amount of electric current passes through the air in the cloud which produces a big electric spark within the cloud. This electric spark is the lightning (see Figure 15). The spark of lightning heats the nearby air too much. This extremely hot air expands explosively causing a loud sound called thunder. When electric charges from the bottom of the electrically charged cloud flow down through the air to the ground, then we see the flash of lightning coming towards the earth. The big water drops in the thundercloud fall to the earth as heavy rain (or hail). In this way, a thunderstorm brings strong winds, thunder, lightning and heavy rains (or hail).

**Precautions To be Taken During a Thunderstorm**

A thunderstorm is always accompanied by lightning. Lightning is a giant electric spark. When lightning strikes the earth, it can kill people. It also damages buildings. **We should take the following precautions during a thunderstorm to protect ourselves from lightning.**

(i) We should not sit near a window during lightning. Open garages, storage sheds and metal sheds are also not safe places to take shelter during lightning.

(ii) We should not take shelter under an umbrella with a metallic end during lightning. This is because metallic end of umbrella may act as a conductor for lightning and harm us.

(iii) We should not take shelter under an isolated and tall tree. This is because an isolated tall tree is more likely to be hit by lightning due to its nearness to the clouds. We should take shelter under a small tree. We should, however, not lie on the ground during lightning.

(iv) A car (or a bus) is a safe place to take shelter during lightning (because its metal body can conduct lightning to earth safely, without harming us).

(v) If we are in water (as in a swimming pool or on a beach) when the thunderstorm begins and lightning takes place, we should get out of water and go inside a building.

Before we describe a cyclone, it is necessary to know what supplies energy to form and sustain it. **The energy required to form and sustain a cyclone comes from the heat of condensation of water vapour present in moist air rising from the surface of hot sea water.** This will become clear from the following discussion. We know that water absorbs heat and changes into water vapour. This absorbed heat gets stored in water vapour. Now, when water vapour gets cooled and condenses to form liquid water, it releases the stored heat. This is called the heat of condensation of water vapour. A cyclone is powered by the heat of condensation of water vapour present in the warm, high moisture air which rises from the warm sea surface and condenses at high altitudes to form clouds. **The sea-water becomes warm because it is heated by the sun’s heat rays.** It is the warm sea-water which provides heat continuously for the evaporation of water to form water vapour. Let us now discuss the cyclone in detail.
CYCLONE

A cyclone is a huge revolving storm caused by very high speed winds blowing around a central area of very low pressure in the atmosphere. A cyclone is formed over warm sea-water and it is about 10 to 15 kilometres high. A cyclone revolves due to the force exerted by the rotation of earth. The centre of a cyclone is a calm area (having very low air pressure). The centre of cyclone is called the ‘eye’ of the cyclone (see Figure 16). The diameter of the eye of cyclone varies from 10 to 30 kilometres. The eye of cyclone is a region free of clouds and it has only light winds. Around the calm and clear eye of cyclone, there is a cloud region of about 150 kilometres in size. In this region, there are very high speed winds (having speeds of 150 km/h to 250 km/h) which are moving in circles around the eye, and thick thunderclouds which produce heavy rain. Away from this region of clouds, the wind speed gradually decreases. A cyclone is known as ‘chakkravaat’ or ‘bavandar’ in Hindi. We will now describe the formation of a cyclone.

How a Cyclone is Formed

A cyclone is formed in the atmosphere over warm sea-water near the equator during the hottest summer months. Factors like temperature, humidity, wind speed, wind direction and rotation of earth, contribute to the development of a cyclone. The formation of a cyclone can be explained as follows:

(i) The sun heats the sea-water too much during summer. Warm and moist air rises up very rapidly from the hot sea surface. This creates area of very low pressure causing cool air to rush in to fill the vacant space.

(ii) As the warm and moist air (containing a lot of water vapour) rises high up in the atmosphere, it gets cooled and the water vapour present in it condenses to form thick clouds (called thunderclouds) releasing a lot of heat in the atmosphere.

(iii) The heat released by the condensation of water vapour in the atmosphere warms the air all around. This warm air rises higher into the atmosphere causing a low pressure. More air rushes up to take the place of warm, rising air. This process is repeated again and again making more and more air to rise up higher and higher in the atmosphere, and also forming more and more thick clouds (or thunderclouds) all around.

(iv) The constant rotation of earth on its axis exerts a force on the rapidly rising columns of air (or winds). The force exerted by the rotation of earth makes the high speed winds revolve in the form of a spiral moving upwards with a great force and create a tunnel of very low pressure inside it (within the thunderclouds) (see Figure 17). The swirling winds move faster and faster forming huge circles. This weather...
condition consisting of a system of high speed winds revolving around a central area of very low pressure is the cyclone. The area of very low pressure at the centre of the cyclone is its eye (see Figure 17).

Once a cyclone is formed, it begins to move over the surface of sea. It is sustained by a steady flow of warm and moist air from the warm sea-water. The strongest winds and the heaviest rains occur in the towering thunderclouds about 20 to 30 kilometres from the centre of the cyclone. The end of a cyclone comes quickly if a cyclone moves over land because it no longer receives heat energy and moisture from warm sea-water. A cyclone is known by different names in different parts of the world. For example, a cyclone is called ‘hurricane’ in the American continent. A cyclone is called ‘typhoon’ in Japan and Philippines.

Destruction Caused by Cyclones

Cyclones are the greatest storms on earth. Cyclones can be very destructive. Cyclones cause widespread destruction and loss of life in coastal areas in three ways: by producing extremely high speed winds; by lifting the sea-water several metres high; and by bringing torrential rains. This is discussed below:

(i) The cyclones bring with them extremely high speed winds which cause a lot of destruction. The tremendous force of high speed winds accompanying a cyclone can topple trees, electric poles, telephone poles and vehicles; damage houses; and hurl people through air, etc., causing a great loss of life and property (see Figure 18). The strong winds of cyclone produce powerful water waves in the sea and push sea water towards the shore even if the cyclone is hundreds of kilometres away.

(ii) The extremely low pressure in the eye of cyclone lifts the water surface of the sea upwards to a height of 3 to 12 metres. The rising sea water appears like a water-wall moving towards the shore (see Figure 19). This water-wall coming from the sea rushes inland with deadly force and causes widespread flooding of low-lying coastal areas. The fast moving flood waters brought in by a cyclone, destroy roads and railway tracks, wash away vehicles, damage houses, drown people and animals, and damage crops causing a great loss of life and property. The floods caused by cyclone also reduce the fertility of soil in the cyclone hit areas. This is because the fertile top soil is washed away by flood waters brought in by cyclone.

(iii) Cyclones bring with them torrential rains. The continuous heavy rains brought by cyclones may further worsen the flood situation in the area. This increases the problems of the cyclone affected people.

(iv) The floods caused by cyclones pollute drinking water sources. Drinking of polluted water spreads water-borne diseases (like typhoid and dysentery). These diseases kill more people in the cyclone affected areas.

The part of land adjoining the sea (or near the sea) is called coast (or coastal area). The ‘length of coast’ is called ‘coastline’. The whole coastline of India is vulnerable to cyclones. This means that the whole coastline of India is exposed to being hit by cyclones. The east coast of India is more vulnerable to cyclones (or cyclonic storms). The west coast of India is less vulnerable to cyclones (or cyclonic storms) both in terms of intensity and frequency of cyclones. All the places (cities and villages) in India which lie
in the coastal areas are likely to be affected by cyclones. For example, the places like Chennai, Mangaluru (Mangalore) and Puri are likely to be affected by cyclones because they are coastal areas (which lie near the sea). On the other hand, those places which are far away from the sea are unlikely to be affected by cyclones. For example, Delhi, Amritsar and Srinagar are far away from the sea, so they are unlikely to be affected by cyclones (which originate in the sea).

In our country, Orissa was hit by a cyclone on 18th October, 1999. This cyclone had a wind speed of 200 km/h. It destroyed 45,000 houses making 7,00,000 people homeless. Many people were killed. Another cyclone hit Orissa on 29th October the same year. It had a wind speed of 260 km/h. This cyclone was accompanied by water waves about 9 metres high. Thousands of people lost their lives. Property worth crores of rupees was destroyed. The cyclone affected electricity supply, communication systems, transport and agriculture.

**Effective Safety Measures By the Government**

The following safety measures should be taken by the Government for the people living in cyclone prone coastal areas to prevent cyclone related disasters:

(i) Cyclone shelters should be constructed in cyclone prone coastal areas. Cyclone shelters are strong buildings usually built on pillars which can withstand high speed cyclone winds and where cyclone’s flood water cannot enter.

(ii) An efficient cyclone forecast and warning service is essential to prevent cyclone related disasters.

(iii) The cyclone warning should be communicated rapidly to the concerned Government agencies, ports, ships, fishermen and general public living in coastal areas through radio, television, telephones, newspapers and other means.

(iv) Government vehicles (such as buses, trucks, etc.) should be kept ready to evacuate people likely to be affected by cyclone from their homes and move them fast to safer places (such as cyclone shelters).

**Action on the Part of People Before a Cyclone Hits Their Area**

The following advance planning is required by the people living in the cyclone prone coastal areas if a cyclone warning has been issued in their area:

(i) Do not ignore the cyclone warnings issued by the Meteorological Department through newspapers, radio or television.

(ii) Make necessary arrangements to shift the essential household goods and domestic animals, etc., to safer places.

(iii) Keep ready the telephone numbers of all the emergency services like police, fire brigade and hospitals.

(iv) Remain in a state of preparedness to evacuate at short notice when asked to do so by the authorities.

**Precautions to be Taken After the Cyclone Hits an Area**

If a person lives in an area which has just been hit by a cyclone, the following precautions should be observed:

(i) Do not drink water that could be contaminated by floods (to avoid water-borne diseases). Drink only clean water which has been stored for emergencies.

(ii) Do not touch wet electric switches and fallen electric power lines. Do not use electrical appliances, if wet.

(iii) Do not enter damaged buildings or flood waters. Avoid driving on roads through standing water as floods may have damaged the roads.

(iv) Do not go out just for the sake of fun. Keep listening to local radio for advice. Go out only when it is safe to do so.
(v) Do not pressurise the rescue teams by making unnecessary demands. Co-operate with the rescue teams and help your neighbours and friends.

**Advanced Technology Has Helped in Protection From Cyclones**

In the early part of the last century, the available technology was not able to detect the approaching cyclone much in advance. In those days, the people living in coastal areas had less than a day to prepare and evacuate their homes to protect themselves from an oncoming cyclone. The situation today is very different. Due to advances in technology, we now have satellites and radars. By making use of satellites and radars, a cyclone alert (or cyclone watch) is now issued 48 hours in advance of any expected storm and a cyclone warning is issued 24 hours in advance. This gives sufficient time to people to prepare and evacuate. The cyclone related message is broadcast over radio every hour or half hour when a cyclone is nearer the coast. Thus, advanced technology has helped in giving us better protection from cyclones.

**TORNADO**

A *tornado* is a violent storm with a column of rapidly rotating winds, having the appearance of a dark, funnel-shaped cloud that reaches from the sky to the ground (see Figure 20). Most of the tornadoes form from thunderstorms. Before a tornado starts, large thunderclouds appear in the sky. One area of the thundercloud becomes specially dark and dense. The air in this area is rotating quickly. A funnel-shaped cloud begins to form and extend downwards to the ground (see Figure 20). The diameter of the narrow end of a tornado (which touches the ground) can be as small as a metre and as large as a kilometre (or even more). Due to very low pressure in it, the funnel of a tornado sucks dust, debris and everything else (including people and vehicles) near its base and throws them out near the top. A tornado moves across the surface of land (or sea) producing very high speed winds. A violent tornado can travel at speeds of about 300 km/h. Most of the tornadoes are weak. Tornadoes are not very frequent in our country.

**Destruction Caused by Tornadoes**

The wind speed in a tornado may reach up to 300 kilometres per hour. Tornadoes cause much damage from the sheer force of its high speed winds. A tornado causes considerable damage as it passes over land. This happens as follows:

(i) Tornado uproots trees, electric poles and telephone poles disrupting power supply and telecommunications.

(ii) Tornado lifts people and vehicles off the ground and hurls them hundreds of metres away. This causes death of many people and damage to vehicles.

(iii) Tornado can cause extensive damage to buildings. When a tornado passes over a building, it sucks up air from around the building. This makes the pressure on the outside of the building much lower than that on the inside, and the building can explode.

**Protection from a Tornado**

The following precautions should be taken for protection during a tornado.

(i) Take shelter in a room situated deep inside the house having no windows or in a basement (underground room). This is the best tornado shelter.
(ii) If a room without windows or basement is not available, then shut all the doors and windows of the house and take shelter under a sturdy table (where falling debris cannot reach). Bend down on your knees and protect your head and neck using your arms (see Figure 21). Stay indoors until it is safe to come out.

(iii) If a person is in a vehicle when a tornado begins, he should get out of the vehicle, go to a ditch or low-lying area and lie flat in it.

(iv) Stay away from fallen electric wires and stay out of damaged areas.

We are now in a position to answer the following questions:

Very Short Answer Type Questions

1. When cold water is poured over a tightly corked tin can containing steam, the tin can gets crushed. What crushes the tin can?
2. What conclusion do you get from the observation that when cold water is poured over a tin can full of steam and corked tightly, the tin can gets crushed?
3. What conclusion do you get from the fact that it is difficult to ride a bicycle against the direction of wind?
4. Which of the two is lighter: warm air or cold air?
5. Which region of the earth gets:
   (a) the maximum heat from the sun?
   (b) the minimum heat from the sun?
6. What is a cyclone known as:
   (a) in American continent?
   (b) in Japan and Philippines?
7. Which of the two is associated with high speed winds: reduced air pressure or increased air pressure?
8. (a) Name an instrument to measure wind speed.
    (b) Name an instrument to find wind direction.
9. What name is given to the winds which blow off from the Indian ocean during summer?
10. Name the direction from which monsoon winds blow into our country during summer.
11. State whether the following statements are true or false:
    (a) A car or bus is not a safe place to take shelter during lightning.
    (b) The coastline of India is not vulnerable to cyclones.
    (c) A cyclone is formed by a very low pressure centre with very high speed winds revolving around it.
    (d) The eye of a cyclone has a very high air pressure.
    (e) The funnel of a tornado sucks dust, debris and everything near it at the base due to low pressure and throws them out near the top.
12. Name three natural phenomena involving high speed winds which can create disasters and pose a threat to life and property.
13. What is the common name of a storm which is accompanied by lightning followed by a loud sound from the clouds?
14. Which coast of India is:
    (a) more vulnerable to cyclones?
    (b) less vulnerable to cyclones?
15. What is the name of a huge revolving storm in which high speed winds move in circles around a central area of very low pressure?
16. Which of the following process absorbs heat and which one releases heat?
    (a) Condensation of water vapour
    (b) Vaporisation of water
17. Which of the two are more frequent in India: cyclones or tornadoes?
18. What is the name of a storm consisting of a column of rapidly rotating air and having the appearance of a funnel-shaped cloud whose lower end touches the ground?
19. Which area of a cyclone is calm, free of clouds and has only light winds?
20. Fill in the following blanks with suitable words:
    (a) Moving air is called ..................
    (b) A bicycle tube becomes tight on filling air because air exerts................
(c) Air ................ on heating and ................. on cooling.
(d) Warm air is ................ than cold air.
(e) Near the earth’s surface............... air rises up whereas..........air comes down.
(f) Winds are generated due to .................heating on the earth.
(g) Air moves from a region of .......... pressure to a region of ..........pressure.
(h) The greater the difference in air pressure in the two regions, the.............the wind blows.
(i) Increased wind speed is accompanied by a ............. air pressure.
(j) The winds generated due to uneven heating on earth between the equator and the poles are not in the exact north-south direction due to the ........... of the earth.
(k) The centre of a cyclone is called its .............
(l) The revolving storm which is formed over warm sea-water is ...........
(m) The storm associated with funnel-shaped cloud that reaches from the sky to the ground is called .......... 
(n) The .............coast of India is less vulnerable to cyclonic storms than the ......... coast.
(o) A cyclone is called .............in American continent and .............in Japan.

**Short Answer Type Questions**

21. Explain why, holes are made in hanging banners and hoardings.
22. State two observations (or experiences) which tell us that air exerts pressure.
23. Explain why, when air is filled into a balloon, the balloon gets inflated.
24. Why does the air filled in a bicycle tube keep it tight ?
25. Explain why, a bicycle tube overfilled with air may burst.
26. Explain why, we have to fill air into a football to inflate it.
27. Why do the leaves of trees, flags and banners flutter when the wind is blowing ?
28. What conclusion do you get from the fact that it is easier to row a boat if there is wind coming from behind you ?
29. What conclusion do you get from the experience that when you fly a kite, the wind coming from your back helps ?
30. What is meant by saying that ‘air expands on heating’ ?
31. Why does hot air (or warm air) rise upwards ?
32. Explain why, smoke always rises up.
33. Would you like to buy a house having windows but no ventilators ? Explain your answer.
34. What is the main cause of wind movements on the surface of the earth ?
35. The uneven heating of earth (which produces winds) can take place under two situations. What are these two situations ?
36. Describe how, winds are produced by the uneven heating on the earth between the equator and the poles.
37. Why do the winds produced by the uneven heating on the earth between the equator and the poles not blow in the exact north-south direction ?
38. Explain how, uneven heating of ‘land’ and ‘ocean water’ in summer generates winds.
39. Explain why, if you hold a thin strip of paper just below your lips and blow air over its surface from your mouth, the strip of paper lifts up.
40. What conclusion do you get from the observation that if you hold a thin strip of paper just below your lips and blow air over its surface from your mouth, the strip of paper lifts up ?
41. Explain why, when we blow air in the space between two inflated balloons (carrying a little water each) and hanging about 10 cm apart on a stick, the two balloons come closer.
42. A small paper ball is kept in the neck of a glass bottle held horizontally. Explain why, it is difficult to force the paper ball into the bottle by blowing air into the bottle.
43. What would happen if high speed winds blow over a house having weak tin roof ? Give reason for your answer.
44. Which of the statements given below is correct ?
   (a) In winter, the winds blow from the land to the oceans.
   (b) In summer, the winds blow from the land towards the oceans.
45. What are monsoon winds ? Why are monsoon winds very important for our country ?
**Long Answer Type Questions**

46. **What is a tornado?** Describe the damage which can be caused by a tornado. What precautions should be taken for protection from a tornado?

47. **What is a cyclone?** Where is a cyclone formed? Name any five factors which help in the development of a cyclone. What is the centre of cyclone known as?

48. **Why are cyclones so destructive?** Describe how a cyclone causes widespread destruction leading to a great loss of life and property. State the various precautions to be observed by a person living in a cyclone hit area.

49. **What is a thunderstorm?** Explain how a thunderstorm is formed. Name two important characteristics of a thunderstorm.

50. **What type of areas are suitable for the frequent development of thunderstorms?** Why? State the precautions which should be observed to protect ourselves from lightning during a thunderstorm.

**Multiple Choice Questions (MCQs)**

51. A violent storm lifts people and cars off the ground and hurls them hundreds of metres away. This storm is likely to be a:
(a) thunderstorm (b) tornado (c) cyclone (d) typhoon

52. Which of the following phenomenon does not occur in the atmosphere?
(a) cyclone (b) earthquake (c) wind (d) tornado

53. The end of a cyclone comes quickly if the cyclone:
(a) moves over sea (b) moves over lake (c) moves over land (d) moves over clouds

54. Which of the following factor does not contribute to the development of a thunderstorm?
(a) temperature (b) wind speed (c) humidity (d) rotation of earth

55. A column of rapidly rotating winds having the appearance of a dark, funnel-shaped cloud reaching from the sky to the ground is called:
(a) thunderstorm (b) tornado (c) cyclone (d) thundercloud

56. High speed winds are accompanied by:
(a) low air pressure (b) high air pressure (c) zero air pressure (d) moderate air pressure

57. Which of the following process provides energy required to form and sustain a cyclone?
(a) condensation of water vapour (b) vaporisation of water (c) kinetic energy of blowing wind (d) fast moving sea waves

58. The instrument to measure the speed of wind is called:
(a) anaeroid barometer (b) anemometer (c) wind vane (d) odometer

59. Which of the following is not a characteristic of a thunderstorm?
(a) spark of light in atmosphere (b) rapidly rotating winds (c) loud noise (d) heavy rains or hail

60. The centre of a cyclonic storm called the ‘eye of cyclone’ is an area of:
(a) very low air pressure (b) moderate air pressure (c) very high air pressure (d) gradually rising air pressure

61. Which of the following is not the name of a huge revolving storm caused by very high speed winds blowing round a central area of very low pressure?
(a) hurricane (b) tornado (c) typhoon (d) cyclone

62. Wind is always associated with:
(a) kinetic energy (b) chemical energy (c) potential energy (d) gravitational energy

63. Which of the following places is not likely to be affected by a cyclone?
(a) Chennai (b) Mangaluru (c) Patna (d) Puri

64. Thunderstorms develop very frequently in areas having:
(a) polar climate (b) tropical climate (c) desert climate (d) temperate climate

65. Which of the following is not a correct precaution to be observed so as to protect from lightning during a thunderstorm?
(a) do not sit near a window (b) do not lie on the ground (c) do not sit in a car (d) do not stand under a tall tree

66. When a storm passes over a building, it sucks up air from around the building and makes the building explode. This storm is most likely to be a:
(a) tornado (b) cyclone (c) thunderstorm (d) typhoon
67. Which of the following can move over the land without coming to an end quickly?
   (a) cyclone (b) hurricane (c) typhoon (d) tornado

68. During a wind-storm, when high speed winds blow over the tin roofs of houses, the tin roofs get lifted and blown away. This happen because:
   A. High speed winds reduce air pressure over the tin roofs
   B. High speed winds increase air pressure over the tin roofs
   C. High speed winds do not change air pressure over the tin roofs
   D. Higher air pressure acts from below the tin roofs
   (a) A and B (b) B and C (c) A and D (d) Only D

69. Which of the following region is more vulnerable to cyclonic storms?
   (a) northern hills of India (b) western deserts of India
   (c) east coast of India (d) west coast of India

70. During an impending storm, a person is advised to take shelter in a room situated deep inside the house having no windows or in a basement. This storm is most likely to be a:
   (a) hurricane (b) thunderstorm (c) tornado (d) typhoon

71. The mouth of a balloon is stretched and fixed tightly over the neck of an empty boiling tube. When this boiling tube is placed in a beaker containing hot water, the balloon fixed over the neck of boiling tube gets inflated. Why?

72. Which one of the following place is unlikely to be affected by a cyclone? Why?
   (a) Chennai  (b) Mangaluru (Mangalore)  (c) Amritsar  (d) Puri

73. A tin can is full of steam and a tight lid is put on it. What will happen if cold water is poured over this tin can? Give reason for your answer.

74. Out of equator, 30°N latitude and 60°N latitude:
   (a) which region has the coldest air?
   (b) which region has the warmest air?
   Give reason for your answer in each case.

75. Due to uneven heating of ‘land’ and ‘ocean water’:
   (a) In which season do winds blow from land towards ocean?
   (b) In which season do winds blow from ocean towards land?

**Questions Based on High Order Thinking Skills (HOTS)**

71. The mouth of a balloon is stretched and fixed tightly over the neck of an empty boiling tube. When this boiling tube is placed in a beaker containing hot water, the balloon fixed over the neck of boiling tube gets inflated. Why?

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**ANSWERS**

1. Air pressure (or Atmospheric pressure) 2. Air around us exerts pressure 7. Reduced air pressure 9. Monsoon winds 11. (a) False  (b) False  (c) True  (d) False  (e) True 13. Thunderstorm 14. (a) East coast  (b) West coast 15. Cyclone 16. (a) Releases heat  (b) Absorbs heat 17. Cyclones 18. Tornado 19. Centre of cyclone called ‘eye’ of cyclone 20. (a) wind (b) pressure (c) expands ; contracts (d) lighter (e) warm ; cold (f) uneven (g) high; low (h) faster (i) reduced (j) rotation (k) eye (l) cyclone (m) tornado (n) west; east (o) hurricane; typhoon 44. (a) 51. (b) 52. (b) 53. (c) 54. (d) 55. (b) 56. (a) 57. (a) 58. (b) 59. (b) 60. (a) 61. (b) 62. (a) 63. (c) 64. (b) 65. (c) 66. (a) 67. (d) 68. (c) 69. (c) 70. (c) 71. The empty boiling tube contains air. This expands on heating and inflates the balloon 72. Amritsar is unlikely to be affected by a cyclone. This is because a cyclone develops over a sea and Amritsar is very far away from the sea 73. The tin can gets crushed: On pouring cold water, the hot steam cools and gets condensed to form water due to which pressure inside the tin can is reduced too much. The large air pressure (or atmospheric pressure) acting on the tin can from outside crushes the tin can inwards 74. (a) 60°N latitude has the coldest air (because it is nearer to the North pole of the earth than 30°N latitude) (b) Equator has the warmest air (because equator is at the minimum distance from the sun) 75. (a) Winter season (b) Summer season

Air exerts pressure
Air expands on heating

Wind is produced by the uneven heating of land and water in oceans
The uppermost layer of earth’s crust (in which plants grow) is called soil (see picture above). **Soil is a dark brown (or black) solid material which is a mixture of ‘rock particles of various sizes’ and decayed plant and animal matter called ‘humus’**. Soil also contains air, water and countless living organisms. Some of the living organisms which are present in the soil are bacteria, fungi, insects (such as ants and beetles), worms (like earthworms), rodents, moles and plant roots. Many of the living organisms present in soil are too small to be seen with naked eyes. Thus, soil is the home for many living organisms. Soil is called *mitti* in Hindi. Soil is an important part of land. We can see soil all around us.

Soil is one of the most important natural resources. In fact, **soil is essential for the existence of life on the earth**. It is in the soil that the plants and trees grow. Soil supports the growth of plants (and trees) by holding their roots firmly and by supplying them with water and nutrients. If there were no soil on the earth, there could be no grass, no crop plants, no trees and hence no food for us or other land animals. Thus, **soil is essential for agriculture**. Agriculture provides us food, clothing and shelter (housing). Some of the important **uses of soil** are given below:

1. Soil is used for growing food (like grains, pulses, fruits and vegetables, etc.).
2. Soil is used to grow trees for obtaining wood for building purposes (timber), for burning as fuel (firewood) and for making paper.
3. Soil is used to grow cotton plants which give us cotton clothes. Soil is also used to grow mulberry trees for rearing silkworms which provide us silk for making silk clothes.
4. Soil is used to make bricks and mortar for building houses.
5. Soil is used to make earthenware or pottery (such as *matkas*, *surahis*, etc.), crockery (cups and plates), toys and statues, etc.

Before we describe how soil is formed, we should know the meaning of the terms ‘weathering’ and ‘humus’. **The process by which huge rocks are broken down into small particles by the action of sun’s heat, wind, rain and flowing river water, etc., is called weathering**. It is called weathering because the rocks are worn away to form small particles by long exposure to the elements of weather (such as heat,
Weathering of rocks is a very, very slow process. It takes thousands of years to weather huge rocks (or break down huge rocks) into fine particles fit to make soil. When plants and animals die, their bodies decompose in nature to form organic matter. The organic matter formed by the decomposition of dead plants and animals by the micro-organisms (like certain bacteria and fungi) is called humus. Humus contains nutrients (like nitrogen and phosphorus, etc.) which are needed by the plants for their growth. Keeping these points in mind, we can now describe how soil is formed.

**How Soil is Formed**

Soil is formed from rocks by the process of weathering. In weathering, rocks are broken down very slowly by the action of sun’s heat, wind, rain, flowing river water, etc., to form tiny rock particles. These tiny rock particles then mix up with humus to form fertile soil. The nature of any soil depends on the rocks from which it has been formed and the type of vegetation that grows in it.

**SOIL PROFILE**

If we look carefully on the sides of a trench made by digging soil from the surface of earth downwards, we will find that the soil consists of three different layers. A vertical section (or cutting) through the soil showing the different layers of soil is called ‘soil profile’. In most simple words, the side view of dug up soil is called soil profile. Soil profile consists of three different layers of soil. Each layer of soil is called a horizon. The three layers of soil in the soil profile are:

1. A-horizon (or Top-soil)
2. B-horizon (or Sub-soil)
3. C-horizon (or Sub-stratum)

The soil profile (consisting of three different layers of soil) is shown in Figure 1. Each layer of soil

![Figure 1. Soil profile.](image-url)
differs in depth, colour, texture (feel) and chemical composition. We will now describe all the three layers of soil in detail, one by one.

1. A-Horizon (or Top-Soil)

The top layer of soil is called A-horizon (see Figure 1). The top layer of soil is also called top-soil. Top-soil is dark in colour. This is because top-soil is rich in minerals and humus. The plant roots grow in the top-soil. The top-soil contains many living things. For example, top-soil is the home of many living organisms like insects (such as ants and beetles), worms (such as earthworms), rodents and moles, etc. Bacteria and fungi also occur in top-soil. Top-soil contains a lot of decayed dead plants and animal remains. In other words, top-soil contains a lot of humus. This humus makes the top-soil very fertile. The top-soil is soft and porous, and can hold more of water. The top-soil is rich in minerals which the plants need for growth. In fact, the plants get all the essential nutrients from the top-soil. Top-soil is the most useful part of the soil.

2. B-Horizon (or Sub-Soil)

The layer of soil which is just below the top-soil is called B-horizon (see Figure 1). It is also known as sub-soil. The sub-soil is made up of slightly bigger rock particles than that of top-soil. It is somewhat harder and more compact than the top-soil. Sub-soil is also lighter in colour than the top-soil. The sub-soil contains very little living organisms. The roots of some of the trees are, however, able to reach sub-soil. The sub-soil has very little humus (decayed organic matter). Due to this, sub-soil is much less fertile as compared to the top-soil. Sub-soil is, however, rich in soluble minerals.

3. C-Horizon (Sub-Stratum)

The layer of soil which is just below the sub-soil is called C-horizon (see Figure 1). It is also called sub-stratum. Sub-stratum is made up of small lumps of broken rocks (or stones) formed by the partial weathering of bed-rock (or parent rock). In other words we can say that sub-stratum consists of partially weathered rocks. In the sub-stratum part of soil, the rock pieces are still breaking down to form smaller and smaller particles.

Below the C-horizon we have unweathered solid rock called bed-rock (or parent rock) (see Figure 1). It is this bed-rock (or parent rock) which has produced the soil over a long period of time.

We usually see the top surface of the soil, not the layers below it. We can, however, see the soil profile at a place (showing the inner layers of soil) in the following situations:

(i) Soil profile can be seen by looking at the sides of a recently dug trench (or ditch).
(ii) Soil profile can be seen while digging a well or foundation of a building.
(iii) Soil profile can be seen at the sides of a road on the hill or a steep river bank.

All these situations give us a side view of soil which tells us that soil consists of three different layers. Wind, temperature, rainfall, light and humidity are some important climatic factors which affect the soil profile and bring changes in the soil structure.

The most important part of soil for us is the top-soil. So, we will discuss the top-soil in detail. Please note that in the following discussion when we talk of soil, it will actually mean top-soil (which is the most fertile soil). We will now discuss the composition of soil.

**COMPOSITION OF SOIL**

The soil is mainly made up of different sized rock particles and humus. In addition to their other functions, the rock particles present in soil also provide mineral salts needed for plant growth. Air, water and living organisms are also essential components of a fertile soil. Thus, the soil is made up of six components: Rock particles (of different sizes), Minerals, Humus (Organic matter), Air, Water and Living organisms. The rock particles present in soil are of different sizes and chemical compositions. On the basis of their sizes, the rock particles present in soil can be divided mainly into four groups: Clay, Silt, Sand and Gravel. These are described on the next page.
(i) The smallest rock particles present in soil form clay. Thus, clay has the smallest sized rock particles in it. Since the size of clay particles is very small, we cannot see single clay particles. Because of its very small particles, clay feels smooth to touch. Clay is known as ‘chikni mitti’ in Hindi.

(ii) The rock particles in soil which are a little larger than clay particles form silt. Thus, silt is made up of rock particles somewhat bigger than that of clay. Due to its slightly bigger sized particles, silt is not so smooth. Actually, the size of silt particles is in-between that of clay and sand. The size of silt particles is bigger than that of clay particles but smaller than those of sand particles. Silt occurs as a deposit in river beds. Floods in rivers deposit the silt from rivers in the fields. Silt is known as ‘gaad’ in Hindi.

(iii) The rock particles in soil which are larger than silt particles form sand. Thus, sand is made up of particles larger than that of silt. Being quite large, sand particles can be easily seen by us. And because of its large sized particles, sand is coarse to touch. Sand is called ‘reit’ or ‘balu’ in Hindi.

(iv) The largest sized rock particles present in soil are called gravel. Gravel is a kind of tiny stones. The amount of gravel present in a good top-soil is very small. Gravel is known as ‘kankad’ or ‘bajri’ in Hindi.

We will now describe an activity to show that soil consists mainly of rock particles of different sizes and humus.

**ACTIVITY TO SHOW THAT SOIL CONSISTS MAINLY OF ROCK PARTICLES OF DIFFERENT SIZES AND HUMUS**

We take a tall gas jar and fill it three-fourths with water. Add about 200 grams of soil into the water in the gas jar. Stir the contents of the gas jar with a glass rod to mix the soil and water completely. Allow the gas jar to stand undisturbed until the soil has settled into different layers (see Figure 2).

If we look carefully at Figure 2, we will find that the rock particles present in the sample of soil settle at the bottom of the gas jar. The rock particles of different sizes form different layers in the gas jar on the basis of their density (or heaviness). The largest particles present in the soil called ‘gravel’ being heaviest, form a layer at the bottom of the gas jar (see Figure 2). The sand particles being lighter than gravel form a layer above the gravel. The silt particles being still lighter form a layer above the sand particles. And clay particles being the lightest rock particles, form a layer above the silt (see Figure 2). The humus present in soil is lighter than water, so humus floats on the surface of water in the gas jar (see Figure 2).

From this activity we conclude that the soil is made up mainly of the rock particles (like clay, silt, sand and gravel), and humus. In other words, the major components of soil are rock particles and humus.

We have just studied that in a good top-soil, gravel is present in very small amount. This means that the main rock particles present in the top-soil are sand, clay and silt. Now, the soils in different geographical areas contain different proportions of sand, clay and silt in them. They also contain different amounts of humus. In other words, the soils in different geographical areas will be different in compositions. So, depending on its composition, a soil can be classified as sandy soil, clayey soil or loamy soil. All these soils have different proportions of rock particles of different sizes. The sizes of rock particles in a soil have a very important influence on the properties of that soil. We will now discuss the various types of soils in detail.
TYPES OF SOIL

There are mainly three basic types of soils. These are: Sandy soil, Clayey soil and Loamy soil. The differences in the compositions of these three types of soil and their properties are discussed below.

1. Sandy Soil

Sandy soil contains mainly sand (having large particles with large spaces) (see Figure 3). It has hardly any clay or silt in it. Sandy soil contains very little humus. Sandy soil is found in desert areas. Sandy soil has large particles with large spaces between them. A disadvantage of sandy soil is that it cannot hold much water in it because the water gets drained out quickly through large spaces between its particles. So, sandy soil dries out quickly which is not good for plants. Sandy soil, however, provides good aeration (air) to the plant roots and it can be ploughed very easily. Sandy soil is light. It has a tendency to blow away if left bare. Sandy soil is less fertile. The fertility of sandy soil can be increased by adding humus to it in the form of manure. Humus improves the water-holding capacity of sandy soil and also supplies it necessary plant nutrients. Sandy soil is not sticky. Due to this, sandy soil cannot be used to make pots (like matkas and surahis, etc.), bricks, toys and statues.

2. Clayey Soil

Clayey soil contains mainly clay (having very small particles with very small spaces) (see Figure 4). It has hardly any sand or silt in it. Clayey soil also contains very little humus. Clayey soil has very good water-holding capacity due to its very small and tightly packed particles. Clayey soil is heavy because it can hold more water than the sandy soil. The smallness of particles of clayey soil is also a disadvantage. This is because the water drains out very slowly through clayey soil which can lead to water-logging of soil and damage the crop plants. Moreover, due to the smallness of its pores, clayey soil is not able to trap enough air for the roots of the plants. Clayey soil is compact and sticky due to which the ploughing of clayey soil is quite difficult. Clayey soil is, however, rich in minerals which is good for the growth of plants. Clayey soil is more fertile than sandy soil. The fertility of clayey soil can be improved by adding some sand and humus (manure) to it. Sand will improve the drainage of clayey soil whereas humus will provide it the necessary plant nutrients. Clayey soil is very sticky. Due to this, clayey soil is used to make pots (like matkas and surahis, etc.), bricks, toys and statues. In fact, clayey soil is the best soil for making pots, bricks, toys and statues.

3. Loamy Soil

Loamy soil is a mixture of sand, clay, silt and humus in the right proportions. Loamy soil is a mixture of large and small rock particles which impart it the desired properties. For example, loamy soil has the right water-holding capacity for the growth of plants. The excess water can also drain out through it easily. Loamy soil has also adequate air spaces between its particles to hold sufficient air needed by plant roots. Loamy soil can also be ploughed easily. Loamy soil contains sufficient amount of humus. So, loamy soil has all the necessary nutrients for the growth of plants. Loamy soil is the most fertile soil. It is the best soil for growing crops. Loamy soil is also known as just ‘loam’.

From the above discussion we conclude that soils are classified on the basis of the relative proportions of rock particles of various sizes.
If the soil contains greater proportion of big particles, it is called sandy soil. If the soil contains greater proportion of fine particles, it is called clayey soil. If the soil contains about the same proportions of large and fine particles, then it is called loamy soil (or loam).

**Differences Between Sandy Soil and Clayey Soil**

The main differences between sandy soil and clayey soil are given below:

(i) Sandy soil contains mainly big rock particles whereas clayey soil contains mainly fine rock particles.
(ii) Sandy soil cannot hold much water but clayey soil has very good water-holding capacity.
(iii) Sandy soil provides good aeration (air) to plant roots but clayey soil is not able to trap enough air for the roots of plants.
(iv) Sandy soil is loose, light and non-sticky whereas clayey soil is compact, heavy and sticky.
(v) Sandy soil is less fertile whereas clayey soil is comparatively more fertile.

**SOILS AND CROPS**

Different types of soils are found in different parts of India. In some parts of India, there is clayey soil, in some parts there is loamy soil whereas in other parts there is sandy soil. Soil is affected by the climatic factors such as wind, rainfall, temperature, light and humidity. The climatic factors as well as the type of soil determine the type of crops and other vegetation which can grow in a region. Different types of crops grow well in different types of soils. Some of the important crops and the types of soils which are suitable for growing these crops are given below:

(i) Clayey soil and loamy soil are both suitable for growing cereals like wheat, and gram (chana). Such soils are good at retaining water. The best soil for growing wheat crop is, however, loamy soil. This is because loamy soil is rich in humus and very fertile.
(ii) Soil rich in clay and organic matter, and having very good capacity to retain water is ideal for growing paddy (rice crop).
(iii) For growing lentil (masoor dal) and other pulses, loamy soil which drains water easily, is required.
(iv) For growing cotton crop, ‘sandy-loam soil’ which drains water easily and can hold plenty of air in it, is more suitable.

**PROPERTIES OF SOIL**

Some of the important properties (or characteristics) of soil are as follows:

1. Soil contains air.
2. Soil contains water (or moisture).
3. Soil can absorb water (or soak up water).
4. Soil allows water to percolate (or pass down through it).

We will now perform some activities to study all these properties of soil, one by one.

**SOIL CONTAINS AIR**

Air is present in the spaces between the soil particles. This air provides the oxygen required for respiration by the roots of plants and other organisms (which live in soil). The presence of air in the soil can be shown by performing a simple activity as follows.
ACTIVITY

We take some dry soil in a beaker. Add water to the beaker and stir the soil and water with a glass rod for a while. We will see the bubbles coming out of the soil (see Figure 5). These bubbles are of the air which was present in spaces between the soil particles. Actually, when we stir the soil with water, then water enters the spaces between the soil particles and expels the air present there. This expelled air is seen in the form of bubbles coming out from the soil. So, this activity shows that soil contains air.

Sand particles are quite large. Sand particles cannot fit closely together, so there are large spaces between sand particles. The large spaces between sand particles are filled with air. Due to this, sandy soil provides much more air to the plant roots. On the other hand, clay particles (being much smaller) pack tightly together leaving little space for air. So, clayey soil provides much less air to the plant roots which grow in it.

SOIL CONTAINS WATER (OR MOISTURE)

Soil always contains some water in it which is called ‘soil moisture’. Water is usually present as a thin film around the soil particles. It is absorbed by the roots of the plants. The capacity of a soil to hold water is important for the growth of various crops. Even a dry looking soil has some water (or moisture) in it. The presence of water (or moisture) in the soil can be shown by performing an activity as follows.

ACTIVITY

We take some dry soil in a hard glass beaker and cover it with a lid (such as a watch glass). Heat the beaker by using a burner. We will see that tiny drops of water are formed on the inner side of the lid (see Figure 6). This shows that even the soil which appears to be dry to us, contains some water. Actually, there is an invisible film of water around the soil particles. When soil is heated, then water present in it evaporates forming hot water vapour (or steam). This hot water vapour rises, gets cooled and condenses on the cold, inner surface of the lid to form drops of liquid water (see Figure 6).

The presence of water (or moisture) in the soil leads to an interesting phenomenon which can be easily observed by us. If we pass through a farmland during a hot summer day, we will see that the air above the soil is shimmering (shining with a slightly shaking light). This happens as follows: The soil in the farmland contains some water. On a hot summer day, this water of soil evaporates to form water vapour. The water vapour coming out of the soil reflects the sunlight irregularly due to which the air above the soil seems to shimmer.

To Find the Percentage of Water (or Moisture) in a Soil

We will now describe an activity to find out the water content (or moisture content) in a given sample of soil. It is found in terms of ‘percentage’ which means ‘water present in 100 grams of a soil’. This can be done as follows.

ACTIVITY

(i) Take some soil and weigh it on a balance. This will give us the original mass of soil taken.
(ii) Place this soil on a newspaper and keep it in bright sunshine to dry. Allow the soil sample to dry for about two hours. After drying, weigh the soil again on a balance. This will give us the mass of dry soil,
(iii) Subtract the mass of dry soil from the original mass of soil. The difference in the mass of soil ‘before and after drying’ will give us the mass of water (or moisture) present in the original mass of soil taken.

The percentage of water (or moisture) in the given sample of soil can then be calculated by using the formula:

\[
\text{Percentage of water in soil} = \left( \frac{\text{Mass of water in soil}}{\text{Original mass of soil}} \right) \times 100
\]

The calculation of water content in a given sample of soil will become clear from the following example.

**Sample Problem.** 200 grams of a soil is taken and dried completely in bright sunshine. The mass of dried soil is found to be 170 grams. Calculate the percentage of water (or moisture) present in the given sample of the soil.

**Solution.** In this case:

Original mass of soil = 200 g (g = gram)

Mass of dried soil = 170 g

So, Mass of water in soil = 200 – 170

= 30 g

We know that:

\[
\text{Percentage of water in soil} = \left( \frac{\text{Mass of water in soil}}{\text{Original mass of soil}} \right) \times 100
\]

\[
= \left( \frac{30 \text{ g}}{200 \text{ g}} \right) \times 100
\]

= \( \frac{30}{2} \)

= 15 per cent

Thus, the given sample of soil contains 15 per cent water in it. We can also say that the given sample of soil contains 15 per cent moisture in it. By saying that a soil contains 15 per cent water, we mean that 100 grams of this soil contains 15 grams of water.

**SOIL CAN ABSORB WATER**

Though soil usually contains some water (or moisture), it can still absorb (or soak up) a lot of water. Absorption is called ‘sokhna’ in Hindi. The absorption of water by soil will become clear from the following activity.

**ACTIVITY**

Let us take two test-tubes and fill equal amounts of water in them. Pour water from one test-tube on the cemented floor in the house. We will find that the water poured on the cemented floor flows down, it is not absorbed by the cemented floor. Let us now pour water from the second test-tube on the soil kept in a flower pot. We will see that the soil absorbs the water quite rapidly. Now, cemented floor does not absorb water because it is not porous. **The soil absorbs water because it is porous (having tiny pores in it).** All types of soils, however, do not absorb water to the same extent. Some soils absorb more water whereas other soils absorb less water.

**To Find the Percentage of Water Absorbed by a Soil**

We will now describe an activity to find out the percentage of water absorbed by a given sample of soil. By saying the percentage of water absorbed by a soil we mean the mass of water absorbed by 100 grams of a soil. Let us describe the activity now.
**ACTIVITY**

(i) Take a filter paper, fold it properly and fix it in a plastic funnel. Keep the funnel (having filter paper fixed in it) in a beaker as shown in Figure 7.

(ii) Take some dry powdered soil and weigh it on a balance. This will give us the mass of soil taken. Pour this weighed soil into the filter paper fixed in the funnel (see Figure 7).

(iii) Fill a measuring cylinder with water and note the initial volume of water taken in the measuring cylinder. Take out water from the measuring cylinder with the help of a dropper and pour it drop by drop on the soil kept in the funnel. All the water should not fall at one spot on the soil. The water should be poured uniformly all over the soil.

(iv) Keep pouring water in the soil kept on filter paper till it just starts dripping from the lower end of the funnel (see Figure 7). Then stop pouring more water on soil. The dripping of water from funnel tells us that the soil taken on the filter paper has absorbed the maximum amount of water. Note the final volume of water left unused in the measuring cylinder.

(v) Subtract the volume of water left in the measuring cylinder from the initial volume of water taken in the measuring cylinder. This difference will give us the volume of water absorbed by the soil taken on filter paper in the funnel.

By using the above observations, the percentage of water absorbed by the soil can be calculated as follows.

Suppose: 

- Mass of soil taken = \(m\) grams
- Initial volume of water = \(v_1\) mL (taken in measuring cylinder)
- Final volume of water = \(v_2\) mL (left in measuring cylinder)

So, Volume of water absorbed = \((v_1 - v_2)\) mL (by soil)

Now, it is known that 1 mL volume of water has a mass equal to 1 gram. So, we can also say that:

- Mass of water absorbed = \((v_1 - v_2)\) grams (by soil)

Percentage of water absorbed = \(\frac{\text{Mass of water absorbed}}{\text{Mass of soil taken}} \times 100\)

Percentage of water absorbed = \(\frac{(v_1 - v_2)}{m} \times 100\)

where 
- \(v_1\) = Initial volume of water (taken in measuring cylinder)
- \(v_2\) = Final volume of water (left in measuring cylinder)

and \(m\) = mass of soil taken
The calculation of percentage of water absorbed by a given sample of soil will become clear from the following example.

**Sample Problem.** 100 mL of water was taken in a measuring cylinder. This water was added dropwise to 50 g of dry soil kept on filter paper in a funnel. When the water just started dripping from the soil in the funnel, the amount of water left in the measuring cylinder was found to be 80 mL. Calculate the percentage of water absorbed by this soil.

**Solution.** Here,
- Initial volume of water, \( v_1 = 100 \text{ mL} \)
- Final volume of water, \( v_2 = 80 \text{ mL} \)
- Mass of soil taken, \( m = 50 \text{ g} \)

Now, we know the formula:

\[
\text{Percentage of water absorbed} = \frac{(v_1 - v_2)}{m} \times 100
\]

\[
= \frac{(100 - 80)}{50} \times 100
\]

\[
= \frac{20}{50} \times 100
\]

\[
= 40 \text{ per cent}
\]

Thus, the percentage of water absorbed by this soil is 40 per cent. This means that 100 grams of this soil can absorb a maximum of 40 grams of water in it.

**SOIL ALLOWS WATER TO PERCOLATE**

Soil is a porous solid substance (having tiny pores in it). When water is poured over soil, then some of it gets absorbed in the soil and the rest passes down the soil. The process in which water passes down slowly through the soil is called percolation of water. Percolation is called ‘risna’ in Hindi. Though water can percolate through all types of soils but the rate of percolation of water through different types of soils is different. The rate of percolation of water tells us how fast water passes down the soil. Please note that whether we call ‘rate of percolation of water’ or ‘percolation rate of water’, it means the same thing.

**To Measure the Percolation Rate of Water in Soil**

The percolation rate of water in a soil is the volume of water in millilitres which passes down the soil per minute. The percolation rate of water in a soil can be measured as follows.

**ACTIVITY**

(i) Take a 20 cm long PVC pipe having a diameter of about 5 cm. At the place where percolation rate of water is to be measured, dig the soil to a depth of about 2 cm in the ground. Place one end of the pipe in the dug up ground and hold it vertically (see Figure 8). Fill a measuring cylinder with water. Note the volume of water taken in the measuring cylinder.

(ii) Pour the water taken in the measuring cylinder in the pipe slowly from the top end (as shown in Figure 8). Note the time when you just start pouring water in the pipe.

(iii) After some time, all the water poured in the pipe will percolate down through the soil, leaving the pipe empty. Note the time again when all the water has percolated down through the soil and the pipe becomes empty.

(iv) The difference in the two ‘time readings’ will give us the time taken by the water taken in the measuring cylinder to percolate into the soil.
The percolation rate of water in the soil can be calculated by using the formula:

\[
\text{Percolation rate of water in soil} = \frac{\text{Volume of water percolated in soil}}{\text{Time taken for percolation}}
\]

The volume of water percolated in soil is measured in ‘millilitres’ (mL) and the time taken is measured in minutes (min). So, the percolation rate of water is expressed in the unit of ‘millilitres per minute’ which is written in short form as mL/min. The calculation of percolation rate of water in soil will become clear from the following example.

**Sample Problem.** 200 mL of water takes 40 minutes to percolate completely in a particular soil. Calculate the percolation rate of water in this soil.

**Solution.** Here, Volume of water percolated = 200 mL
And, Time taken for percolation = 40 min
Now, we know the formula:

\[
\text{Percolation rate} = \frac{\text{Volume of water percolated}}{\text{Time taken for percolation}}
\]

\[
\text{Percolation rate} = \frac{200 \text{ mL}}{40 \text{ min}} = 5 \text{ mL/min}
\]

Thus, the percolation rate of water in this soil is 5 millilitres per minute. By saying that the percolation rate of water in this soil is 5 millilitres per minute, we mean that 5 millilitres of water passes down this soil every one minute.

Sandy soil is quite loose, so the percolation rate of water is highest in sandy soil. On the other hand, clayey soil is very compact. So, the percolation rate of water is lowest in the clayey soil. It has been found that 8 to 10 days after the rains, the level of water in a well rises. **The sandy soil (having the highest percolation rate) allows the rainwater to reach a well faster and in greater amount.** Also, since sandy soil has the highest percolation rate, it retains the least rainwater in it. On the other hand, the clayey soil (having the lowest percolation rate) retains the highest amount of rainwater in it.

In rainwater harvesting, more rainwater is made to percolate into the soil by digging ‘percolation pits’. We have already studied rainwater harvesting in Class VI. Paddy (rice crop) is planted in standing water in the fields. Paddy also requires a lot of irrigation water afterwards. **The soil with a low percolation rate of water would be the most suitable for growing paddy (rice crop)** because it will allow the water to remain in the fields for a much longer time.

Before we discuss soil erosion, we should know the meaning of the term ‘vegetation’. **All the plants growing on the surface of earth are called vegetation.** Vegetation includes green grass, herbs, shrubs, bushes, crop plants as well as trees. It is the fertile top-soil of the earth which makes the vegetation grow. **Vegetation covers the soil like a green sheet spread on the surface of earth.** Another point to be noted is that extreme scarcity (or extreme shortage) of food is called famine. We will now discuss soil erosion.

**SOIL EROSION**

The top-soil is very fertile. This top-soil is often carried away by strong winds or washed away by heavy rains. **The removal of fertile top-soil from land by wind or water is called soil erosion** (see Figure 9). The loss of fertile top soil at a place exposes the infertile sub-soil which cannot be used to grow plants and trees. And in the absence of plants and trees, the area becomes a desert. In desert, soil erosion occurs mainly through the wind.
Soil erosion does not occur easily where the land is covered by vegetation (trees and other plants). Soil erosion occurs easily in those areas of land which are not covered by vegetation (trees and other plants) or have very little vegetation. Thus, soil erosion is more severe in areas such as bare land or deserts. We will now describe why the soil covered by vegetation is not eroded easily but the soil not covered by vegetation (or bare soil) is eroded very easily.

1. If there is vegetation (trees and other plants) on land, then the roots of vegetation (trees and other plants) growing in the soil bind the particles of top-soil firmly. Due to the binding of soil particles by the roots of trees and plants, the blowing wind and flowing rainwater are not able to carry away top-soil and hence soil erosion does not occur. On the other hand, the soil not covered by vegetation (trees and other plants) is easily eroded because there are no roots of trees and plants in it which can bind the soil particles together and prevent them from being carried away by strong winds or flowing rainwater (Actually, in the absence of plant roots, the soil becomes loose).

2. If there is vegetation (trees and other plants) on land, then much of the falling rain hits the trees and plants before it hits the soil. In this way, the cover of vegetation softens (or reduces) the effect of heavy rains on the soil. The soil does not become loose easily and the flowing rainwater is not able to carry away top-soil. Due to this, soil erosion does not occur. If, however, there is no vegetation (trees and other plants) on land to soften the effect of heavy rains, the bare soil becomes loose quickly by the force of falling rainwater and erodes easily. This is because, being loose, it is easily carried away by flowing rainwater or strong winds.

**Cause of Soil Erosion**

Soil erosion is caused mainly by the large scale cutting down of forest trees and other plants (which is called deforestation). A large number of forest trees are cut down everyday for obtaining wood for burning as fuel (firewood), for building purposes (timber) and for the manufacture of paper. When the forest trees and other plants are cut down, then the top soil gets exposed and becomes loose (because there are no roots to bind soil and no cover to soften the effect of falling rain). Blowing wind and flowing rainwater can then carry away this loose soil easily causing soil erosion.

**Effects of Soil Erosion**

The important effects of soil erosion are as follows:

1. Soil erosion can turn lush green forests into deserts and spoil the environment. When the fertile top-soil in a forest gets removed by soil erosion, then the infertile sub-soil is left behind. No forest plants can grow in this remaining infertile soil due to which the once lush green forest can gradually turn into a desert. This spoils our environment.
2. **Soil erosion can lead to famines (excessive scarcity of food).** When the fertile top-soil is removed by soil erosion, then the food crops do not grow well in the remaining infertile soil. And due to bad crops, there is an excessive shortage of food-grains in that area. The people do not get sufficient food to eat and this leads to starvation deaths.

3. **Soil erosion can cause floods.** The soil carried away from land by the flowing rainwater gradually deposits on river beds (decreasing their depth). So, when it rains heavily, the river cannot take away all the rainwater quickly. Due to this, river water overflows from its banks and causes severe floods by submerging surrounding areas. These floods cause damage to life and property.

**Prevention of Soil Erosion**

Soil is a very important natural resource in which our food is grown. So, we should protect soil by preventing its erosion. Soil erosion can be prevented in the following ways:

1. **Soil erosion can be prevented by preventing large scale cutting down of forest trees.** The large scale cutting down of forest trees is called *deforestation.* So, we can also say that soil erosion can be prevented by preventing *deforestation.*

2. **Soil erosion can be prevented by afforestation (large scale growing of forest trees in place of cut down trees).** If the trees have to be cut down from the forests for various needs, then new trees should be planted in place of the cut down trees (see Figure 10). In this way the forests will continue to have sufficient number of trees all the time. And this tree cover will prevent soil erosion of the forest land.

3. **Soil erosion can be prevented by increasing the green cover (vegetation) around us by planting more trees and plants ourselves.**

**SOIL POLLUTION**

The contamination of soil with waste materials (especially used polythene bags and plastics), pesticides, fertilisers, acid rain and industrial chemical wastes, etc., is called soil pollution. The various sources of soil pollution and their effects are as follows:

1. **Dumping of waste materials (such as polythene bags, plastics, glass and metal objects) causes soil pollution** (see Figure 11). Some waste materials (like paper and vegetable wastes) rot after some time and become harmless. But the waste materials such as polythene bags and other plastics (plastic bottles, etc.) do not rot on their own and remain as such indefinitely. So, *polythene bags and plastics pollute the soil.* They also kill the living organisms. For example, if the cattle (like cow) eats up the polythene bags alongwith the thrown food, it may even die. *There is a demand to ban polythene bags and plastics because they cause soil pollution and may also kill the living organisms.* The used glass and metal objects also do not rot in nature and cause soil pollution.

2. **The use of pesticides in agriculture causes soil pollution.** Pesticides are the poisonous chemical substances which are sprayed on standing crops to save them from the harmful insects and diseases. Some of these pesticides also mix up with the soil in the fields and pollute it. So, the grains, fruits and vegetables grown in this polluted soil contain pesticides. When we
eat such contaminated grains, fruits or vegetables, the pesticides present in them enter our bodies and damage our health in the long run.

3. The excessive use of fertilisers in agriculture causes soil pollution. Chemical fertilisers are added to soil in the fields to increase food production. The excessive use of chemical fertilisers makes the soil highly acidic or alkaline. When the soil becomes highly acidic or alkaline it is said to be polluted. This soil becomes unfit for the growth of crop plants.

4. Acid rain causes soil pollution. Acid rain makes the soil highly acidic. This acidic soil becomes toxic (or poisonous) for plant growth. In this way, pollution caused by acid rain makes the soil less fertile.

5. Dumping of industrial wastes causes soil pollution. Many industries (or factories) dump their waste products containing harmful chemicals on soil. These chemicals cause soil pollution and harm the plants which grow in it and the cattle which graze on it.

Prevention of Soil Pollution

The soil pollution can be prevented in the following ways:

(i) The use of polythene bags should be avoided to prevent soil pollution. This can be done by using bags made of paper, cloth or jute.

(ii) Wherever possible, used plastic objects should be sent to factories for recycling to prevent soil pollution. Discarded glass and metal objects can also be recycled.

(iii) The use of pesticides in agriculture should be minimised to reduce soil pollution.

(iv) The use of excessive chemical fertilisers should be avoided in agriculture to prevent soil pollution.

(v) Steps should be taken to reduce the emission of acidic gases like sulphur dioxide and nitrogen oxides from factories which cause acid rain.

(vi) The industrial chemical wastes should be treated properly to make them harmless before dumping into soil.

We are now in a position to answer the following questions:

Very Short Answer Type Questions

1. When some dry soil is added to water in a beaker and stirred with a glass rod, bubbles are seen coming out of the soil. What do these bubbles consist of?

2. Which component of soil makes the air above the soil in a farmland shimmer on a hot summer day?

3. What is the function of air present in the spaces between the soil particles?

4. Which type of soil:
   (a) is the best for making pots, bricks, toys and statues?
   (b) can hold very little water?

5. Which two soils are suitable for growing cereals like wheat, and gram?

6. Which is the best soil for growing wheat crop?

7. Which type of soil is ideal for growing paddy (rice crop)?

8. What kind of soil is required for growing lentil (masoor dal) and other pulses?

9. Which type of soil is more suitable for growing cotton crop?

10. Name the different types of rock particles present in soil.

11. Name the rock particles present in a soil which are bigger than clay particles but smaller than sand particles.

12. Arrange the following rock particles which occur in soil in the increasing order of their sizes (keeping the smallest one first):
    Sand, Clay, Gravel, Silt

13. Which important component of fertile soil is missing from the following?
    Air, Water, Rock particles, Minerals, Living organisms

14. Name the natural process which breaks down huge rocks slowly to form tiny particles fit to make soil.

15. With which substance should the tiny rock particles mix to form fertile soil?

16. What name is given to the side view of soil as seen in a recently dug up trench?
17. Out of sandy, loamy and clayey soils:
(a) which one has the maximum water-holding capacity?
(b) which one has the minimum water-holding capacity?
18. Name the most fertile soil for growing plants.
19. Which soil contains the right proportions of sand, clay, silt and humus?
20. What is the collective name for the various layers of soil?
21. Name the three layers of soil in terms of ‘horizons’.
22. Which horizon of soil profile contains a lot of humus?
23. Which layer of soil is the most fertile?
24. What lies beneath C-horizon?
25. Name any five living organisms found in soil.
26. Which type of soil would have:
(a) lowest percolation rate of water?
(b) highest percolation rate of water?
27. What type of carry bags would you use if polythene bags are banned one day?
28. (a) Name the three basic types of soils.
(b) What name is given to the removal of top soil by wind or water?
29. (a) Name any two factors which bring about the removal of top soil during soil erosion.
(b) Which part of the trees and plants binds the soil together and prevents soil erosion?
30. Fill in the following blanks with suitable words:
(a) The mixture of rock particles and humus is called ..............
(b) Each layer of soil is called a ..............
(c) The roots of small plants grow entirely in the .............. soil.
(d) The middle layer of soil is called .............. horizon.
(e) A vertical section through different layers of soil is called soil ..............
(f) Tree and other plant roots firmly bind the .............. particles.
(g) In the absence of trees and plants, soil becomes ..............
(h) In desert areas, soil erosion occurs mainly through ..............
(i) Increasing green cover (vegetation) helps prevent soil ..............
(j) The use of .............. bags should be banned to avoid soil pollution.
(k) Percolation rate of water in soil is expressed in the unit of ..............

Short Answer Type Questions

31. What happens when a test-tube full of water is:
(a) poured on cemented floor?
(b) poured on soil in a flower pot?
32. Explain why, when some water is poured on soil, it gets absorbed but the same water flows down when poured on a cemented floor.
33. Which of the two provides more air to plant roots: sandy soil or clayey soil? Why?
34. State the important properties of soil.
35. How is loamy soil very useful for the crops?
36. Can we make a pot with sandy soil? Give reason for your answer.
37. Match the items given in column I with those in column II:

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) A home for living organisms</td>
<td>(a) Large particles</td>
</tr>
<tr>
<td>(ii) Upper layer of the soil</td>
<td>(b) All kinds of soils</td>
</tr>
<tr>
<td>(iii) Sandy soil</td>
<td>(c) Dark in colour</td>
</tr>
<tr>
<td>(iv) Middle layer of the soil</td>
<td>(d) Small particles and packed tight</td>
</tr>
<tr>
<td>(v) Clayey soil</td>
<td>(e) Lesser amount of humus</td>
</tr>
</tbody>
</table>
38. Name the various components of soil. A little of soil is stirred with water in a beaker and allowed to stand. Which component of soil will float on the surface of water?
39. A student conducted an experiment to determine the percolation rate of water in a soil. He observed that it took 45 minutes for 180 mL of water to percolate through the soil. Calculate the percolation rate of water in soil.
40. Explain why, the soil covered by vegetation is not eroded easily but the bare soil is eroded easily.
41. How do trees and other plants prevent soil erosion?
42. What are the various ways in which soil erosion can be prevented?
43. Write the differences between sandy soil and clayey soil.
44. Make a list of the important uses of soil.
45. Explain why, there is growing demand to ban polythene bags and plastics.

**Long Answer Type Questions**

46. What is meant by ‘soil profile’? Draw a sketch of the soil profile and label the various layers. Name any two situations in which we can see the soil profile at a place.
47. What is meant by sandy soil, clayey soil and loamy soil? Give any two properties each of sandy soil, clayey soil and loamy soil.
48. What is soil? How is soil formed? Describe an activity to show that soil contains water.
49. What is meant by ‘soil erosion’? State the cause of soil erosion. What are the effects of soil erosion?
50. What is meant by soil pollution? Name any four things which can cause soil pollution. How can soil pollution be prevented?

**Multiple Choice Questions (MCQs)**

51. In addition to the rock particles, the soil contains:
   (a) air and water  (b) water and plants  
   (c) minerals, organic matter, air and water  (d) water, air and plants
52. The water-holding capacity is highest in:
   (a) sandy soil  (b) clayey soil  (c) loamy soil  (d) mixture of sandy and loamy soils
53. Which of the following present in soil has the smallest sized rock particles?
   (a) gravel  (b) silt  (c) clay  (d) sand
54. The best soil for growing paddy is the one which has:
   (a) low percolation rate of water  (b) high percolation rate of water  
   (c) moderate percolation rate of water  (d) zero percolation rate of water
55. The removal of fertile top soil from land by wind or water is called soil:
   (a) corrosion  (b) erosion  (c) effusion  (d) diffusion
56. The manufacture of which of the following materials on a large scale is a cause of soil erosion?
   A. Plastics  B. Paper  C. Polyester  D. Plywood
   (a) A and B  (b) B and C  (c) B and D  (d) Only D
57. Which one of the following cannot be an effect of soil erosion?
   (a) desertification  (b) desalination  (c) flooding  (d) famine
58. The component of soil which makes the air above the soil in a farmland shimmer on a hot summer day is:
   (a) humus  (b) air  (c) water  (d) sand
59. Which of the following cannot prevent soil erosion?
   (a) reforestation  (b) deforestation  (c) silviculture  (d) plantation
60. The process by which huge rocks are broken down into small particles by the action of sun’s heat, wind, rain and flowing water, etc., is called:
   (a) farming  (b) smothering  (c) erosion  (d) weathering
61. Which of the following do not cause soil pollution?
   A. Jute bag  B. Acid rain  C. Cardboard  D. Plastic bag
   (a) A and B  (b) B and C  (c) A and C  (d) C and D
62. In order to make fertile soil, the tiny rock particles should be mixed with:
   (a) clay  (b) silt  (c) humus  (d) sand
63. Which type of soil can lead to the maximum water-logging in the fields?
   (a) loamy soil  (b) clayey soil  (c) sandy soil  (d) sandy-loam soil
64. One of the following is not a type of soil. This one is:
   (a) loamy soil  (b) silty soil  (c) clayey soil  (d) sandy soil
65. The best soil for growing wheat crop is:
(a) clayey soil  (b) sandy soil  (c) loamy soil  (d) sandy-loam soil

Questions Based on High Order Thinking Skills (HOTS)

66. It has been observed that 8 to 10 days after the rains, the level of water in a well rises. Which type of soil would allow rainwater to reach the well faster and in greater amount? Give reason for your choice.

67. Soil A has a high percolation rate of water whereas soil B has a low percolation rate of water. Which of the two soils, A or B, is most suitable for growing paddy (rice crop)? Why?

68. Explain why, if we pass through a farmland during a hot summer day, the air above the land appears to be shimmering.

69. A soil sample weighing 150 g is dried completely by keeping in sunshine. The mass of dried soil is 135 g. Calculate the percentage of water (or moisture) in the given sample of soil.

70. 200 mL of water was taken in a measuring cylinder. This water was added dropwise to 120 g of dry soil kept on filter paper in a funnel. When the water just started dripping from the funnel, the amount of water left in the measuring cylinder was found to be 140 mL. Calculate the percentage of water absorbed by this soil.

ANSWERS

1. Air  2. Water  4. (a) Clayey soil (b) Sandy soil  11. Silt  12. Clay < Silt < Sand < Gravel  13. Humus  14. Weathering  15. Humus  17. (a) Clayey soil (b) Sandy soil  24. Bed rock (or Parent rock)  30. (a) soil (b) horizon (c) top (d) B (e) profile (f) soil (g) loose (h) wind (i) erosion (j) polythene (k) mL/min  37. (i) b (ii) c (iii) a (iv) e (v) d  38. Humus  39. 4 mL/min  51. (c)  52. (b)  53. (c)  54. (a)  55. (b)  56. (c)  57. (b)  58. (c)  59. (b)  60. (d)  61. (c)  62. (c)  63. (b)  64. (b)  65. (c)  66. Sandy soil; Highest percolation rate of water  67. Soil B; Paddy (rice crop) needs a lot of standing water for its growth  68. The soil in the farmland contains some water. On a hot summer day, this water of soil evaporates forming water vapour. The water vapour coming out of the soil reflects the sunlight irregularly due to which the air above the soil seems to be shimmering  69. 10 per cent  70. 50 per cent
We need energy to walk, run, climb the stairs, wash clothes, and cook food. Even when we are talking, eating, reading, writing or sleeping, energy is required. The processes like digestion of food, beating of heart, and movement of ribs and diaphragm during breathing, etc., which take place inside our body also need energy for their working. In fact, we need energy to perform all the activities which maintain our life, and also to do work. We get this energy from the food which we eat. The food has stored energy. **The stored energy of food is released slowly during the process of respiration which takes place inside our body all the time** (even when we are sleeping). It is this energy which is then utilised in carrying out various life processes and doing our work. Respiration is essential because it provides us energy from the food which we eat and digest. So, **all the living organisms need to respire to get energy from food required for their survival**. Many times we see our parents insisting that we should eat food regularly. This is because food is like a fuel for our body which provides us energy to maintain our life and stay healthy. **It is not only the human beings who need energy. All other animals and plants also require energy.** We will now discuss the process of respiration and how it provides energy to human beings, other animals, as well as plants.

**RESPIRATION**

All the organisms (plants and animals) require energy for performing various activities and maintaining their life. This energy is obtained by the breakdown of digested food during the process of respiration. **The process of releasing energy from food is called respiration.** Respiration occurs in all the living cells. The process of respiration involves taking in oxygen (of air) into the cells, using it for releasing energy by burning food, and then eliminating the waste products (carbon dioxide and water) **from the body.** Most living things need oxygen (of air) to obtain energy from food. This oxygen reacts with
the food (like glucose) present in the body cells and burns them slowly to release energy. This energy is used by the living things. The process of respiration can be written in the form of a word equation as follows:

\[
\text{Glucose} + \text{Oxygen} \rightarrow \text{Carbon dioxide} + \text{Water} + \text{Energy}
\]

During respiration, the energy-rich food (like glucose) is broken down by oxygen into carbon dioxide and water, and energy is released (see Figure 1). This energy is used up by the organism (plant or animal). In fact, respiration is a kind of slow burning (or slow combustion) of food at ordinary temperature to produce energy. During respiration, oxygen is taken in and carbon dioxide is given out. Thus, the process of respiration involves the exchange of gases: oxygen and carbon dioxide. The process of respiration is the reverse of photosynthesis. This is because photosynthesis is the making of food (like glucose) by absorbing sunlight energy, whereas respiration is the breaking of food (like glucose) to release energy.

There are two main parts in the process of respiration:

(i) Breathing (taking in oxygen from air and releasing carbon dioxide), and

(ii) Using oxygen in the cells of the organism for releasing energy from food (like glucose).

The air which we ‘breathe in’ is transported to all the parts of the body and ultimately to each cell of the body. In the cells, oxygen (of air) brings about the breakdown of glucose (food). The process of breakdown of food in the cells of the body with the release of energy is called respiration. Since the process of respiration which releases energy from food takes place inside the cells of the body, it is also called cellular respiration. The process of cellular respiration is common to all the living organisms (humans, other animals as well as plants). It takes place in all the cells of an organism.

**AEROBIC AND ANAEROBIC RESPIRATION**

Respiration usually takes place in the presence of oxygen (of air). Respiration can, however, also take place in the absence of oxygen of air, though it is very rare. This means that the breakdown of food (like glucose) to release energy can occur in the presence of oxygen as well as in the absence of oxygen. Based on this, there are two types of respiration: aerobic respiration and anaerobic respiration. These two types of respiration are discussed below.

1. **Aerobic Respiration**

The respiration which uses oxygen is called aerobic respiration. In other words, when the breakdown of glucose food occurs with the use of oxygen, it is called aerobic respiration. It is called aerobic respiration, because it uses ‘air’ which contains oxygen (‘aerobic’ means ‘with air’). In aerobic respiration, the glucose food is completely broken down into carbon dioxide and water with the use of oxygen, and energy is released. The breaking down of food during aerobic respiration can be represented by means of a word equation as follows:

\[
\text{Glucose} + \text{Oxygen} \rightarrow \text{Carbon dioxide} + \text{Water} + \text{Energy}
\]

The energy released during aerobic respiration is used by the organism. Most of the living organisms carry out aerobic respiration (by using oxygen of air). For example, humans (man), dogs (see Figure 2), cats, lions, elephants, cows, buffaloes, goat, deer, birds, lizards, snakes, earthworms, frogs, fish, and insects
(such as cockroach, grasshopper, houseflies, mosquitoes and ants, etc.), and most of the plants carry out aerobic respiration by using oxygen of air (to obtain energy). All the organisms which obtain energy by aerobic respiration cannot live without the oxygen (of air). This is because if there is no oxygen, they cannot get energy from the food which they eat. Aerobic respiration produces much more energy because complete breakdown of glucose (food) occurs during aerobic respiration by the use of oxygen. The complete breakdown of glucose (food) produces carbon dioxide and water.

2. Anaerobic Respiration

The respiration which takes place without using oxygen is called anaerobic respiration. In other words, when the breakdown of glucose (food) occurs without the use of oxygen, it is called anaerobic respiration. It is called anaerobic respiration because it takes place without air which contains oxygen (‘anaerobic’ means ‘without air’). The microscopic organisms like yeast (and certain bacteria) obtain energy by anaerobic respiration. In anaerobic respiration, the micro-organisms like yeast break down glucose (food) in the absence of oxygen to form alcohol and carbon dioxide, and release energy. The breaking down of glucose (food) during anaerobic respiration carried out by yeast can be represented by writing a word equation as follows:

\[
\text{Glucose (Food)} \xrightarrow{\text{No oxygen}} \text{Alcohol} + \text{Carbon dioxide} + \text{Energy}
\]

The energy produced in this anaerobic respiration is used by the yeast. Only a few living organisms carry out anaerobic respiration to obtain energy (without using oxygen of air). For example, yeast (see Figure 3) and certain bacteria carry out anaerobic respiration in the absence of oxygen to obtain energy. All the organisms which obtain energy by anaerobic respiration can live without the oxygen (of air). For example, yeast is an organism which can live without the oxygen of air because it obtains energy by the process of anaerobic respiration. Those organisms which obtain energy by the process of anaerobic respiration (without using oxygen) are called anaerobes. Thus, yeast is an anaerobe. Yeast can survive in the absence of oxygen.

Yeast is a single-celled organism. Actually, yeast is a single-celled fungus. In yeast, a single cell represents the whole organism. Yeast is used to make alcoholic drinks (such as wine and beer), and bread. This happens as follows: Yeast respires anaerobically and during this process, yeast converts glucose into alcohol. Yeast is, therefore, used in industry to make alcohol. This alcohol is used in making wine and beer. Anaerobic respiration in yeast also produces carbon dioxide gas. In bread-making, the carbon dioxide produced by yeast makes the bread rise. Thus, anaerobic respiration in yeast is used to make alcohol (wine, beer, etc.) and bread. Anaerobic respiration (as in yeast) produces much less energy because only partial breakdown of glucose (food) occurs in anaerobic respiration in the absence of oxygen. The products of this partial breakdown of glucose (food) are alcohol and carbon dioxide.

Anaerobic Respiration in Muscles

We (human beings) normally obtain energy by aerobic respiration. But under certain conditions (when...
extra energy is needed), anaerobic respiration can take place in our muscles for a short time. When the oxygen gets used up faster in our muscle cells than can be supplied by the blood, then a temporary deficiency of oxygen occurs in the muscle cells. For example, when we do a heavy physical exercise (fast running, cycling or weightlifting, etc.), our muscles need a lot of energy. To produce more energy, our muscles need more oxygen. But the supply of oxygen through blood is limited and hence insufficient. Under these conditions, anaerobic respiration takes place in the muscle cells (without oxygen) to produce extra energy and fulfil the demand for more energy. Thus, **anaerobic respiration takes place in our muscle cells during any vigorous physical activity when oxygen gets used up faster in the muscle cells than can be supplied by the blood**.

When anaerobic respiration takes place in our muscle cells in the absence of oxygen, then glucose (food) breaks down partially to form lactic acid and releases some energy. This extra energy helps us in doing hard physical exercise. The breaking down of glucose (food) during anaerobic respiration in muscles to release energy can be represented by a word equation as follows:

\[
\text{Glucose (Food)} \xrightarrow{\text{No oxygen}} \text{Lactic acid + Energy (Anaerobic respiration in muscles)}
\]

Please note that during heavy physical exercise (or any other hard work), most of the energy is produced by aerobic respiration. Anaerobic respiration in muscles provides only some extra energy which is needed under these circumstances (see Figure 4). Please note that anaerobic respiration does not take place only in the muscles of human beings, it also takes place in the muscles of other animals such as lions, tigers, deer, etc., when they run very fast and require much more energy than normal.

**After a heavy physical exercise (very fast running, etc.), we sometimes get muscle cramps** (Painful contractions of muscles are called cramps) (see the man on right side in Figure 4). This can be explained as follows: During heavy exercise, some of our muscles respire anaerobically. The anaerobic respiration by muscles brings about partial breakdown of glucose (food) to form lactic acid. This lactic acid accumulates in the muscles. **The accumulation of lactic acid in the muscles causes muscle cramps.** Thus, muscle cramps occur due to the accumulation of lactic acid in muscles when the muscles respire anaerobically (without oxygen) while doing hard physical exercise. **We can get relief from cramps in muscles caused by heavy exercise by taking a hot water bath or a massage.** Hot water bath (or massage) *improves* the circulation of blood in the muscles. Due to improved blood flow, the supply of oxygen to the muscles increases. This oxygen breaks down lactic acid accumulated in muscles into carbon dioxide and water, and hence gives us relief from cramps. Before we end this discussion, we would like to give the main points of similarities as well as differences between aerobic respiration and anaerobic respiration. These are given below.

**Similarities Between Aerobic and Anaerobic Respiration**

<table>
<thead>
<tr>
<th>Aerobic respiration</th>
<th>Anaerobic respiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. In aerobic respiration, energy is produced by the breakdown of food (like glucose).</td>
<td>1. In anaerobic respiration also energy is produced by the breakdown of food (like glucose).</td>
</tr>
<tr>
<td>2. Aerobic respiration takes place in the cells of the organism.</td>
<td>2. Anaerobic respiration also takes place in the cells of the organism.</td>
</tr>
</tbody>
</table>

![Figure 4. During vigorous physical exercise (such as running fast) leg muscles respire anaerobically (without oxygen) to produce extra energy.](image)
### Differences Between Aerobic and Anaerobic Respiration

<table>
<thead>
<tr>
<th>Aerobic respiration</th>
<th>Anaerobic respiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aerobic respiration takes place in the presence of oxygen.</td>
<td>1. Anaerobic respiration takes place in the absence of oxygen.</td>
</tr>
<tr>
<td>2. Complete breakdown of food occurs in aerobic respiration.</td>
<td>2. Partial breakdown of food occurs in anaerobic respiration.</td>
</tr>
<tr>
<td>3. The end products in aerobic respiration are carbon dioxide and water.</td>
<td>3. The end products in anaerobic respiration may be alcohol and carbon dioxide (as in yeast), or lactic acid (as in muscles).</td>
</tr>
<tr>
<td>4. Aerobic respiration produces a considerable amount of energy.</td>
<td>4. Much less energy is produced in anaerobic respiration.</td>
</tr>
</tbody>
</table>

### BREATHING

We can live without food and water for many days but we cannot live for more than a few minutes without air. This is because air is necessary for breathing. During breathing, we take air into our lungs through the nose, and then expel it. The ordinary air which we take into the lungs is rich in oxygen but the air expelled from the lungs is rich in carbon dioxide. We can now define breathing as follows: **Breathing is the process by which air rich in oxygen is taken inside the body of an organism and air rich in carbon dioxide is expelled from the body (with the help of breathing organs).** Different organisms have different organs for breathing depending on their structure and oxygen requirements. The breathing in human beings takes place through the organs called ‘lungs’ (see Figure 5).

The taking in of air rich in oxygen into the body during breathing is called ‘inhalation’ and giving out (or expelling) the air rich in carbon dioxide is called ‘exhalation’. Both, inhalation and exhalation take place regularly during breathing. **A breath means ‘one inhalation plus one exhalation’.** We know that air contains oxygen. So, when we breathe in air, it is actually the oxygen gas present in air which is utilised by our body (to break down food and produce energy). Thus, we ‘breathe in’ air to supply oxygen to the cells of our body (for the breakdown of food to release energy), and we ‘breathe out’ to remove waste product carbon dioxide from our body (which is produced during the breakdown of food in the cells).

We normally breathe air through our nose (or sometimes even through the mouth). Now, if we close our nostrils and mouth tightly, we soon start feeling uneasy and cannot hold our breath even for one minute! (see Figure 6). This shows how essential breathing of air is to keep us alive. And when we release the breath after holding it for some time, we have to breathe **deeply**. This deep breathing is to supply the extra oxygen to our body to make up for the oxygen which was not available during the time we held our breath. **Breathing is a continuous process which goes on all the time and throughout our life and that of other animals as well as plants.** The mountaineers carry oxygen cylinders with them for breathing because the amount of air available to a person for breathing at high altitude is **much less** than that available on the ground.
Breathing Rate

We have just learnt that a breath means ‘one inhalation plus one exhalation’. The number of times a person breathes in one minute is called breathing rate. On an average, an adult human being at rest breathes in and out 15 to 18 times in a minute. So, the average breathing rate in an adult human being at rest is 15–18 times per minute. Women breathe slightly faster than men. Breathing rate of a person is not constant always. The breathing rate of a person changes according to the oxygen requirements of the body. For example, the breathing rate of a person is the slowest when he is sleeping because minimum energy is required by the body during sleep which can be provided by a slow rate of breathing. The breathing rate of a person increases with increased physical activity (like exercise, running, weightlifting, etc.) (see Figure 7). When the breathing rate increases, greater amount of air goes into the lungs. With more air going into the lungs, the blood can absorb oxygen at a faster rate. Thus, faster breathing supplies more oxygen to the body cells for producing more energy (by the rapid breakdown of food) needed for doing heavy physical exercise, etc. During heavy physical exercise, the breathing rate of an adult human being can increase up to 25 per minute (or even more). For example, if a person runs a distance, his breathing rate increases. Running makes a person breathe faster because the faster breathing rate supplies more oxygen to the body cells for the speedy breakdown of food for releasing more energy required for running. When we run (or do some other physical exercise), not only do we breathe faster, we also take ‘deep breaths’ so as to inhale more air (and get more oxygen) for the speedy release of energy from food. It is a common observation that an athlete breathes faster and deeper than usual even after finishing a race. This is because during the race, the leg muscles of athlete have produced extra energy by doing anaerobic respiration (without using oxygen). By breathing faster and deeper, the athlete is giving back oxygen to the muscles which it could not give earlier at the time of running (due to lack of oxygen at that time).

Please note that whenever a person needs extra energy, he breathes faster than usual. Due to faster breathing, oxygen is supplied to our body cells at a faster rate. The faster supply of oxygen increases the speed of breakdown of food due to which more energy is released rapidly. It is a common observation that we feel hungry after doing a heavy physical exercise (or any other heavy physical activity). This is because to provide extra energy for doing heavy physical exercise, the food has broken down very rapidly (by faster breathing) and made us feel hungry. Another point to be noted is that the breathing rate in children is higher than that of adults. Children breathe about 20 to 30 times per minute.

How Do We Breathe

We will now learn the mechanism of breathing. That is, we will now learn how air from outside is sucked into our lungs during inhaling (breathing in), and how air from our lungs is pushed out during exhaling (breathing out). The process of breathing takes place in our lungs. Lungs are connected to our nostrils (holes in the nose) through nasal passage (or nasal cavity) and windpipe. When we inhale air, it enters our nostrils, passes through nasal passage and windpipe, and reaches our lungs. Our two lungs hang in an airtight space in our body called ‘chest cavity’. Around the sides of the chest cavity is the rib cage with sheets of muscles between the ribs. The rib cage encloses the lungs in it [see Figure 8(a)]. At the bottom of the chest cavity is a curved sheet of muscle called diaphragm [see Figure 8(a)]. Diaphragm forms the floor of chest cavity. Breathing involves the movements of the rib cage and the diaphragm. This happens as follows:
**Breathing in.** When we breathe in (or inhale), then two things happen at the same time: (i) the muscles between the ribs contract causing the rib cage to move upward and outward, and (ii) the diaphragm contracts and moves downward [see Figure 8(a)]. The upward and outward movement of rib cage, as well as the downward movement of diaphragm, both increase the space in the chest cavity and make it larger [see Figure 8(a)]. As the chest cavity becomes larger, air is sucked in from outside into the lungs. The lungs get filled up with air and expand.

![Figure 8](image)

(a) Breathing in : chest cavity becomes bigger, air is sucked into lungs
(b) Breathing out : chest cavity becomes smaller, air is pushed out of lungs

**Figure 8.** The mechanism of breathing.

**Breathing out.** When we breathe out (or exhale), even then two things happen at the same time: (i) the muscles between the ribs relax causing the rib cage to move downward and inward, and (ii) the diaphragm relaxes and moves upward [see Figure 8(b)]. The downward and inward movement of rib cage, as well as the upward movement of diaphragm, both decrease the space in our chest cavity and make it smaller [see Figure 8(b)]. As the chest cavity becomes smaller, air is pushed out from the lungs.

The process of breathing in of air and breathing out goes on continuously all day and all night. The breathing movements in our body can be felt easily as follows: Place one hand on the middle of your chest and the other hand on the abdomen (as shown in Figure 9). Take a few deep breaths and release them. We can feel the up and down movements of our chest and abdomen caused by ‘breathing in’ and ‘breathing out’ of air. If we observe carefully, we can also see the up and down movements of the abdomens of animals such as cows, dogs and cats, etc., as they breathe.

![Figure 9](image)

**Figure 9.** Feeling breathing movements in our body.

![Figure 10](image)

**Figure 10.** Measuring the chest size.
The size of our chest increases during the process of breathing in of air (because the chest cavity becomes bigger). **Different people can expand their chest by different amounts.** We can measure the maximum expansion in the chest size as follows: First measure the size of chest with a measuring tape while holding the breath, after exhaling normally (see Figure 10). Then take a very deep breath (so as to cause maximum expansion in chest), hold the breath for a while and measure the size of the chest in this expanded position. The difference in the two readings of the measuring tape will give the maximum expansion in the size of the chest which can be brought about by us.

**ACTIVITY TO DEMONSTRATE THE MECHANISM OF BREATHING**

We can demonstrate the mechanism of breathing by performing a simple activity as follows: The apparatus required for this activity is shown in Figure 11(a). A big bell jar B is taken (The bell jar is a glass jar whose bottom is open). A glass tube T branching into two smaller tubes at its lower end is fitted in the mouth of the bell jar with the help of a cork. Two balloons are tied at the two ends of the tube T as shown in Figure 11(a). A thin rubber sheet S is tied around the open bottom of the bell jar. In this apparatus, the space inside the bell jar represents the *chest cavity*, the balloons represent the *lungs* whereas the rubber sheet represents the *diaphragm*.

![Diagram](image)

**Figure 11.** Diagrams to show the action of diaphragm in breathing.

(i) In order to show the process of ‘breathing in’ air, we pull the rubber sheet downwards [see Figure 11(b)]. In this case, the space in the bell jar increases, lowering the air pressure inside the bell jar. The air from outside rushes in through the tube T into balloons due to which the balloons get inflated (their size increases) [see Figure 11(b)]. This shows the action of diaphragm during inhaling of air.

(ii) In order to show the process of ‘breathing out’ of air, we release the rubber sheet [see Figure 11(c)]. In this case, the space in the bell jar decreases. The air from inside the balloons goes out through the tube T due to which the balloons get deflated (their size decreases) [see Figure 11(c)]. This shows the action of diaphragm during exhaling of air.

The action of rubber sheet in this activity shows how we inhale and exhale air during breathing with the help of the downward and upward movement of diaphragm in our body. When the diaphragm moves downward during inhaling, the lungs get filled with air. But when the diaphragm moves upward during exhaling, then the air is forced to go out of the lungs. This activity, however, does not show the action of rib cage during breathing.
What Happens to the Air Which We Breathe During Respiration

The air which we breathe in from the atmosphere is called ‘inhaled air’ and the air which we breathe out (from our lungs through nose or mouth) is called ‘exhaled air’. We know that air is a mixture of gases such as nitrogen, oxygen, carbon dioxide and water vapour, etc. Now, the air which we ‘breathe in’ is a mixture of gases and the air which we ‘breathe out’ is also a mixture of gases. The only difference in the inhaled air and exhaled air is that they contain different proportions of oxygen, carbon dioxide and water vapour. The proportion of nitrogen gas in the inhaled air and exhaled air remains the same (78 per cent) because it is neither used up in respiration nor produced during respiration. We will now discuss what causes changes in the proportions of oxygen, carbon dioxide and water vapour in the inhaled air and exhaled air.

(i) The Case of Oxygen. The air which we inhale contains a higher proportion of oxygen. Now, some of the oxygen of inhaled air is used up in breaking down glucose food during respiration. So, the exhaled air which comes out after the process of respiration contains a lower proportion of oxygen. Thus, exhaled air contains less oxygen than inhaled air.

(ii) The Case of Carbon Dioxide. The air which we inhale contains a lower proportion of carbon dioxide. Now, during respiration when oxygen breaks down glucose food, then some carbon dioxide is produced. So, the exhaled air that comes out after the process of respiration contains a higher proportion of carbon dioxide. Thus, exhaled air contains more carbon dioxide than inhaled air.

(iii) The Case of Water Vapour. The air which we inhale contains only a little of water vapour. When glucose (food) is broken down by oxygen during respiration, then water is also produced (alongwith carbon dioxide). So, the exhaled air contains a lot more water vapour than inhaled air.

From the above discussion we conclude that during the process of respiration, when glucose (food) is broken down to release energy, then some of the oxygen of inhaled air is used up, whereas carbon dioxide and water are produced. This is why, the exhaled air contains less of oxygen but more of carbon dioxide and more of water vapour. The amount of oxygen, carbon dioxide and water vapour in inhaled air and exhaled air is given below:

<table>
<thead>
<tr>
<th>Inhaled Air</th>
<th>Exhaled Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>Oxygen</td>
</tr>
<tr>
<td>21%</td>
<td>16.4%</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>0.04%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Water vapour</td>
<td>Water vapour</td>
</tr>
<tr>
<td>A little</td>
<td>A lot</td>
</tr>
</tbody>
</table>

It is a common observation that if we exhale air on a mirror through our mouth, then a patch of moisture is formed on the mirror surface. This is because the exhaled air coming from our mouth contains a lot of water vapour. This water vapour condenses on the mirror surface to form tiny droplets of water (which appear as a patch of moisture). We will now describe an activity to show that carbon dioxide gas is formed during the process of respiration in our body.

**ACTIVITY TO SHOW THAT CARBON DIOXIDE IS PRODUCED DURING RESPIRATION**

We know that carbon dioxide gas turns lime-water milky. The fact that carbon dioxide is produced during respiration can be shown by demonstrating the effect of inhaled air and exhaled air on lime-water. The apparatus to demonstrate the effect of inhaled air and exhaled air on lime-water is shown in Figure 12. The apparatus consists of two boiling tubes A and B fitted with two-holed corks. The boiling tubes A and B are connected through a special type of glass tube C. The left arm of glass tube C is short which goes in the boiling tube A. The right arm of glass tube C is long and dips in lime water in boiling tube B (see Figure 12). The boiling tube A has another bent glass tube D whose longer side dips in lime-water contained in it. The boiling tube B has also another short, bent tube E in it which does not dip in lime-water.
Figure 12. Testing inhaled air and exhaled air for carbon dioxide.

To perform the activity, we put the top end of the tube in mouth and ‘breathe in’ and ‘breathe out’ gently. When we breathe in, then the inhaled air (fresh air) enters the glass tube and passes through the lime-water in boiling tube A. And when we breathe out, then the exhaled air (coming from our lungs) passes through the lime-water in boiling tube B. We continue to breathe in and breathe out for about five minutes. We will find that the lime-water in boiling tube A (in which inhaled air is passed) turns milky only slightly but the lime-water in boiling tube B (in which exhaled air is passed) turns milky appreciably. This shows that less carbon dioxide is present in inhaled air but much more carbon dioxide is present in exhaled air. From this observation we conclude that carbon dioxide is produced during respiration (which comes out in exhaled air).

RESPIRATION IN HUMANS

We have already studied that the process of digestion in human beings produces energy-rich simple compounds like glucose. The digested food (glucose) is carried to all the cells of our body by the blood circulatory system. The human beings obtain energy from the digested food (glucose) by the process of respiration which takes place in every cell. In human beings, many organs take part in the process of respiration. We call them organs of respiratory system. The main organs of human respiratory system are: Nose, Nasal passages (Passages in the nose), Trachea, Bronchi, Lungs and Diaphragm. The human respiratory system is shown in Figure 13.

Our nose has two holes which are called nostrils (see Figure 13). There is a passage in the nose behind the nostrils. This is called nasal passage (or nasal cavity). The nasal passage joins the nostrils to the trachea (see Figure 13). The trachea is a tube which is also called windpipe. The upper end of trachea has a voice box called larynx. The trachea (or windpipe) branches into two smaller tubes called ‘bronchi’ at its lower end (see Figure 13) (The singular of bronchi is bronchus). The two bronchi are connected to the two lungs—one to the left lung and other to the right lung (see Figure 13).

Each bronchus divides in the lungs to form a large number of still smaller tubes called ‘bronchioles’. The smallest bronchioles have tiny air-sacs at their ends (see Figure 13). The pouch-like air-sacs at the ends of the smallest bronchioles are called ‘alveoli’. The walls of alveoli are very thin and they are surrounded by very thin blood capillaries. The exchange of gases between the air and blood takes place across the walls of the alveoli.
The diaphragm is a curved sheet of muscle below the lungs. **The breathing organs of human beings are lungs.** Our lungs lie in the chest cavity, which is bound by the rib cage and diaphragm. The muscles of rib cage and diaphragm help in ‘breathing in’ and ‘breathing out’.

When we breathe in and out, our chest goes up and down (or heaves). This happens as follows: When we ‘breathe in’ air, our chest cavity expands. This expansion movement of the chest cavity helps in sucking in air (containing oxygen in it). On the other hand, when we ‘breathe out’ air, then the chest cavity contracts. This contraction movement of the chest cavity helps in squeezing out carbon dioxide from the walls of the lungs and expelling it from the body. We will now describe the working of respiratory system in human beings.

We normally breathe in air (containing oxygen) through the nose. The air enters the nostrils, passes through the nasal passage, larynx, trachea, bronchi, and finally reaches the lungs (see Figure 13). In the lungs, air passes through a large number of small tubes called bronchioles and then reaches the tiny air-sacs called alveoli. The alveoli are surrounded by very thin blood vessels called capillaries which carry blood in them. The oxygen of air diffuses out from the alveoli into the blood in the capillaries. **The blood carries oxygen to all the parts of the body. This oxygen is carried by a red pigment called ‘haemoglobin’ present in the red blood cells.**

As blood passes through the tissues of the body, the oxygen present in it diffuses into the cells. This oxygen combines with the digested food (glucose) present in cells to release energy. The materials like fatty acids and glycerol (produced by the digestion of fats) are also oxidised during respiration to produce energy. Carbon dioxide and water are produced by the oxidation of food during respiration. The waste products of respiration, carbon dioxide and water, enter into blood. Blood carries the carbon dioxide and water to the alveoli in the lungs. From the lungs, carbon dioxide and water vapour are removed with the
air we breathe out. In this way, the process of gaseous exchange is completed in the human respiratory system.

**Sneezing**

The sudden expulsion of air from the nose (without our control over it) due to the irritation of nasal passage, is called sneezing (see Figure 14). **We often sneeze when we inhale air containing dust, smoke or pollen, etc.** This happens as follows: The air around us sometimes contains various types of small, unwanted particles such as dust, smoke, pollens, etc. Now, there are some very fine hair inside our nose in the nasal passage (or nasal cavity). When we inhale air, the unwanted particles present in air usually get trapped in the hair present in our nasal passage. Sometimes, however, the particles of dust, smoke and pollens, etc., present in inhaled air get past the hair in the nasal passage and irritate the lining of nasal passage, as a result of which we sneeze. Sneezing expels all the unwanted particles from the inhaled air so that a dust free, clean air enters into our lungs (see Figure 14). Please note that whenever we sneeze, we should cover our nose properly with a handkerchief so that the unwanted particles which we expel during sneezing are not inhaled by other persons nearby us.

**Yawning**

The action of opening one’s mouth wide while taking a long and deep breath of air (without any control over it) is called yawning (see Figure 15). Yawning is called ‘jambhai’ or ‘ubasi’ in Hindi. A person yawns when he is tired, bored, stressed, over-worked, feeling sleepy or drowsy. There are many theories about why people yawn. According to one theory, **yawning is caused by insufficient oxygen in the body.** This is said to happen as follows: When we are tired, bored, stressed, over-worked, feel sleepy or drowsy, we do not breathe as deeply as we normally do and hence our breathing rate slows down. Due to slower breathing rate, less oxygen (of air) goes into our body which is insufficient for respiration (production of energy). Yawning helps in bringing more oxygen into our blood because during yawning our mouth opens wide and we take a long and deep breath of air.

**Smoking**

The lungs are very delicate organs which are essential for breathing and keeping us alive. **The biggest enemy of our lungs is the habit of smoking.** Smoking tobacco in the form of beedi, cigarette or cigar damages our lungs gradually and causes ill health. Smoking sends tobacco smoke inside the body. The chemicals present in tobacco smoke damage the lungs in many ways. Some of the **harmful effects of smoking** are as follows:

(i) Smoking destroys the lung tissue gradually due to which breathing becomes very difficult.

(ii) Smoking causes lung cancer (see Figure 16).

(iii) Smoking causes heart diseases.

![Figure 14. Sneezing.](image)

![Figure 15. Yawning.](image)

![Figure 16. Smoking is injurious to health.](image)
Smoking also damages the health of non-smokers who inhale the air containing tobacco smoke. Smoking kills. Many people die every year from diseases caused by smoking. The bad habit of smoking must be avoided to lead a healthy life.

**BREATHING AND RESPIRATION IN OTHER ANIMALS**

We have just studied that the breathing organs of human beings are lungs. Just like human beings, the animals such as cows, buffaloes, dogs, cats, lions, goats, deer, elephants, frogs, lizards, snakes and birds also have lungs for breathing. So, the process of breathing and respiration in these animals is similar to that in humans. There are, however, a large number of animals which do not have lungs for breathing. Some of the animals which do not have lungs for breathing are earthworm, fish, cockroach, grasshopper, mosquitoes, houseflies and ants. The animals such as cockroach, grasshopper, mosquito, housefly and ant are called insects. So, we can also say that insects do not have lungs for breathing. We will now describe the process of breathing and respiration in earthworm, fish and insects (such as cockroach and grasshopper, etc.), which do not have lungs.

1. **Breathing in Earthworm**

The earthworm breathes through its skin (see Figure 17). The skin of earthworm is quite thin and moist. Gases can easily pass through the skin of earthworm. The skin of earthworm has a good blood supply. So, the earthworm absorbs the oxygen (of air) needed for respiration through its thin and moist skin. This oxygen is then transported to all the cells of the earthworm by its blood where it is used in respiration (production of energy). The carbon dioxide produced during respiration is carried back by the blood. This carbon dioxide is expelled from the body of the earthworm through its skin. Thus, in earthworm the exchange of gases takes place through the thin and moist skin. Frogs live on land as well as in water. Though frogs have lungs for breathing, they can also breathe through their moist skin. Thus, frog is an animal which can breathe through lungs as well as its moist skin (see Figure 18).

2. **Breathing in Fish**

There are many animals which live in water. The animals living under water have ‘gills’ for breathing. Gills are the organs which help the animals living in water to use oxygen dissolved in water for breathing. Gills are projections of the skin. Gills have blood vessels for the exchange of respiratory gases (oxygen and carbon dioxide).

Fish lives in water. The fish has special organs of breathing called ‘gills’. The gills help the fish to use oxygen which is dissolved in water (in which it lives). The fish has gills on both the sides of its head (see Figure 19). The gills are covered by gill covers so they are not visible from outside. For breathing, the fish uses the oxygen which is dissolved in water. This happens as follows: The fish breathes by taking in water through its mouth and sending it over the gills (see Figure 19).
When water passes over the gills, the gills extract dissolved oxygen from this water. The extracted oxygen is absorbed by the blood and carried to all the parts of the fish for respiration (release of energy). The carbon dioxide produced during respiration is brought back by the blood into the gills for expelling into the surrounding water. The fish has no lungs like us, the exchange of gases in fish takes place in the gills. Some other aquatic animals like prawn, crab and fresh water mussel also respire through gills or similar structures.

Most of the snails live in water and have gills for breathing. They use gills to extract oxygen dissolved in water. Some of the snails who live on land have developed a kind of lung. So, the land snails breathe by using the lung. There are, however, some sea-animals like dolphins and whales which live in water but do not have gills. Dolphins and whales breathe in air through their nostrils (called blowholes) which are located on the upper parts of their heads. Dolphins and whales come to the surface of sea-water from time to time to breathe in air. We (human beings) cannot survive under water because we have no gills to make use of oxygen dissolved in water for breathing. We have to take along oxygen gas cylinder for breathing under water.

3. Breathing in Insects

All the insects have tiny holes on the sides of their body which are called ‘spiracles’ (see Figure 20).

![Figure 20. An insect breathes through tiny holes called ‘spiracles’ and thin air-tubes called ‘tracheae’.](image)

The spiracles on the body of insects are connected to a network of thin air-tubes called ‘tracheae’ which spread into the whole body of the insect (The singular of tracheae is trachea). The breathing in all the insects takes place through tiny holes (called spiracles) and thin air-tubes (called tracheae). This happens as follows: Air (rich in oxygen) enters into the insect through spiracles by the up and down movements of its body. This air goes into the network of thin air-tubes called tracheae. From the tracheae, oxygen of air diffuses into the body tissues of insect and reaches each and every cell of its body where it is utilised in respiration (production of energy). Carbon dioxide produced during respiration in the cells diffuses into tracheae and carried to the spiracles where it is expelled in the process of breathing. Thus, in insects the exchange of gases occurs through tracheae.

The spiracles (tiny holes) and tracheae (air-tubes) are found only in insects and not in any other group of animals. For example, cockroach is an insect, so a cockroach has spiracles (tiny holes) on the sides of its body and tracheae (air-tubes) throughout its body for the process of breathing and respiration. The insects such as grasshoppers, mosquitoes, houseflies, bees and wasps also have spiracles and tracheae for breathing and respiration.

Please note that insects have blood in their body but it is not red because it does not contain haemoglobin. Since the blood of insects does not contain haemoglobin, so it cannot carry oxygen to all the parts of the body. Every part of the body of an insect gets oxygen through a network of big and small air-tubes.

RESPIRATION IN PLANTS

Like animals, plants also need energy. The plants get energy by the process of respiration in which glucose food (prepared by them) breaks down in the presence of oxygen (of air) to form carbon dioxide
and water with the release of energy. This energy is used by the plant for carrying out its various life processes. Thus, like other living organisms, plants also respire for their survival. Plants take oxygen from air for respiration and give out carbon dioxide. So, just like animals, respiration in plants also involves the exchange of gases: oxygen and carbon dioxide. The respiration in plants differs from that of animals in that in plants, each part (like leaves, roots, etc.) can carry out respiration independently. In other words, in plants, each part can independently take in oxygen from air, utilise it to obtain energy, and give out carbon dioxide. We will now describe the respiration in the leaves and roots of a plant, one by one.

1. Respiration in Leaves

The leaves of plants have tiny pores on their surface which are called stomata (see Figure 21). The exchange of gases (oxygen and carbon dioxide) in the leaves during respiration takes place through stomata. This happens as follows: Oxygen from air enters into a leaf through stomata and reaches all the cells by the process of diffusion. This oxygen is used in respiration in the cells of the leaf. The carbon dioxide produced during respiration diffuses out from the leaf into air through the same stomata. So, we can also say that the plants breathe through the tiny pores in their leaves called stomata.

2. Respiration in Roots

The roots of a plant are under the ground but root cells also need oxygen to carry out respiration and release energy for their own use. The roots obtain oxygen for breathing and respiration from the soil as follows: Air is present in-between the particles of soil (see Figure 22). The roots of a plant take up air from the spaces between the soil particles. Actually, the roots of a plant have a very large number of tiny hair on them which are called ‘root hair’. The root hair are in contact with the air in the soil particles (see Figure 22). Oxygen from air in soil particles diffuses into root hair and reaches all the cells of the root where it is utilised in respiration. Carbon dioxide produced in the cells of the root during respiration goes out through the same root hair by the process of diffusion. Thus, the respiration in roots occurs by the exchange of gases (oxygen and carbon dioxide) through the root hair. If a potted plant is over-watered for a long time, then the plant may ultimately die. This is because too much water expels all the air from in-between the soil particles. Due to this, oxygen is not available to the roots for aerobic respiration. Under these conditions, the roots of plant respire anaerobically producing alcohol. This may kill the plant.

Please note that plants carry out photosynthesis (for making food) only during the day time when sunlight is available. On the other hand, plants carry out respiration (to obtain energy) during the day time as well as at night (because they require energy all the time). We will now answer a question based on respiration taken from the NCERT book.

Sample Problem. Three test-tubes are taken and labelled A, B and C. Each test-tube is half filled with water.

(a) In test-tube A, a snail is kept,
(b) In test-tube B, a water plant is kept, and
(c) In test-tube C, a snail and a water plant, both are kept.

The three test-tubes are then placed in sunlight. Which test-tube would have the highest concentration of carbon dioxide? Why?
**Answer.** *(a)* Test-tube A contains a snail in water. The snail will use up oxygen for respiration and produce carbon dioxide.

*(b)* Test-tube B contains a ‘water plant’ in water. The water plant will do photosynthesis by using carbon dioxide and water, and produce oxygen. The water plant will use some of this oxygen for respiration and produce carbon dioxide. This carbon dioxide will then be used by the plant in photosynthesis.

*(c)* Test-tube C contains both, a snail and a water plant. The carbon dioxide produced by the respiration in snail will be all used up by the water plant in photosynthesis.

From the above discussion we conclude that the test-tube A containing only snail will have the highest concentration of carbon dioxide because there is no plant to use up the carbon dioxide produced during the respiration in snail.

We are now in a position to answer the following questions:

**Very Short Answer Type Questions**

1. Name the process by which energy is released from the digested food.
2. Name the two gases which are exchanged during respiration.
3. State whether the following statements are true or false:
   - *(a)* Respiration is a type of combustion at ordinary temperature.
   - *(b)* Oxygen is released during the process of respiration.
   - *(c)* Energy can be released in the cells without oxygen.
   - *(d)* During heavy exercise, the breathing rate of a person slows down.
   - *(e)* The size of chest cavity increases during inhalation.
   - *(f)* Frogs breathe through lungs as well as skin.
   - *(g)* Fish has lungs for breathing.
   - *(h)* Whales and dolphins live in water and breathe through gills.
   - *(i)* Insects breathe through spiracles and tracheae.
4. Name an animal in which exchange of gases during breathing takes place through its thin and moist skin.
5. Name one animal which can breathe through lungs as well as skin.
6. Name an animal which breathes through gills.
7. Name one animal which gets oxygen for breathing and respiration through tiny holes (spiracles) in its body which are connected to a network of thin air-tubes (tracheae).
8. Name one organism which can live without oxygen.
9. Name one anaerobe (anaerobic organism).
10. What type of respiration usually takes place in yeast?
11. Name the substance whose build up in the muscles during vigorous physical exercise may cause cramps.
12. Name the single-celled organism which is used to make wine and beer by the process of anaerobic respiration.
13. What happens to your breathing rate when you:
   - *(a)* exercise?
   - *(b)* go to sleep?
14. *(a)* Name the skeletal structure surrounding the chest cavity.
    *(b)* Name the muscular floor of the chest cavity.
15. Which contains more carbon dioxide: inhaled air or exhaled air?
16. Which contains less oxygen: inhaled air or exhaled air?
17. Which contains more water vapour: inhaled air or exhaled air?
18. What are the percentages of oxygen and carbon dioxide:
    - *(a)* in inhaled air?
    - *(b)* in exhaled air?
19. Name the breathing organs in the human body.
20. In the lungs:
    - *(a)* what substance is taken into the body?
    - *(b)* what substance is removed from the body?
21. Which gases are exchanged in our lungs?
22. Where does the blood absorb oxygen in the human body?
23. Name the red pigment in blood which carries oxygen in the human body.
24. Name the openings in our body through which we inhale air.
25. Name one bad habit which can cause lung cancer.
26. Which group of animals have spiracles and tracheae for breathing and respiration?
27. What is the average breathing rate of a human adult at rest?
28. Name the air-tubes of insects.
29. Name the small openings (holes) on the sides of the body of an insect.
30. Name any two parts of plant through which exchange of gases takes place during respiration.
31. Which of the two can respire independently: plant parts or animal parts?
32. From where do roots absorb air needed for respiration?
33. State any one use of yeast.
34. Fill in the following blanks with suitable words:
   (a) The process of respiration is the reverse of ............
   (b) Food can also be broken down without using ............
   (c) Anaerobic respiration in muscles occurs if there is no ............ available.
   (d) Anaerobic respiration by yeast converts glucose into ............ which is used in making wine and beer.
   (e) Yeast is a ............celled organism.
   (f) If a person is doing exercise, his breathing rate ............
   (g) Breathing involves the movement of ............ and the ............cage.
   (h) When we exercise, not only do we breathe faster, we also take ............ breaths.
   (i) The taking in air rich in oxygen into the body is called ............
   (j) The expelling of air rich in carbon dioxide from the body is called ............
   (k) In human body, oxygen and carbon dioxide are exchanged in the ............
   (l) In earthworm, exchange of gases occurs through the ............
   (m) In fishes, exchange of gases occurs through ............
   (n) In insects, exchange of gases occurs through ............
   (o) Dolphins and whales breathe through ............
   (p) In plant cells, oxygen is used to break down ............ into carbon dioxide and water, and release ............

Short Answer Type Questions

36. What is meant by respiration? Write a word equation for it. What is the main difference between aerobic respiration and anaerobic respiration?
37. What are the two main parts in the process of respiration? What type of respiration takes place (a) in the absence of oxygen, and (b) in the presence of oxygen?
38. Match the items given in column I with those given in column II:
   
<table>
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<th>Column I</th>
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<tr>
<td>(i) Yeast</td>
<td>(a) Earthworm</td>
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<td>(ii) Diaphragm</td>
<td>(b) Gills</td>
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<td>(iii) Skin</td>
<td>(c) Alcohol</td>
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<td>(iv) Leaves</td>
<td>(d) Chest cavity</td>
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<td>(v) Fish</td>
<td>(e) Stomata</td>
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<td>(vi) Frog</td>
<td>(f) Lungs and skin</td>
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<tr>
<td>(vii) Insects</td>
<td>(g) Tracheae</td>
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39. In which type of respiration, aerobic or anaerobic, more energy is released from the same amount of glucose (food)? Why?
40. List the similarities between aerobic respiration and anaerobic respiration.
41. List the differences between aerobic respiration and anaerobic respiration.
42. Why does running make a man breathe faster?
43. Explain why, whenever a person needs extra energy, he breathes faster.
44. Why does an athlete breathe faster and deeper than usual even after finishing the race?
45. Why do we usually feel hungry after a heavy physical exercise?
46. What would happen if a potted plant is over-watered for a long time? Give reason for your answer.
47. Which will turn lime water milky more appreciably: inhaled air or exhaled air? Why?
48. Explain why, exhaled air contains more carbon dioxide than inhaled air.
49. Explain why, exhaled air contains less oxygen than inhaled air.
50. Explain why, exhaled air contains more water vapour than inhaled air.
51. Explain why, when we exhale air from our mouth on to a mirror, a patch of moisture is formed on the mirror surface?
52. Why do all the organisms respire?
53. What is yeast? What type of respiration is carried out by yeast?
54. Why do mountaineers carry oxygen gas cylinders with them?
55. Why do we often sneeze when we inhale a lot of dust-laden air?
56. State the harmful effects of smoking.
57. Define ‘breathing rate’. How does the breathing rate in children differ from that in adults?
58. Name the breathing organs in (a) fish (b) earthworm (c) frog, and (d) insect.
59. Describe the process of breathing and respiration in the following animals:
   (a) Earthworm  (b) Frog  (c) Fish  (d) Insects
60. Describe the process of respiration:
    (a) in the leaves of a plant.
    (b) in the roots of a plant.

Long Answer Type Questions

61. (a) What is meant by aerobic respiration? Explain by writing a word equation. Name one organism which normally uses aerobic respiration.
    (b) What type of respiration takes place in human muscles during heavy physical exercise?
62. (a) Define anaerobic respiration. Write a word equation for this process. Name an organism which always uses anaerobic respiration.
    (b) What type of respiration usually takes place in humans?
63. (a) What are the main organs of respiratory system in humans?
    (b) Draw a labelled diagram of human respiratory system.
64. (a) What causes ‘yawning’? What are the various situations under which yawning occurs?
    (b) What happens to the breathing rate when a person is tired, bored, feels sleepy or drowsy? How does yawning improve the situation?

Multiple Choice Questions (MCQs)

66. During heavy exercise, we get cramps in the legs due to the accumulation of:
    (a) carbon dioxide  (b) lactic acid  (c) alcohol  (d) water
67. The normal range of ‘breathing rate’ per minute of an average adult person at rest is:
    (a) 9 – 12  (b) 15 – 18  (c) 21 – 24  (d) 30 – 33
68. During inhalation, the diaphragm:
    (a) moves downwards  (b) moves upwards
    (c) moves towards left  (d) moves towards right
69. During exhalation, the rib cage:
    (a) moves upward and outwards  (b) moves downward and inwards
    (c) moves from side to side  (d) does not move at all
70. In cockroaches, air enters the body through:
    (a) lungs  (b) gills  (c) spiracles  (d) skin
71. One of the following does not have gills for breathing. This one is:
    (a) prawn  (b) crab  (c) whale  (d) fish
72. Which of the following is not a part of the human respiratory system?
    (a) lungs  (b) oesophagus  (c) trachea  (d) diaphragm
73. One of the following is not produced during the anaerobic respiration in yeast. This one is:
(a) carbon dioxide  (b) energy  (c) lactic acid  (d) alcohol

74. As compared to inhaled air, the exhaled air contains more of:
A. Water vapour  B. Oxygen  C. Carbon dioxide  D. Nitrogen
(a) A and B  (b) A and C  (c) Only C  (d) B and D

75. Which of the following has haemoglobin-containing blood?
(a) grasshopper  (b) cockroach  (c) goose  (d) wasp

76. The energy of food which we eat is released slowly inside our body by the process called:
(a) transpiration  (b) pollination  (c) restoration  (d) respiration

77. Which of the following is not a product of aerobic respiration?
(a) carbon dioxide  (b) alcohol  (c) energy  (d) water

78. Yeast converts glucose into:
(a) starch  (b) alcohol  (c) lactic acid  (d) yogurt

79. Which of the following are not the products of anaerobic respiration in muscles?
A. Carbon dioxide  B. Energy  C. Alcohol  D. Lactic acid
(a) A and B  (b) B and C  (c) A and C  (d) B and D

80. During respiration in humans, the exchange of gases takes place in:
(a) bronchi  (b) alveoli  (c) bronchioles  (d) trachea

81. Which of the following does not have lungs for breathing?
(a) lizard  (b) frog  (c) fish  (d) fox

82. One of the following organisms can live without the oxygen of air. This organism is:
(a) Amoeba  (b) Yak  (c) Yeast  (d) Leech

83. When air is blown from mouth into a test-tube containing lime water, the lime water turns milky due to the presence of:
(a) oxygen  (b) carbon dioxide  (c) nitrogen  (d) alcohol

84. Which of the following is most likely to have a much higher breathing rate?
(a) man  (b) dog  (c) sparrow  (d) fish

85. The animal which can breathe through the lungs as well as through skin is:
(a) fish  (b) dolphin  (c) frog  (d) crocodile

Questions Based on High Order Thinking Skills (HOTS)

86. In an experiment to demonstrate the mechanism of breathing by using a bell jar, two balloons in the bell jar and a rubber sheet tied to the open end of bell jar:
(a) What does the space in the bell jar represent?
(b) What do the balloons in the bell jar represent?
(c) What does the rubber sheet tied over the open end of bell jar represent?

87. Name the type of respiration in which the end products are:
(a) alcohol and carbon dioxide.
(b) carbon dioxide and water.
(c) lactic acid.

88. There are three animals X, Y and Z. The animal X can stay in water as well as on land and can breathe through its moist skin as well as lungs. The animal Y always lives is water and has gills for breathing. On the other hand, animal Z lives in soil and breathes only through its skin.
(a) Which animal could be a fish?
(b) Which animal could be an earthworm?
(c) Which animal could be a frog?
(d) Name one animal which always lives in water but has no gills for breathing.

89. What are the products obtained in the anaerobic respiration:
(a) if it takes place in muscles?
(b) if it takes place in yeast?

90. Consider the following animals:
Fish, Grasshopper, Cockroach, Earthworm, Frog, Cow, Goat, Man, Lizard, Snake
Which of these animals:

(a) breathes only through skin?
(b) breathes through skin as well as lungs?
(c) breathe only through lungs?
(d) breathe through spiracles and tracheae?
(e) breathes through gills?

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85. **(c)**

**Hint.** The fish lives in water and uses the oxygen dissolved in water for breathing. Since the amount of oxygen dissolved in water is low as compared to the amount of oxygen in air on land, therefore, the rate of breathing is much higher in fish than the land animals like man, dog and sparrow. A higher rate of breathing provides more oxygen to fish from water. 85. **(c)** 86. **(a)** Chest cavity 87. **(a)** Anaerobic respiration in yeast 88. **(a)** Y 89. **(a)** Lactic acid and energy 90. **(a)** Earthworm **(b)** Frog 91. **(a)** Oxygen **(b)** Carbon dioxide **(c)** Oxygen **(d)** Alcohol **(e)** Single **(f)** Increases **(g)** Diaphragm; rib 92. **(i)** Inhalation 93. **(j)** Exhalation 94. **(k)** Lungs 95. **(l)** Skin 96. **(m)** Gills 97. **(n)** Tracheae 98. **(o)** Blowholes 99. **(p)** Glucose; energy 100. **(q)** Carbon dioxide 101. **(r)** Lungs 102. **(s)** Diaphragm.