This Book Belongs to:
Name ..........................................................................................
Roll No......................................................................................
Class and Section ........................................................................
School ........................................................................................
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

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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)

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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All the living organisms like man, animals and plants need food for their growth and survival. The green plants can synthesise their food by the process of photosynthesis by using inorganic substances like carbon dioxide gas and water in the presence of sunlight energy. Man and other animals cannot make food by photosynthesis from carbon dioxide gas and water by using sunlight energy. They need readymade organic food nutrients like carbohydrates, fats, and proteins, etc., for their growth and development. Man obtains his food from plants as well as animals. In other words, man has to grow plants and rear animals (bring up animals) to meet his requirements of food.

Many types of plants are grown on a large scale in vast fields because the food grains produced by them are consumed in large amounts. Wheat and rice are two common examples. These are called food grains. In addition to food grains, pulses, vegetables and fruits are also grown on a large scale because they are an important part of our food. The animals such as cow and buffalo are reared to obtain milk whereas goat, fish and hen are reared to get meat and eggs. In this Chapter, we will study the different practices of obtaining food from both, plants as well as animals. Before we go further, we should know the meaning of the word ‘crop’. This is discussed below.

Crops

When the same kind of plants are grown in the fields on a large scale to obtain foods like cereals (wheat, rice, maize), pulses, vegetables and fruits, etc., it is called a crop. For example, a crop of wheat means that all the plants grown in the fields are that of wheat (see Figure 1). A crop
is called 'fasal' in Hindi. Crops are grown in the soil in the fields by farmers (kissan). Some of the examples of crops are given below:

(i) Cereal crops: Wheat, Paddy (Rice), Maize, Millet (Bajra, Jawar), Barley

(Grain crops)

(ii) Pulses: Gram (Chana), Peas, Beans

(iii) Oil seeds: Mustard, Groundnut, Sunflower

(iv) Vegetables: Tomato, Cabbage, Spinach

(v) Fruits: Banana, Grapes, Guava, Mango, Orange, Apple

**Types of Crops**

Different crops grow well in different seasons of the year. For example, a crop may grow well in rainy season during summer but it may not grow well in winter season. Similarly, another crop may grow well in winter season but not in rainy season. Based on the seasons (in which they grow well), all the crops are categorised into two main groups:

1. Kharif crops, and
2. Rabi crops.

The crops which are sown in the rainy season are called kharif crops. The rainy season in India is generally from June to September. The sowing for kharif crops starts in June–July at the beginning of southwest monsoon because these crops (particularly paddy) need substantial amount of water. The kharif crops are harvested at the end of monsoon season during September (or October). Some of the examples of kharif crops are: Paddy, Maize, Millet, Soyabean, Groundnut and Cotton. The kharif crops are sometimes also called ‘summer crops’. Please note that ‘paddy’ is ‘rice still in the husk’. So, paddy crop gives us rice. In other words, paddy is rice crop. Paddy is grown only in the rainy season because it requires a lot of water. Paddy cannot be grown in the winter season because water available in winter is much less. On the other hand, if wheat is sown in the kharif season, it will not grow well. This is because wheat plants cannot tolerate too much water of the rainy season.

The crops grown in the winter season are called rabi crops. The time period of rabi crops is generally from October to March. The sowing for rabi crops begins at the beginning of winter (October–November) and the crops are harvested by March (or April). Some of the examples of rabi crops are: Wheat, Gram (Chana), Peas, Mustard, and Linseed.

The people who have no permanent homes and continuously move from one place to another are called ‘nomads’ (or wanderers). Till about 10000 B.C., people were nomadic. They were continuously moving (or wandering) in groups from place to place in search of food and shelter. These nomadic people ate raw fruits and vegetables found in nature and started hunting animals for food. Later, they settled near the sources of water such as rivers and cultivated land to produce wheat, paddy (rice) and other food crops. This is how agriculture was born. The growing of plants (or crops) in the fields for obtaining food (like wheat, rice, etc.) is called agriculture. Agriculture is called ‘khetibari’ or ‘krishi’ in Hindi. We will now describe the various agricultural practices.

**BASIC PRACTICES OF CROP PRODUCTION**

In order to raise a crop (or cultivate a crop) successfully and profitably for food production, a farmer has to perform a large number of tasks in a sequence (one after the other). The various tasks performed by a farmer to produce a good crop are called agricultural practices. The various agricultural practices which are carried out at various stages of crop production are:

1. Preparation of soil,
2. Sowing,
3. Adding manure and fertilisers,
4. Irrigation,
5. Removal of weeds,
6. Harvesting, and
7. Storage of food grains.

In addition to these regular agricultural practices, one more agricultural practice called ‘Rotation of crops’ is undertaken sometimes to improve the fertility of soil and increase the crop yield. The various agricultural practices require certain tools or implements which are called agricultural implements. We will now describe all the agricultural practices in detail to know how food is produced on a large scale.

1. PREPARATION OF SOIL

The upper layer of earth is called soil. The crop plants are grown in soil. Soil provides minerals, water, air, humus and anchorage (fixing firmly), to the plants. Preparation of soil is the first step in cultivating a crop for food production. The soil is prepared for sowing the seeds of the crop by (i) ploughing, (ii) levelling, and (iii) manuring. Each one of these steps has its own significance. This is described below.

The process of loosening and turning the soil is called ploughing (or tilling). Ploughing (or tilling) of fields is done by using an implement called plough. Ploughs are made of wood or iron, and they have an iron tip for easy penetration into the soil. The ploughs are pulled by a pair of bullocks or by a tractor (see Figures 2 and 3). Actually, the ploughing of small fields is done with the help of animals like bullocks while large fields are ploughed by using tractors. The loosening of soil by ploughing is beneficial because of the following reasons:

(i) The loose soil allows the plant roots to penetrate freely and deeper into the soil so that plants are held more firmly to the ground.
(ii) The loose soil allows the roots of plants to breathe easily (even when the roots are deep). This is because loose soil can hold a lot of air in its spaces.
(iii) The loose soil helps in the growth of worms and microbes present in the soil who are friends of the farmer since they help in further turning and loosening the soil. They also add humus to the soil.
(iv) Ploughing also uproots and buries the weeds (unwanted plants) standing in the field and thereby suffocates them to death.
(v) The loosening and turning of soil during ploughing brings the nutrient rich soil to the top so that the plants can use these nutrients.

If the soil is very dry, it breaks into large mud ‘crumbs’ during ploughing. The mud crumbs are then broken down by using a soil plank called ‘crumb crusher’.

Figure 2. Ploughing the fields with the help of bullocks.
Figure 3. Ploughing the fields by using tractor.
The ploughed soil is quite loose so it is liable to be carried away by strong winds or washed away by rain water. The removal of top soil by wind and water is called soil erosion. **The ploughed soil is levelled by pressing it with a wooden leveller (or an iron leveller) so that the top soil is not blown away by wind or drained off by water (and soil erosion is prevented).** The levelling of ploughed soil is beneficial because of the following reasons:

(i) The levelling of ploughed fields (by pressing) prevents the top fertile soil from being carried away by strong winds or washed away by rain water.

(ii) The levelling of ploughed fields helps in the uniform distribution of water in the fields during irrigation.

(iii) The levelling helps in preventing the loss of moisture from the ploughed soil.

The levelling of ploughed soil in the fields is done by using an implement called leveller. The soil leveller is a heavy wooden plank or an iron plank. The soil leveller can be pulled by bullocks or by tractor.

‘**Manuring**’ means ‘adding manure to the soil’. Sometimes, manure is added to the soil before ploughing. Addition of manure to soil before ploughing helps in the proper mixing of manure with the soil. Manure is first transported to the fields. It is then spread out in the fields. When this field is ploughed, the manure gets mixed in the soil properly. Manure contains many nutrients required for the growth of crop plants. So, **manuring is done to increase the fertility of the soil before seeds are sown into it.** Once the soil is ploughed, levelled and manured, it is ready for the sowing of seeds. The soil is watered before sowing.

**Agricultural Implements**

Before sowing the seeds, it is necessary to loosen and turn the soil in the fields so as to break it to the size of grains. The loosening and turning of soil in the fields is done with the help of various agricultural implements (or tools). The main agricultural implements (or tools) used for loosening and turning the soil are: Plough, Hoe and Cultivator.

(i) **PLOUGH.** Plough is a large agricultural implement which is used for ploughing (or tilling) the soil in the fields. The traditionally used wooden plough is shown in Figure 4. The wooden plough consists of a long log of wood which is called plough shaft (see Figure 4). There is a handle at one end of the plough shaft. Below the handle is a strong triangular iron strip called ploughshare. The other end of plough shaft can be attached to a wooden beam which is fixed at right angles to the plough shaft (see Figure 4). This beam is placed over the neck of two bullocks (or oxen) so as to pull the plough. Thus, the plough is drawn by a pair of bullocks (or other animals such as buffaloes, camels, etc.) (see Figure 2). When the plough is pulled by the bullocks, the farmer holds the handle of the plough and presses down the handle due to which the ploughshare digs into the soil, loosens it and turns it. Nowadays, the traditional wooden plough is increasingly being replaced by the iron plough.

(ii) **HOE.** Hoe is an agricultural implement (or tool) which is used for removing weeds, and loosening and turning the soil (see Figure 5). Hoe consists of a long rod of wood or iron. There is a handle (having
grip) at one end of the hoe. A strong, broad and bent plate of iron is fixed below the handle and acts like a blade. The other end of hoe has a beam which is put on the neck of bullocks. Thus, a hoe is also pulled by animals such as a pair of bullocks. The hoe is a kind of modified plough.

(iii) CULTIVATOR. The cultivator is a tractor driven agricultural implement which is used for loosening and turning the soil in the fields quickly (see Figure 6). A cultivator has many ploughshares which can dig into a considerable area of soil at the same time, loosen it and turn it. Due to this, many fields can be ploughed (or tilled) in a short time by using a cultivator. In this way, the use of cultivator saves labour and time. Nowadays, ploughing of large fields is done by using the tractor driven cultivators (see Figure 3).

2. SOWING

Once the soil in the field has been prepared by ploughing, levelling and manuring, etc., seeds of the crop can be sown in it. The process of scattering seeds (or putting seeds) in the ground soil for growing the crop plants is called sowing. Sowing is the most important part of crop production. Before sowing, good quality seeds are selected. Good quality seeds are clean and healthy seeds free from infection and diseases. Farmers prefer to use seeds which give high yield of food grains.

Selection of Seeds

ACTIVITY

We can select good, healthy seeds for sowing as follows: Put all the seeds in a bucket containing water and stir well. Most of the seeds will settle down at the bottom whereas some seeds will float on top. The seeds which sink at the bottom of the bucket are the healthy seeds. On the other hand, the seeds which float on water are the spoiled seeds. This can be explained as follows: Healthy seeds are heavy, so they sink in water. The seeds which have been partially eaten by pests or damaged by disease become hollow and light, and hence float on water. The seeds may also be treated with fungicide solutions before sowing to prevent the seed-borne diseases of crops.

Methods of Sowing Seeds

Seeds are sown in the soil either by hand or by seed drill. Thus, there are two methods of sowing the seeds in the soil. These are:

(i) Sowing by hand, and

(ii) Sowing with a seed drill.

The sowing of seeds by hand (or manually) is called broadcasting. In the sowing with hand or manually, the seeds are taken in hand and gradually scattered in the entire ploughed field. This method is, however, not very good because there is no proper spacing or proper depth at which the seeds are sown by hand. Moreover, the seeds scattered on the surface of the soil for sowing can be picked up and eaten by the birds.

The implement used for sowing is a seed drill. A seed drill is a long iron tube having a funnel at the top (see Figure 7). The seed drill is tied to back of the plough and seeds are put into the funnel of the seed drill. And as the plough makes furrows in the soil, the seeds from the seed drill are gradually released and sown into the soil furrows made by the plough. Thus, by using a seed drill for sowing, the seeds are sown at the correct depth and correct intervals (or spacings). The seeds sown with a seed drill are in regular rows. Moreover, when the seeds are sown in furrows by a seed-drill, the seeds get covered by soil. Due to this,
these seeds cannot be picked up and eaten by the birds. It is obvious that the **sowing with seed-drill is much better than sowing by hand**. A bullock driven seed-drill has just one long iron tube with a funnel. The tractor driven seed-drill has 5 to 6 iron tubes joined together with a common funnel at the top (see Figure 8). When the seeds are put into the funnel of such a seed drill, the seeds are released through all the tubes and get sown into 5 or 6 furrows of soil simultaneously. By using such tractor driven seed-drills, the sowing of seeds can be completed quickly. Most of the **crops** like wheat, gram (chana), maize and millet etc, are grown (or cultivated) by sowing the seeds directly into soil.

**Precautions for Sowing Seeds**

The following precautions should be taken while sowing seeds in the soil.

(i) **The Seeds Should be Sown at Right Depth in the Soil Suitable For Germination.** If the seeds are just spread on the surface of the soil, then the seeds will be eaten up by the birds. And if the seeds are sown too deep, then they may not germinate because they cannot breathe (cannot get sufficient air) at greater depth. So, the seeds should be sown at right depth in the soil which is suitable for germination. This right depth is learnt by experience.

(ii) **The Seeds Should be Sown at Right Intervals or Spacings.** The seeds should neither be placed too close nor too far apart. This is because if the seeds are sown too close, then plants formed from them will also be too close, and will not get enough sunlight, water, and other nutrients. Thus, an appropriate distance between the seeds is important to avoid overcrowding of plants. This allows the plants to get sufficient sunlight, nutrients and water from the soil. On the other hand, if the seeds are sown too far apart, then it will be a wastage of field space.

(iii) **The Seeds Should Not be Sown in a Dry Soil.** Moisture in the soil is necessary for the germination of seeds. So, if seeds are sown in a dry soil, they may not germinate at all.

(iv) **The Seeds Should Not be Sown in a Highly Wet Soil.** If the seeds are sown in a highly wet soil, then on drying, the soil surface becomes hard and because of this hard surface of soil, the germinating plumule will be unable to come out of ground. Moreover, the seeds are not able to respire properly due to lack of air under these conditions of hard surface of soil.

**Advantages of Sowing with a Seed Drill**

The sowing of seeds with a seed drill has the following advantages:

(i) By using a seed drill for sowing, the seeds are sown at correct depth and correct intervals (or spacings).

(ii) The seeds sown with a seed drill are in regular rows.

(iii) When the seeds are sown in furrows by a seed drill, the seeds get covered by soil and hence these seeds cannot be picked up and eaten by birds. This prevents damage caused by birds.

(iv) Sowing by using a tractor-driven seed drill saves time and labour.
Transplanting (or Transplantation)

Though most of the crops are grown by sowing the seeds directly in the soil but in some crops like paddy (rice) and many vegetables, the seeds are not directly sown in the soil in large fields. In the case of crops like paddy (rice) and vegetables like tomatoes and chillies (mirch), the seeds are first sown in a small plot of land or nursery and allowed to grow into tiny plants called seedlings by providing them with a good dose of nutrients. After the seeds have grown into tiny plants called seedlings in the seed-bed or nursery, only the healthy and well developed seedlings are then picked out from the nursery bed and transferred or transplanted to the regular field. The process of transferring the seedlings from the nursery to the main field by hand is called transplantation or transplanting. During transplantation, proper distance is kept between the various seedlings and also between the various rows of seedlings, to enable each and every plant (formed from seedlings) to get sufficient sunlight, water and other nutrients for normal and healthy growth (see Figure 9). The process of transplantation gives us many advantages over the direct sowing which ultimately leads to an increase in the yield of the crop.

The various advantages of the transplantation process are given below:

(i) The process of transplantation enables us to select only the better and healthy seedlings for the cultivation of crops. The bad seedlings can be rejected. This selection is, however, not possible when the seeds are directly sown in the soil.

(ii) The process of transplantation allows better penetration (deeper penetration) of the roots in the soil.

(iii) The process of transplantation promotes better development of the shoot system of plants.

(iv) The process of transplantation allows the seedlings to be planted at the right spacings so that the plants may get uniform dose of sunlight, water and nutrients.

The practice of transplantation is used in the cultivation of paddy crop (rice crop) and in the cultivation of many vegetables like tomatoes and chillies. We will now discuss manures and fertilisers.

3. Adding Manure and Fertilisers

The crop plants need a number of mineral elements for their growth which they get from the soil through their roots. Now, repeated growing of crops in the same field removes a lot of precious mineral elements, organic matter and other materials from the soil. Due to this the soil becomes infertile after some time, and the crop yield decreases. So, unless the depleted plant nutrients are put back into the soil from time to time, the growth of crop would be poor. The deficiency of plant nutrients and organic matter in the soil is made up by adding manures and fertilisers to the soil.

**Manures**

Manure is a natural fertiliser. A manure is a natural substance obtained by the decomposition of animal wastes like cow-dung, human wastes, and plant residues, which supplies essential elements and humus to the soil and makes it more fertile. Manures are prepared from animal wastes, human wastes and plant residues by the action of micro-organisms. In order to prepare manure, farmers dump animal wastes (animal dung, etc.) and plant wastes (like leaves, etc.) in pits at open places and allow it to decompose slowly. The decomposition is carried out by some micro-organisms. The decomposed animal and plant matter is used as organic manure.
Manures contain a mixture of various nutrient elements and a lot of organic matter (humus) recycled from bio-mass wastes (animal and plant wastes). Though manures are not very rich in plant nutrients like nitrogen, phosphorus and potassium, but they are rich in organic chemical nutrients like humus. Thus, manures provide a lot of organic matter like humus to the soil and this humus improves the physical and chemical properties of the soil. A manure improves the soil texture for better retention of water and aeration. This is because, being porous, humus can hold more water and air in the soil. In fact, manure makes up the general deficiency of the nutrients in the soil.

A manure is, however, very bulky and voluminous due to which it is inconvenient to store and transport. Moreover, a manure is not “nutrient specific”, and hence it is not much helpful when a particular nutrient is required in the soil for a particular crop. A chemical fertiliser, on the other hand, is nutrient specific.

**Chemical Fertilisers**

Manures are not able to supply the required quantities of the essential plant nutrients like nitrogen, phosphorus and potassium, etc. So, they are to be supplemented with chemical fertilisers. A chemical fertiliser is a salt or an organic compound containing the necessary plant nutrients like nitrogen, phosphorus or potassium, to make the soil more fertile. A chemical fertiliser is rich in a particular plant nutrient (such as nitrogen, phosphorus or potassium). Some examples of fertilisers are: Urea, Ammonium sulphate, Superphosphate, Potash and NPK (N = Nitrogen ; P = Phosphorus ; K = Potassium).

The chemical fertilisers are nutrient specific. This means that a chemical fertiliser can provide only nitrogen, only phosphorus or only potassium to the soil, as required. The chemical fertilisers have plant nutrients in a concentrated form. So, they provide quick replenishment of plant nutrients in the soil and restore its fertility. Chemical fertilisers have high solubility in water. So, they are easily absorbed by the plants. Chemical fertilisers are made in factories. Chemical fertilisers are easy to transport, store and handle because they come in bags (see Figure 10). The chemical fertilisers absorb moisture very quickly, so they are packed in air-tight bags.

The chemical fertilisers can be applied before sowing, during irrigation or sprayed on standing crops (see Figure 11). The use of fertilisers has helped the farmers to get better yield of crops such as wheat, paddy (rice) and maize, etc. The excessive use of fertilisers is harmful due to the following reasons:

(i) The excessive use of fertilisers changes the chemical nature of soil and makes the soil less fertile. For example, the excessive use of fertilisers can make the soil highly acidic or alkaline. The highly acidic or alkaline soil becomes less fertile.
(ii) The excessive use of fertilisers causes water pollution in ponds, lakes and rivers, etc.

In order to maintain the fertility of soil, we should substitute some of the fertilisers by organic manure or leave the field fallow (uncultivated) in-between two crops. When a field is kept uncultivated for some time, its fertility is restored naturally.

**ACTIVITY TO SHOW THE EFFECT OF MANURE AND FERTILISER ON THE GROWTH OF PLANTS**

Take three empty flower pots and mark them A, B and C (see Figure 12). Put some ordinary soil in pot A. Add some soil mixed with a little cow-dung manure in pot B. And take some soil mixed with a little urea fertiliser in pot C. Pour the same amount of water in all the three flower pots. Now take some **moong** or **gram** seeds and germinate them. Select equal sized seedlings of **moong** or **gram**. Plant these seedlings in each of the three flower pots. Keep the flower pots in a sunny place and water them daily. Observe the growth of seedlings in the three flower pots after 7 to 10 days. We will find that the seedlings planted in ordinary soil in pot A show the minimum growth [see Figure 12(a)]. The seedlings planted in soil containing manure in pot B show better growth [see Figure 12(b)]. But the seedlings planted in soil containing fertiliser in pot C show the maximum growth as well as the fastest growth [see Figure 12(c)]. From this activity we conclude that manure and fertilisers help the plants to grow better and faster.

Before we end this discussion, we would like to give the main differences between manures and fertilisers in tabular form.

<table>
<thead>
<tr>
<th>Differences between Manures and Fertilisers</th>
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<tbody>
<tr>
<td><strong>Manure</strong></td>
</tr>
<tr>
<td>1. A manure is a natural substance obtained by the decomposition of animal wastes like cow dung, human waste, and plant residues.</td>
</tr>
<tr>
<td>2. A manure is not very rich in essential plant nutrients like nitrogen, phosphorus and potassium.</td>
</tr>
<tr>
<td>3. A manure provides a lot of organic matter like humus to the soil.</td>
</tr>
<tr>
<td>4. A manure is absorbed slowly by the plants because it is not much soluble in water.</td>
</tr>
<tr>
<td>5. Manure can be prepared in the fields.</td>
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</table>
Advantages of Manure

The manure is an organic material. The organic manure is considered better than fertilisers because of the following reasons:

(i) Manure enhances the water-holding capacity of the soil.
(ii) Manure makes the soil porous due to which the exchange of gases becomes easy.
(iii) Manure increases the number of useful microbes in the soil.
(iv) Manure improves the texture of the soil.

Another method of replenishing the soil with nutrients (such as nitrogen) is through crop rotation. Before we discuss crop rotation as a means of improving the fertility of soil, we should know something about leguminous plants or leguminous crops. The pulses, peas, beans, groundnut, gram (chana) and clover (berseem) are leguminous crops. The root nodules of leguminous plants have nitrogen-fixing bacteria (called Rhizobium bacteria) which can directly fix (or convert) the nitrogen gas present in air to form nitrogen compounds. In other words, leguminous crops have the ability to fix atmospheric nitrogen to form nitrogen compounds. These nitrogen compounds go into the soil and improve its fertility. Some of these nitrogen compounds are used by the leguminous crop for its own growth and the rest of nitrogen compounds are left in the soil. Thus, planting a leguminous crop like pulses, peas, beans, groundnut, gram and clover, etc., in a field results in nitrogen-rich soil.

The planting of a leguminous crop in a field has the same effect as adding nitrogenous fertiliser in the field. Since leguminous crops can fix the atmospheric nitrogen themselves by using nitrogen-fixing bacteria present in their root nodules, therefore, nitrogenous fertiliser is not required for growing leguminous crops. On the other hand, cereal crops like wheat, maize, paddy, and millet, etc., are non-leguminous crops which do not have the ability to fix (or convert) the nitrogen gas of air into nitrogen compounds. Keeping these points in mind, we will now describe crop rotation.

Crop Rotation

The fertility of soil can be improved by crop rotation. The practice in which different types of crops (leguminous crops and non-leguminous crops) are grown alternately in the same field or soil is called crop rotation. In crop rotation, the cereal crops like wheat, maize, paddy and millet are grown alternately with leguminous crops like pulses, peas, beans, groundnut and clover, etc., in the same field. For example, when a cereal crop like maize crop is grown first, it takes away a lot of nitrogen from the soil for its growth and makes the soil nitrogen deficient. And next, when the leguminous crop like pulses or groundnut is grown in the same field, then the leguminous crop with its nitrogen fixing bacteria, enriches the soil with nitrogen compounds and increases its fertility. And when another cereal crop like wheat is grown after that, then wheat can utilise this extra nitrogen from the soil for its growth and produce a bumper crop. In this way, rotating different crops (leguminous and non-leguminous crops) in the same field replenishes the soil with nitrogen naturally and leads to increase in the crop production. Rotation of crops has the following advantages:

(i) Rotation of crops improves the fertility of the soil by replenishing it with nitrogen and hence brings about an increase in the production of food grains.
(ii) Rotation of crops saves a lot of nitrogenous fertiliser. This is because the leguminous crops grown during the rotation of crops can fix atmospheric nitrogen with the help of their nitrogen fixing bacteria, and there is no need to add nitrogenous fertiliser to the soil.

3. Irrigation

All the crop plants need water for their growth. The crop plants absorb water from the soil. The amount of water in the soil is not constant throughout the year. Water from the soil is lost constantly by evaporation and percolation to lower depths of the ground. It is, therefore, necessary to supply water to the crop plants in the fields, periodically. The process of supplying water to crop plants in the fields is called
irrigation. Just as we cannot survive without water for a long time, in the same way, plants also cannot survive without water for a long time. For example, if we stop watering plants grown in our home for a considerable time, the plants become pale, wilt and ultimately die. Water is absorbed by the roots of the plants. Alongwith water, minerals and fertilisers are also absorbed by crop plants. Plants contain nearly 90 per cent water.

**Why is Irrigation Necessary**

(i) Irrigation before ploughing the fields makes the soil soft due to which the ploughing of fields becomes easier.

(ii) Irrigation is necessary to provide moisture for the germination of seeds. This is because seeds do not grow in dry soil.

(iii) Irrigation is necessary to maintain the moisture of soil for healthy crop growth so as to get good yield.

(iv) Irrigation is necessary for the absorption of nutrient elements by the plants from the soil. The irrigation water dissolves the nutrients present in the soil to form a solution. This solution of nutrients is then absorbed by the roots for the development of plants.

(v) Water supplied to the crops during irrigation protects the crop plants from hot air currents as well as frost.

**Factors Affecting Irrigation Requirements of Crops**

The irrigation requirements (or water requirements) of crops depend on three factors:

(i) Nature of the crop,

(ii) Nature of the soil, and

(iii) Season.

Each crop needs a specific amount of water during the various stages of its growth and ripening. Some crops need more water whereas others require less water. For example, paddy crop (rice crop) is transplanted in standing water and requires continuous irrigation whereas other crops like wheat, gram (chana) and cotton, etc., do not require so much water. For cereal crops like wheat, irrigation is needed only at three stages: before ploughing the field; at the time of flowering; and at the time of development of grain.

There are two important types of soils in which the crops are grown; Sandy soil and Clayey soil. The crops grown in a sandy soil need irrigation more frequently whereas the frequency of irrigation for the crops grown in a clayey soil is comparatively less. This can be explained as follows: Sandy soil is highly porous having high permeability. So, when we irrigate the crops standing in a sandy soil, then water quickly percolates down the soil and the crop plants are not able to absorb adequate amount of water. So, due to the poor water retaining capacity of the sandy soil, the crops cultivated in sandy soil need more frequent irrigation. On the other hand, clayey soil is much less permeable than sandy soil due to which it can retain water for a much longer time. So, when the crop grown in a clayey soil is irrigated, the water remains in the soil for a longer time, and hence the plants can absorb this water in adequate amount. So, due to better water retaining capacity of the clayey soil, the crops cultivated in clayey soil need irrigation less frequently.

![Figure 13. Water in canal is used for irrigation.](image)
The frequency of irrigation of crops also varies from season to season. For example, the frequency of irrigation (or watering) of the crops is higher in summer season. This is because during the hot days of summer, the rate of evaporation of water from the soil and the leaves of crop plants is increased. On the other hand, the frequency of irrigation (or watering) of the crops is comparatively lower in the colder winter season.

**Sources of Irrigation**

Crops are supplied water for irrigation from different sources like: **Rivers, Canals, Wells, Tube-wells, Dams (Reservoirs), Ponds and Lakes.** Even **rain** is a source of irrigation of crops. The water available in wells, lakes and canals is lifted up by different methods in different regions for taking it to the fields.

**Traditional Methods of Irrigation**

The various traditional methods of irrigation are:

1. **Moat (Pulley system),**
2. **Chain pump,**
3. **Dhekli,** and
4. **Rahat (Lever system).**

**MOAT.** In the moat system of irrigation, water is drawn out from a well by using a big container tied to a long rope which moves over a pulley fixed at one edge of the well (see Figure 14). The rope tied to container is usually pulled by animals such as bullock (buffalo or camel). When the rope is pulled at the free end, the container filled with water (tied at the other end of rope) comes out of the well (see Figure 14).

![Figure 14. Moat.](image)

The farmer pours out water from the container into the fields and lowers empty container back into the well to get it refilled. The water-filled container again comes out of the well when the bullock pulls the rope and this process is repeated to get a continuous supply of water for irrigation.

**CHAIN PUMP.** Chain pump is an arrangement to lift water from a source of water like a stream, pond or lake (which is at a lower level than the fields) so as to provide irrigation in the fields. A chain pump consists of two large wheels, one fixed at the lower level of water source and the other fixed at the higher level above the fields (see Figure 15). The two wheels are connected by a chain passing over them. On the chain are hung small buckets. Below the bottom wheel is the source of water (like a stream, pond or lake) from which the water is to be lifted up to the fields. A handle is attached to the axle of the upper wheel. When the handle attached to the upper wheel is rotated by the farmer, the wheels connected by the chain start turning. When the lower wheel turns, the buckets attached to chain dip in the stream and get filled with water (see Figure 15). The moving chain then lifts these buckets filled with water up to the upper
wheel where the buckets tilt, and get emptied in the fields to provide water for irrigation. The moving chain then carries the empty buckets down to the lower wheel to be filled with water again. This process is repeated due to which the water from stream (pond or lake) is continuously lifted up into the fields.

**Dhekli.** Dhekli is an arrangement to lift water from shallow wells by using the principle of simple lever (The word ‘dhekli’ means ‘lever-beam of well’). In dhekli, a long wooden beam is supported over a forked vertical support fixed in the ground near the well in such a way that its longer arm is towards the well and shorter arm away from it (see Figure 16). A bucket is tied to the end of longer lever arm with a rope in such a way that it hangs over the mouth of the well. A weight is tied to the end of shorter lever arm. In order to lift water from the well, the end of longer lever arm carrying the bucket is pulled down by the rope. When the bucket is lowered into the well, it gets filled with water. On releasing the rope, the weight attached to the end of shorter lever arm comes down and lifts the water-filled bucket out of the well. The farmer then gets hold of the bucket, tilts it and pours out its water into the field. This process is repeated so as to get a large amount of water from the well required for irrigation.

**Rahat (lever system).** In the rahat system of irrigation, water is drawn out from a well. In this method, there is a large wheel fixed on an axle above the mouth of the well (see Figure 17). A long belt with many, many small metal pots is put over the circumference of big wheel which can move over the wheel when the wheel turns. The lower end of the long belt of pots dips in the water of the well. The big wheel is turned by using a lever system driven by the force of bullocks (or other animals such as buffalo or camel). When the bullocks move the long, horizontal handle of the lever-system by
going round and round, the big wheel fixed over the mouth of well starts rotating. When the wheel rotates, the water filled pots come out of the well one after the other, go over the wheel, come downward, pour water in a channel, get emptied and then go down again into the well to bring out more water (see Figure 17). The water brought out by the pots connected to a continuously rotating belt is used for irrigation in the fields.

**The Use of Pumps For Irrigation**

The human labour or cattles are used to lift water in the traditional methods of irrigation. So, the traditional methods of irrigation are cheaper but less efficient. The traditional methods of irrigation are not used much these days. These days, pumps are commonly used for lifting water (from wells, ponds, lakes, streams and rivers). These pumps are run by electricity, diesel, biogas or solar energy. When a pump is used to draw out water from a narrow well, it is called a tube-well. Nowadays, tube-wells are being used increasingly for lifting underground water to be used for irrigation in agriculture (see Figure 18). We will now describe some modern methods of irrigation in which though the water is pumped out through tube-wells but used in such a way that its wastage is prevented.

**Modern Methods of Irrigation**

The modern methods of irrigation help us to use water economically (by preventing its wastage). The two main modern methods of irrigation are :

(i) **Sprinkler system**, and

(ii) **Drip system**.

**SPRINKLER SYSTEM.** In the sprinkler system of irrigation, a main pipeline is laid in the fields. Perpendicular pipes having rotating nozzles at the top are joined to the main pipeline at regular intervals. When water from a tube-well is allowed to flow through the main pipeline under pressure with the help of a pump, it escapes from the rotating nozzles (see Figure 19). This water gets sprinkled on the crop plants as if it is raining. The sprinkler system of irrigation is more useful for the **uneven land** where sufficient water is not available. The sprinkler system is also very useful for **sandy soil**.

![Figure 18. Tube-well.](image18)

![Figure 19. Sprinkler system of irrigation.](image19)

![Figure 20. Drip irrigation system.](image20)
DRIP SYSTEM. In the drip irrigation system, there is a network of narrow pipes (or tubes) with small holes, in the fields (see Figure 20). When water flows through the narrow pipes, it falls drop by drop at the position of roots of the plants. This water is absorbed by the soil in the root zone of the plants and utilised by the plants. There is no run-off (or wastage) of irrigation water. Drip system is the best technique for watering (or irrigating) fruit plants, trees and gardens. Drip irrigation system has the following advantages:

(i) Drip system provides water to plants drop by drop. So, water is not wasted at all.
(ii) Drip system minimises the use of water in agriculture. So, drip system of irrigation is very useful in those regions where the availability of water is poor.

We will now discuss the removal of weeds from crop fields.

5. REMOVING THE WEEDS (OR WEEDING)

When we grow a food crop in the field, then in addition to the crop plants, many small, unwanted plants also germinate and grow in the field naturally. The unwanted plants (or wild plants) which grow alongwith a cultivated crop are called weeds (see Figure 21). The growth of weeds in the fields is harmful because they consume a lot of fertiliser, water, sunlight and space, meant for the crop plants and reduce the crop yield, and lower the quality of food grains. Since the presence of weeds in the fields will reduce the crop-yield, therefore, it is necessary to remove them from time to time. Though most of the weeds get uprooted during the ploughing of fields but they reappear when the crop grows. The weeds multiply and spread very fast because they produce a large quantity of seeds.

The type of weeds vary from field to field, from crop to crop, and also from season to season. Some of the common weeds (unwanted plants) found in wheat and rice fields are:

(i) Wild oat (Javi)
(ii) Grass (Ghass)
(iii) Amaranthus (Chaulai)
(iv) Chenopodium (Bathua)

Since weeds are harmful to the crops, they must be removed from the fields. The process of removing weeds (unwanted plants) from a crop field is called weeding. Weeding is necessary because weeds compete with crop plants for water, nutrients, light and space, and hence affect the growth of the crop. Some weeds are poisonous for human beings and animals whereas some weeds interfere in harvesting. The best time for the removal of weeds is before they produce flowers and seeds. Weeding is done by hand or with the help of implements like trowel (khurpa). Weeds can also be destroyed (or controlled) by spraying special chemicals called weedicides in the crop fields. Thus, the various methods of weeding (controlling weeds or eradicating weeds) are as follows:

1. Removal of Weeds by Pulling Them Out With Hand. Weeds can be removed from the crop fields just by pulling them up with hands (see Figure 22). When we pull the weeds, they get uprooted from the field. These uprooted weeds can then be thrown away.

2. Removal of Weeds by Using a Trowel (Khurpa). Weeds can be removed by digging or cutting them close to the ground from time to time with the help of an implement called trowel (or khurpa). A trowel (or khurpa) is shown in Figure 23.
3. **Destroying the Weeds by Spraying Special Chemicals Called Weedicides.** The poisonous chemicals which are used to kill weeds (unwanted plants) in the fields are called weedicides. Some of the common weedicides are: **2,4-D, MCPA and Butachlor.** A solution of the weedicide in water is sprayed on the standing crops in the fields with a sprayer (see Figure 24). The weedicides kill (destroy) the weeds (unwanted plants) but do not damage the main crop. The weedicides are sprayed in the crop fields before the flowering and seed formation in the weeds takes place. Since weedicides are poisonous chemicals, therefore, spraying of weedicides may affect the health of the person who handles the weedicide sprayer. The weedicides should be sprayed on the standing crops very carefully. During the spraying of weedicides, the person should cover his nose and mouth properly with a piece of cloth (so as to prevent the inhaling of poisonous weedicide).

6. **HARVESTING**

It normally takes about three or four months for a food crop to mature. Lush green wheat fields and paddy fields turn to golden yellow at the end of this period (see Figure 25). This change in colour from green to golden is due to the maturity of crop or ripening of crop. Once the crop has matured then it is ready for cutting and gathering. **The cutting and gathering of the matured food crop is called harvesting.** In harvesting, the crops like wheat or rice are cut close to the ground by hand using a cutting tool called sickle (see Figure 26). This is called manual harvesting. In large fields, wheat and paddy crops are cut by a motorised machine called harvester.

After harvesting the crop, the next step is threshing. **The process of beating out the grains from the harvested crop plants is called threshing.** Threshing is done to take out the grain from its outer covering called chaff. In the traditional method of threshing, the harvested crop is spread on the ground in a small
area and various cattle like bullocks, buffaloes and camels are made to walk over it again and again in a
circle. The cattle’s feet crush the harvested crop plants due to which the chaff breaks up and the grain
comes out. During threshing, the leaves and stems of the crop plants are converted into very small pieces
called hay which is used as a fodder for animals. In larger farms, a motorised machine called thresher is
also used for the threshing process.

Though the process of threshing brings out grains from the cut and dried crop plants, but this grain is
mixed with chaff (outer inedible covering of grain) and hay, and has to be cleaned by separating from chaff
and hay, before it can be used. This is done by the process of winnowing. The process of separating grain
from chaff and hay with the help of wind is called winnowing. When the grain mixed with chaff and hay is
made to fall from a height in blowing wind, the grain, being heavy, falls straight to the ground, whereas the
chaff and hay, being much lighter, are carried some distance away by the wind. In this way, the grains form a
separate heap and can be collected and packed in gunny bags.

These days ‘combines’ (also called combine harvesters) are being used in large farms for harvesting
related operations (see Figure 27). A combine is a huge machine which cuts the standing cereal crop (like
wheat) in the fields, threshes it and separates the chaff from grain in one operation. This grain is clean and can
be directly filled in gunny bags (and there is no need of winnowing). One of the disadvantages of using the
machines like ‘combines’ is that it reduces the yield of hay (bhooosa) which is used as a fodder for cattle. This
is because the combines cut only the upper part of the standing crop, and not from near the ground.

The stubs of crop plants left in the fields after harvesting are sometimes burnt by the farmers. The
burning of stubs is harmful due to two reasons:

(i) The burning of stubs of crop plants in the fields causes air pollution.
(ii) The burning of stubs in the fields may cause accidental fire to the harvested crop lying in the fields
and damage it.

Harvest Festivals. When the crops mature and become ready to be harvested, the fields turn golden
yellow. The sight of golden fields of standing crops, laden with grains, fills the hearts of farmers with joy.
The period of harvest is of great joy and happiness in all the parts of India. Men and women celebrate the
harvest season in the form of festivals. The special festivals in India associated with the harvest seasons
are : Pongal, Baisakhi, Holi, Nabanya, and Bihu. We will now discuss the storage of food grains.

7. STORAGE OF FOOD GRAINS

The fresh food grains (like wheat) obtained by the harvesting of
crops contain more moisture than required for their safe storage. So, the food grains (like wheat) obtained by harvesting the crops are
dried in the sunshine before storing, to reduce their moisture. It is
necessary to reduce the moisture content of grains before storing to
prevent their spoilage during storage. This is because the higher
moisture content in food grains promotes the growth of fungus and
moulds on the stored grains which damages them (and makes them
lose their germination capacity). The farmers store the dried food
grain at home in metal bins (metal drums) and jute bags (called
gunny bags). Dried neem leaves are used for storing food grains at
home. For example, when wheat is stored at home in iron drums,
then some dried neem leaves are put in it. Dry neem leaves protect the stored food grains from pests such as insects and micro-organisms.

The Government Agencies like Food Corporation of India (FCI) buy grains from farmers on large scale and store it in big godowns so that it can be supplied throughout the country, round the year. **The large scale storage of food grains (like wheat and rice) is done in two ways:**

(i) in gunny bags, and
(ii) in grain silos.

The most common method of storing food grains on a large scale is to fill them in gunny bags, stitch the mouth of gunny bags tightly, and keep these gunny bags one over the other in big godowns (see Figure 29). Pesticide solutions are sprayed on the stacked gunny bags in the godown from time to time to protect the grains from damage by pests during storage. The population of rats in the godown is also controlled by killing them with rat poison from time to time. Though a gunny bag is not an ideal container for food grains but its greatest advantage is that food grains filled in gunny bags can be easily transported and distributed at various places.

In addition to the gunny-bag method of storing food grains, the grain-silos are also used for storing food grains on large scale (or bulk storage of food grains). The grain-silos are specially designed big and tall cylindrical structures (see Figure 30). The grain-silos have inbuilt arrangements for the protection of stored food grains from pests (like insects) and micro-organisms.

**FOOD FROM ANIMALS**

Though we get most of our food from crop plants, animals also provide us food. The food provided by animals consists of **Milk, Eggs and Meat**. The food obtained from animals is very rich in proteins. In fact, animal food provides certain proteins which are not present in plant foods. Most of the food obtained from animals also contains a good amount of fat but it contains very little of carbohydrates. Animal food, however, contains minerals and vitamins. The food obtained from animals is more expensive than that obtained from plant sources. The animals which provide us food are mainly of two types:

1. Milk yielding animals (or Milch animals), and
2. Meat and Egg yielding animals.

The examples of milk yielding animals (or milch animals) are: Cow, Buffalo and Goat. Milk is a perfect natural diet. Milk and its products (called dairy products) like Butter, Ghee, Curd and Cheese are highly nutritious foods. The examples of meat and egg yielding animals are: Goat, Sheep, Fish, and...
Poultry (Chicken, Hen and Duck). Out of these animals, goat, sheep and fish give us meat. **Poultry gives us meat as well as eggs.** Honey is another nutritious food obtained from animals. It is obtained from insects called ‘bees’ (or honeybees).

**Animal Husbandry**

Just as each crop has its own requirements of proper soil, irrigation, manures and fertilisers and weedicides, in the same way, each domestic animal has its own needs of food, shelter, and health care. **The branch of agriculture which deals with the feeding, shelter, health and breeding of domestic animals is called animal husbandry.** The various practices necessary for raising animals for food and other purposes (or the elements of animal husbandry) are:

1. Proper feeding of animals,
2. Proper shelter for animals,
3. Prevention and cure of animal diseases, and
4. Proper breeding of animals.

Milk giving animals (milch animals or milch cattle) like cows and buffaloes are reared on small scale in rural homes. On a large scale, they are reared in big dairy farms.

**Fish as Food**

Fish is an important source of animal food. Many people living in the coastal areas (sea-side areas) consume fish as a major part of their diet. Fish is rich in proteins. It is a highly nutritious and easily digestible food. Fish liver oil is rich in vitamin A and vitamin D. For example, Cod liver oil (or Cod fish liver oil) is rich in vitamin A and vitamin D. We are now in a position to answer the following questions:

**Very Short Answer Type Questions**

1. Which agricultural practice is carried out with the help of a sickle?
2. What name is given to the cutting and gathering of a food crop like wheat or paddy?
3. Name the tool (or implement) used in the traditional harvesting of crops.
4. Name the process of beating out the grains from harvested crop.
5. Name the machine used in recovering the grain from already cut crop.
6. Name the machine which does the cutting of standing crops and recovers the grain too.
7. Name the process in which grains are separated from chaff and hay with the help of wind.
8. Name three food materials obtained from animals.
9. Name two domestic animals which are used to obtain milk.
10. Name one meat yielding animal and one egg yielding animal.
11. Name an animal food obtained from insects.
12. What name is given to that branch of agriculture which deals with feeding, shelter, health and breeding of domestic animals?
13. Name the major food nutrient provided by fish.
14. Name the vitamin/vitamins present in cod liver oil.
15. Name one Government Agency which is involved in procuring food grains (like wheat and rice) from farmers and storing them properly.
16. What type of organisms grow on stored food grains having higher moisture content?
17. Which crop is generally grown between two cereal crops in crop rotation to restore the fertility of soil?
18. State one advantage of growing a leguminous crop between two cereal crops.
19. Name the nitrogen-fixing bacteria present in root nodules of leguminous plants.
20. Which agricultural practice comes first: harvesting or weeding?
21. Which is the first step in the cultivation of a crop?
22. For what purpose is a hoe used?
23. Name the implement used in sowing.
24. Name the practice used for cultivating paddy.
25. Name the two types of substances which are added to the fields by the farmers to maintain the fertility of soil.
26. Some grass is growing in a wheat field. What will it be known as?
27. Name one crop which can tolerate standing water (water-logging) in the field and one which cannot.
28. Which is the best time for the removal of weeds?
29. Name two types of substances which are added to the fields by the farmers to maintain the fertility of soil.
30. Fill in the following blanks with suitable words:
   (a) The same kind of plants grown and cultivated on a large scale at a place is called ............
   (b) The first step before growing crops is ............... of soil.
   (c) For growing a crop, sufficient sunlight, ..........., and ............ from the soil are essential.
   (d) Damaged seeds would ............... on top of water.
   (e) Crop rotation helps in the replenishment of soil with ............
   (f) The supply of water to crops at different intervals is called ............
   (g) The unwanted plants present in a crop field are called ............
   (h) Dried .............. leaves are used for storing food grains at home.
   (i) Many people living in the ............... areas consume fish as a major part of their diet.

**Short Answer Type Questions**

31. (a) Why is it necessary to dry the harvested food grains before storage?
   (b) What are the two ways in which farmers store food grains?
32. Out of drip system and sprinkler system of irrigation, which one is more suitable:
   (a) for uneven land?
   (b) for sandy soil?
   (c) for watering fruit plants?
   (d) where availability of water is poor?
33. (a) What are weeds? Name any one weed found in a crop field.
   (b) How do weeds affect the growth of crops?
34. Explain how, the irrigation requirements depend on the nature of the crop.
35. Explain how, the irrigation requirements of a crop depend on the nature of soil in which the crop is grown.
36. Describe the sprinkler system of irrigation. State its advantages.
37. Explain the drip system of irrigation. State two advantages of the drip system of irrigation.
38. How do the irrigation requirements of a wheat crop differ from that of a paddy crop?
39. Explain why, the frequency of irrigation of crops is higher in summer season.
40. How are weeds removed from the crop fields? Name one implement used for weeding.
41. If wheat is sown in the kharif season, what would happen? Discuss.
42. Which of the following are kharif crops and which are rabi crops?
   - Wheat, Paddy, Gram, Maize, Mustard, Cotton, Soyabean, Linseed, Peas, Groundnut
43. What is a crop? Give two examples of crops.
44. What are the two types of crops based on seasons? Give one example of each type.
45. Name the various agricultural practices in the right sequence in which they are undertaken by the farmers.
46. Describe briefly, how soil is prepared for sowing the seeds.
47. Why do farmers carry out levelling of the ploughed fields?
48. What are the advantages of sowing seeds with a seed drill?
49. Explain why, the seeds should be sown at right spacings.
50. What is ploughing (or tilling)? Name any two implements used for tilling the fields.
51. State two beneficial effects of ploughing the fields (or loosening and turning the soil).
52. (a) State the function of Food Corporation of India.
   (b) What is done to protect the grains stored in gunny bags in big godowns from damage?
53. Define manure. What are the advantages of manure?
54. What is a fertiliser? Name any two fertilisers. State two harmful effects caused by the excessive use of fertilisers.
55. Explain how, soil gets affected by the repeated growing of crops in the same fields. How does use of fertilisers help the farmers?
56. What is weeding? Why is weeding necessary?
57. What are weedicides? Name one weedicide.
58. What precaution should be taken while spraying weedicides? Why?
59. Give any four differences between manures and fertilisers.
60. Define the terms: (i) harvesting, (ii) threshing, and (iii) winnowing.

61. (a) What are the two ways in which food grains are stored on a large scale?
   (b) What is the advantage of storing food grains in gunny bags?

62. Name two traditional methods of irrigation and two modern methods of irrigation.

63. What is a ‘combine’ which is used in agriculture? State its functions.

64. What is ‘animal husbandry’?

65. What are the various practices necessary for raising animals for food and other purposes?

**Long Answer Type Questions**

66. (a) What is meant by kharif crops? Give two examples of kharif crops.
   (b) What is meant by rabi crops? Give two examples of rabi crops.

67. (a) What is meant by ‘sowing’? What are the various methods of sowing the seeds?
   (b) What precautions should be taken in sowing the seeds?

68. What are good quality seeds? You are given a sample of wheat seeds. How will you select good, healthy seeds for sowing?

69. (a) What is the process of ‘transplantation’ in agriculture? Give examples of two crops which are usually grown by this process.
   (b) State two advantages of the process of transplantation in growing crops.

70. (a) What is irrigation? Why is irrigation necessary?
   (b) Name the various sources of irrigation in our country.

**Multiple Choice Questions (MCQs)**

71. Which of the following crops would enrich the soil with nitrogen?
   (a) apple (b) pea (c) paddy (d) potato

72. Which of the following is not a kharif crop?
   (a) paddy (b) mustard (c) maize (d) groundnut

73. In agriculture, broadcasting is used for:
   (a) ploughing the fields (b) rotating the crops (c) removing the weeds (d) sowing the seeds

74. Fish liver oil is rich in:
   A. Vitamin A  B. Vitamin B  C. Vitamin C  D. Vitamin D
   (a) A and B (b) B and C (c) A and D (d) only D

75. Which of the following is not grown by transplantation?
   (a) chillies (b) tomatoes (c) peas (d) paddy

76. Which of the following is not a rabi crop?
   (a) soyabean (b) peas (c) wheat (d) linseed

77. One of the following crop is not cultivated by sowing its seeds directly into soil. This one is:
   (a) wheat (b) gram (chana) (c) paddy (d) maize (makka)

78. Tomatoes are cultivated by the practice called:
   (a) transpiration (b) translocation (c) transportation (d) transplantation

79. Which of the following cannot be provided to the soil by a chemical fertiliser?
   (a) nitrogen (b) humus (c) potassium (d) phosphorus

80. Which of the following is not grown by transplantation?
   (a) chillies (b) tomatoes (c) paddy (d) papaya

81. The *Rhizobium* bacteria present in the root nodules of pea plants can fix one of the following from the atmosphere. This one is:
   (a) hydrogen (b) oxygen (c) nitrogen (d) halogen

82. The process of beating out grains from the harvested wheat crop is called:
   (a) beating (b) crushing (c) threshing (d) weeding

83. The food obtained from animals is very rich in:
   (a) fats (b) carbohydrates (c) minerals (d) proteins

84. The Government Agency responsible for purchasing grains from the farmers, safe storage and distribution is:
   (a) CBI (b) FBI (c) FCI (d) FDI

85. The process of removing unwanted plants from a crop field is called:
   (a) breeding (b) weeding (c) transplanting (d) harvesting

86. Poultry gives us:
   (a) eggs (b) meat (c) meat as well as eggs (d) honey
87. Which of the following is not a correct statement for sowing seeds?

(a) seeds should be sown at right intervals
(b) seeds should be sown at right depth
(c) seeds should be sown in dry soil
(d) seeds should not be sown in highly wet soil

88. Which of the following system of irrigation is preferred for the uneven land?

(a) chain pump irrigation system
(b) sprinkler irrigation system
(c) drip irrigation system
(d) river irrigation system

89. The two crops which are not grown by sowing their seeds directly into the soil in large fields are:

A. Peas  B. Tomatoes  C. Chillies  D. Maize

(a) A and B  (b) B and C  (c) A and C  (d) only C

90. The best technique of watering the fruit plants and trees is:

(a) chain pump system  (b) sprinkler system  (c) moat (pulley system)  (d) drip system

Questions Based on High Order Thinking Skills (HOTS)

91. Arrange the following practices in the correct order as they appear in the sugarcane crop production:

Sending crop to sugar factory; Irrigation; Harvesting; Sowing; Preparation of soil; Ploughing the field; Manuring.

92. Match items in column A with those in column B:

A  

(i) Kharif crops  (a) Food for cattle
(ii) Rabi crops  (b) Urea and superphosphate
(iii) Chemical fertilisers  (c) Animal excreta, cow-dung, and plant waste
(iv) Organic manure  (d) Wheat, gram, pea
  
B  

(e) Paddy and maize

93. Name two crops which are cultivated:

(a) by sowing seeds directly into fields.
(b) by transplanting.

94. Farmers in Northern India grow legumes as fodder in one season and wheat in the next season.

(a) What is this practice known as?
(b) How does this practice help in the replenishment of soil?

95. A student lists the following agricultural practices for crop production:

Irrigation; Removal of weeds; Preparation of soil; Storage of food grains; Sowing; Adding manure and fertilisers

Which agricultural practice is missing from the above list?

ANSWERS

20. Weeding  26. Weed  30. (a) crop (b) preparation (c) nutrients; water (d) float (e) nitrogen (f) irrigation

21. (g) weeds (h) neem (i) coastal  32. (a) Sprinkler system (b) Sprinkler system (c) Drip system (d) Drip system

71. (b) 72. (b) 73. (d) 74. (c) 75. (c) 76. (a) 77. (c) 78. (d) 79. (b) 80. (d) 81. (c) 82. (c) 83. (d) 84. (c)

85. (b) 86. (c) 87. (c) 88. (c) 89. (b) 90. (d) 91. Ploughing the field; Preparation of soil; Sowing; Manuring; Irrigation; Harvesting; Sending crop to sugar factory  92. (i) e (ii) d (iii) b (iv) c  93. (a) Wheat; Gram (b) Paddy; Tomatoes  94. (a) Crop rotation  (b) The Rhizobium bacteria present in the root nodules of legumes fix the nitrogen gas of the atmosphere to form nitrogen compounds. Some of these nitrogen compounds go into the soil and replenish it  95. Harvesting

Soil preparation and sowing

Harvesting and storage of food grains
Many living organisms are present in soil, water, and air around us. Some of these organisms are so small that we cannot see them with naked eyes. We need a magnifying instrument called microscope to see these extremely small organisms. These extremely small organisms are known as micro-organisms (micro = extremely small). We can now say that: Those organisms which are too small to be seen without a microscope are called micro-organisms. Thus, micro-organisms cannot be seen with the naked eye. Micro-organisms can be seen only with the help of a microscope.

Though we cannot see the micro-organisms around us, we become aware of the presence of micro-organisms through their actions like spoiling our food and causing diseases. Thus, some of the micro-organisms are harmful to us. The micro-organisms like certain bacteria and fungi make our food go bad. The micro-organisms also cause diseases in humans, other animals and plants. The diseases like common cold, malaria, skin infections, typhoid, tuberculosis, tetanus, cholera, measles, chickenpox, smallpox and AIDS, etc., are all caused by the action of various types of micro-organisms. Some of the micro-organisms grow on our food and cause food poisoning.

Some of the micro-organisms are also useful to us. For example, the micro-organisms like certain bacteria help in making food products such as curd and cheese. Micro-organisms are also useful in making bread, cakes, pastries, alcohol, acetic acid (vinegar) and medicines called antibiotics. Some micro-organisms decompose the organic waste of dead plants and animals into simple substances and clean up the environment. They also help in recycling the materials (like carbon and nitrogen) in nature.

Major Groups of Micro-Organisms

Micro-organisms are classified into five major groups. These groups are: Bacteria, Viruses, Protozoa, and some Fungi and Algae. Micro-organisms may be unicellular (single celled) or multicellular (many-celled). Please note that the singular of bacteria is bacterium; the singular of viruses is virus; the
singular of protozoa is protozoan; the singular of fungi is fungus; and the singular of algae is alga. We will now describe the various types of micro-organisms very briefly.

1. Bacteria

Bacteria are very small, single-celled micro-organisms which have cell walls but do not have an organised nucleus and other structures (see Figure 1). Bacteria are found in large numbers everywhere: in air; soil and water; every surface around us; on our bodies and even inside our bodies. Bacteria are larger than viruses but still very small. Unlike viruses, bacteria feed, move and respire, as well as reproduce on their own. There are mainly three groups of bacteria on the basis of their shape: spherical bacteria, rod-shaped bacteria and spiral bacteria. The two common examples of bacteria are Lactobacillus bacteria and Rhizobium bacteria. Some of the bacteria are useful and help in making foods (like curd), nitrogen fixation and decomposition of waste organic matter. On the other hand, some of the bacteria cause diseases. Some of the human diseases caused by bacteria are cholera, typhoid, tuberculosis (TB), diphtheria, whooping cough and food poisoning.

2. Viruses

Viruses are the smallest micro-organisms which can develop only inside the cells of the host organisms (which may be animal, plant or bacterium). Viruses are much smaller than bacteria (see Figure 2). Viruses do not show most of the characteristics of living things. For example, viruses do not respire, feed, grow, excrete, or move on their own. They just reproduce. Viruses are able to reproduce if they enter a living cell. That is, viruses can reproduce and multiply only inside the cells of other organisms (such as animal cells, plant cells or bacteria cells). Thus, as long as viruses are outside the living cells, they behave as non-living things. But as soon as the viruses enter the living cells of other organisms, they start behaving as living things by carrying out the process of reproduction. Due to this reason, viruses are said to lie on the border line dividing the living things from non-living things. Viruses are the agents of disease. Viruses cause a variety of diseases in human beings, other animals and plants. The human diseases such as common cold, influenza (flu), measles, polio, chickenpox, and smallpox are all caused by viruses. The two examples of viruses are ‘common cold virus’ and ‘Human Immunodeficiency Virus’ (HIV). Common cold virus causes common cold disease whereas HIV causes AIDS disease (AIDS stands for Acquired Immune Deficiency Syndrome). Diseases caused by virus (or viral diseases) cannot be treated with antibiotics.

3. Protozoa

Protozoa are a group of single-celled micro-organisms which are classified as animals. Protozoa are animal like just as algae are plant like. Protozoa are found in ponds, lakes, dirty water drains, rivers, seawater and damp soil. Some common examples of protozoa are: Amoeba, Paramecium, Entamoeba and Plasmodium. A few protozoa are shown in Figure 3. Many protozoa are parasites and cause diseases. Diseases like dysentery and malaria are caused by protozoa. For example, Entamoeba is a protozoan which causes a disease known as amoebic dysentery.
And *Plasmodium* is a protozoan which causes a disease called malaria in humans. *Plasmodium* is commonly known as ‘Malarial Parasite’ (MP).

4. Algae

Algae is a large group of simple, plant-like organisms. They 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. Some of the examples of algae are: *Chlamydomonas*, *Spirogyra*, Blue-green algae; Diatoms and Seaweeds (see Figure 4). Only some of the algae are unicellular. Most of the algae are multicellular. For example, *Chlamydomonas* and diatoms are single-celled algae whereas blue-green algae and *Spirogyra* are multicellular algae. The blue-green algae have the ability to fix nitrogen gas of atmosphere.

5. Fungi

Fungi are a large group of organisms which do not have chlorophyll and do not photosynthesise. Some examples of fungi are: Yeast, Moulds (such as Bread mould, *Penicillium* and *Aspergillus*), Mushrooms, Toadstools and Puffballs (see Figure 5). All fungi (except yeast) are made up of fine threads called hyphae (pronounced as hi-fee). Some fungi look like plants but they cannot make their own food like the plants do. Fungi need moist and warm conditions to grow. Most of the fungi are saprophytes which feed on dead things like remains of dead plants and animals. Some of the fungi are parasites. They feed on living things and cause diseases. A mould is a fur-like growth of minute fungi occurring on organic matter in moist and warm conditions. Some of the examples of mould fungi are: *Rhizopus* (Bread mould), *Penicillium* and *Aspergillus*. The fungi like yeast and moulds are very small in size and can be seen clearly only with a microscope. Thus, yeast and moulds are the fungi which can be considered to be micro-organisms. The fungi such as mushrooms, toadstools and puffballs are bigger in size. Some of the human diseases caused by fungi are ringworm and athlete’s foot.

**Where Do Micro-Organisms Live**

Micro-organisms are found practically everywhere in all types of habitats. Micro-organisms are found in air, soil and water bodies (like ponds, lakes, wells, rivers and sea). Micro-organisms can live and survive in almost all kinds of environment like hot springs, ice-cold waters, saline water (salty water), desert soil or marshy land. They also occur in dead and decomposed organic matter (plant and animal matter). Micro-organisms are present inside the human body and that of other animals. The micro-organisms also live as parasites on other living things, including us.
We can show the presence of micro-organisms in soil and water by performing the following activities:

(i) Collect some moist soil from the field in a beaker and add water to it. After the soil particles have settled down, observe a drop of water from the beaker under a microscope. We will see tiny organisms moving around. This observation shows that soil contains micro-organisms.

(ii) Take a few drops of water from a pond. Spread this water on a clean glass slide and observe through a microscope. We will see some tiny organisms moving around. This observation shows that pond water contains micro-organisms.

We will now discuss the useful and harmful micro-organisms in detail.

**MICRO-ORGANISMS AND US**

Initially it was thought that all the micro-organisms are harmful and cause diseases. Later on scientists discovered that only a handful of micro-organisms are harmful and cause diseases. Most of the micro-organisms are harmless and some of the micro-organisms are even beneficial to us (or useful to us). Micro-organisms play an important role in our lives. We will now describe the beneficial effects and harmful effects of micro-organisms in detail, one by one.

**FRIENDLY MICRO-ORGANISMS (OR USEFUL MICRO-ORGANISMS)**

Micro-organisms are used for various purposes by human beings as well as in nature. Some of the beneficial effects (or uses) of micro-organisms are as follows:

(i) Micro-organisms are utilised in the making of curd, bread and cake.
(ii) Micro-organisms are used in the production of alcohol, wine and acetic acid (vinegar).
(iii) Micro-organisms are used in the preparation of medicines (or drugs) called antibiotics.
(iv) Micro-organisms are used in agriculture to increase the fertility of soil by fixing atmospheric nitrogen gas (to form nitrogen compounds).
(v) Micro-organisms clean up the environment by decomposing the organic matter of dead plants, dead animals and animal wastes into harmless and useful simple substances. In this way, micro-organisms help in the recycling of materials in nature.

We will now study the beneficial effects (or uses) of micro-organisms in somewhat detail.

1. Making of Curd

Milk is turned into curd by bacteria. In order to make curd, a little pre-made curd is added to warm milk and set aside for some time. Curd contains several micro-organisms including *Lactobacillus* bacterium (Plural of *Lactobacillus* is *Lactobacilli*). *Lactobacilli* bacteria promote the formation of curd from milk. When a little of pre-made curd is added to warm milk, then *Lactobacilli* bacteria present in curd multiply in milk and convert it into curd. This happens as follows: Milk contains a sugar called lactose. *Lactobacilli* bacteria convert the lactose sugar into lactic acid. This lactic acid then converts milk into curd. We can now say that the micro-organism utilised in making curd from milk is bacterium (or bacteria). The name of this bacterium is *Lactobacillus*. An important ingredient of *idlis* and *bhaturas* is curd. Curd is added in making *idlis* and *bhaturas* to make them soft and spongy. Bacteria are also involved in the making of cheese, pickles, and many other food items.

2. Making of Bread

Yeast is used in the baking industry for making bread. When yeast is mixed in dough for making bread, the yeast reproduces rapidly and gives out carbon dioxide gas during respiration. The figure: The micro-organism ‘yeast’ is used to make bread.
bubbles of carbon dioxide gas fill the dough and increase its volume. This makes the bread ‘rise’. The holes in the bread are due to the bubbles of carbon dioxide given off during the baking process (see Figure 6). This makes the bread light, soft and spongy. For the same reason, yeast is also used in making cakes and pastries. We can perform an activity to demonstrate the action of yeast in the making of bread as follows.

**ACTIVITY**

Take half a kilogram of white flour (maida), add some sugar and mix with warm water. Then add a small amount of yeast powder and knead the mixture of white flour, sugar, yeast powder and water to make a soft dough [see Figure 7(a)]. Keep this dough aside for about 2 hours. We will find that the volume of dough has increased [see Figure 7(b)]. We say that the dough rises. From this discussion we conclude that yeast is the micro-organism used in making bread, cakes and pastries. Yeast is a fungus.

3. Commercial Use of Micro-Organisms

Micro-organisms are used for the large scale production of alcohol and acetic acid (vinegar). Yeast is the micro-organism which is used for the large scale production of alcohol. This alcohol is then used in making wine, beer and whisky as well as industrial spirit. So, we can now say that yeast is used to produce alcoholic drinks (such as wine, beer, whisky, etc.) and industrial spirit. Yeast is capable of converting sugar into alcohol (and carbon dioxide). The sugar for making alcohol comes from substances such as cane juice and fruit juices, or from substances such as barley, maize, rice, etc. (that contain starch which gets converted into sugar). The process of conversion of sugar into alcohol by the action of yeast is called fermentation. Fermentation was discovered by Louis Pasteur in 1857. In order to make alcohol, yeast is grown on natural sugars present in grains like barley, maize, rice, cane juice and fruit juices, etc. Yeast converts sugar into alcohol. This alcohol is then used for various purposes. We can carry out the process of alcoholic fermentation in the laboratory as follows.

**ACTIVITY**

Take a 500 mL beaker and fill it three-fourths with water. Dissolve 2 or 3 teaspoonfuls of sugar in it. Add half a teaspoonful of yeast powder to the sugar solution. Cover the beaker and allow the mixture of sugar solution and yeast powder to stand in a warm place for 4 to 5 hours. Now, smell the solution. We will get a characteristic pleasant smell coming from the beaker. This is the smell of alcohol (because sugar has been converted into alcohol by yeast). Now taste the solution from the beaker. We will get a ‘burning taste’. This burning taste is due to the formation of alcohol.

A dilute solution of acetic acid is called vinegar. Bacteria can turn alcohol into acetic acid (or vinegar). In order to produce acetic acid (or vinegar) on a large scale, first alcohol is made by using yeast. The Acetobacter bacteria are then added to alcohol and air is bubbled through it. In the presence of oxygen (of air), Acetobacter bacteria convert alcohol into acetic acid (or vinegar).
4. Medicinal Use of Micro-Organisms

A medicine which stops the growth of, or kills the disease-causing micro-organisms is called an antibiotic. **The source of antibiotic medicines are micro-organisms.** The antibiotics are manufactured by growing specific micro-organisms (and used to cure a number of diseases). These days, a large number of antibiotics are being produced from micro-organisms such as fungi and bacteria. **Some of the common antibiotics which are made from fungi and bacteria are: Penicillin, Streptomycin, Erythromycin and Tetracycline.** Nowadays, many antibiotics are also being made synthetically. Many different antibiotics are now available to treat a wide variety of diseases caused by pathogenic micro-organisms. Antibiotics kill the disease-causing micro-organisms but usually do not damage human body cells.

The first antibiotic ‘penicillin’ was discovered by chance and extracted from the tiny fungus (a mould) called ‘*Penicillium*’. This happened as follows: In 1929, Alexander Fleming was cultivating a culture of disease-causing bacteria. Suddenly he found the spores of a little green ‘fungus’ in one of his culture plates. He noticed that the presence of tiny green fungus stopped the growth of disease-causing bacteria. In fact, it also killed many of the disease-causing bacteria. From this fungus (or mould) called ‘*Penicillium*’, the antibiotic penicillin was made. Thus, penicillin is an antibiotic medicine which is made from the fungus ‘*Penicillium*’. Penicillin controls bacterial and fungal infections.

**Antibiotics are used to treat many diseases in humans.** Whenever we fall ill, the doctor may give us some antibiotic tablets, capsules or injections (such as penicillin) (see Figure 8). Antibiotics are very effective in curing diseases caused by micro-organisms such as bacteria and fungi. **Antibiotics are, however, not effective against diseases caused by viruses.** For example, antibiotics cannot be used to cure diseases like ‘common cold’, ‘flu’, and ‘viral fever’ because these are caused by viruses. **Some precautions to be observed in the use of antibiotics are as follows:**

(i) Antibiotics should be taken only on the advice of a qualified doctor.

(ii) A person must complete the ‘full course’ of antibiotics prescribed by the doctor.

(iii) The antibiotics should be taken in proper doses as advised by the doctor. If a person takes antibiotics in wrong doses (or when not needed), it may make the antibiotics less effective when the person might need it in future.

(iv) Antibiotics should not be taken unnecessarily. Antibiotics taken unnecessarily may kill the useful bacteria in the body and harm us.

**Antibiotics can be used to treat many diseases in animals.** Antibiotics are even mixed with the feed of live stock (cattle like cows, buffaloes, etc.) and poultry birds to control microbial diseases in animals. **Antibiotics are also used to control many plant diseases.**

**Vaccine**

We have just studied that micro-organisms are used to make medicines called antibiotics which can cure many diseases in human beings, animals and plants. Micro-organisms are also used to make vaccines. **A vaccine is a special kind of preparation (or medicine) which provides immunity (or protection) against a particular disease.** Vaccines are given to healthy persons so that they may not get certain diseases throughout their life (even if they are exposed to the pathogens of these diseases later on in life). These days vaccines are made on a large scale from micro-organisms to protect human beings and other animals from several diseases. A vaccine works as follows:

A vaccine contains the dead or weakened but alive micro-organisms of a disease (which are harmless and do not actually give a disease). When the vaccine containing dead or alive micro-organisms is introduced into the body of a healthy person orally (by mouth) or by injection, the body of that person...
responds by producing some substances called ‘antibodies’ in its blood. These antibodies kill any ‘alive’ disease-causing micro-organisms present in the vaccine. Some of the antibodies remain in the blood of the person for a very long time and fight against the same micro-organisms and kill them if they happen to enter the body naturally at a later date (when the person is exposed to disease). So, due to the presence of antibodies in the blood, a person remains protected from that particular disease. Thus, a vaccine develops the immunity from a disease.

A number of diseases can be prevented by vaccination. Vaccination is the process of giving a vaccine orally (by mouth) or by injection which provides protection against a particular disease. For keeping good health, we must prevent the diseases by vaccination at the proper time. Since children are more susceptible to diseases, so all the children should be vaccinated at proper ages to provide them immunity from certain diseases. The diseases which can be prevented by vaccination of children at proper age are: Polio, Smallpox, Cholera, Typhoid, Hepatitis, Tuberculosis (TB), Tetanus, Measles, Rabies, Diphtheria and Pertussis (Whooping cough). To develop the fighting capability in the body to a disease in called ‘immunisation’. After getting vaccinated, the child becomes ‘immune’ to a particular disease. This means that the child becomes protected against that disease. He will never get that disease. Edward Jenner discovered the vaccine for smallpox in 1798. A worldwide campaign against smallpox has finally led to its eradication from most parts of the world. Under the National Health Programme in our country the vaccines for several diseases are given free of cost at all the Government Health Centres. Polio disease is prevented by giving Oral Polio Vaccine (OPV) (see Figure 9). Many times we see advertisements on TV and in newspapers to protect the children from polio under the Pulse Polio Programme by giving them polio drops. The polio drops given to children are actually a vaccine.

5. Increasing Soil Fertility

Some of the micro-organisms present in the soil can fix nitrogen gas from the atmosphere to form nitrogen compounds. These nitrogen compounds mix with the soil and increase the fertility of soil. For example, some bacteria and blue-green algae are able to ‘fix’ nitrogen gas from the atmosphere to enrich the soil with nitrogen compounds and increase its fertility. The nitrogen-fixing bacteria and blue-green algae are called biological nitrogen fixers. The nitrogen-fixing blue-green algae are shown in Figure 10. Since blue-green algae store in them nitrogen compounds made by nitrogen-fixation, they are used as fertiliser in agriculture. The addition of blue-green algae to barren fields increases the nitrogen content of the soil and makes it fertile. Rhizobium bacteria present in the root nodules of leguminous plants (like peas, beans, etc.) also fix atmospheric nitrogen and increase soil fertility.

6. Cleaning the Environment

Some micro-organisms (like certain bacteria and fungi) decompose the organic matter present in dead plants, dead animals and animal wastes, and convert them into simple substances which mix up with the soil. These simple substances contain plant nutrients which are again used by new plants for their growth. Since micro-organisms decompose the harmful and smelly dead remains of plants and animals, and...
animal wastes (like faeces, dung, urine, etc.) into harmless materials, they clean the environment. If, however, there were no micro-organisms (called decomposers) in the soil, then the dead plants, dead animals and animal wastes would keep on piling up in the environment and make it dirty. In addition to cleaning the environment, the micro-organisms also help in recycling the nutrients (present in dead plants, dead animals and animal wastes) in nature which can then be used as food by green plants. If there were no micro-organisms (called decomposers), then the nutrients present in dead plants, dead animals and animal wastes would never be released for use by new plants.

**ACTIVITY**

We will now describe an activity to show that some micro-organisms decompose waste plant materials and convert them into useful manure. Take two flower pots and mark them A and B. Fill each flower pot half with soil. Take some plant wastes such as fruit and vegetable peels, fallen leaves, etc., and bury them in soil in pot A. Bury a polythene bag, an empty glass bottle and a broken plastic toy in the soil in pot B. Keep both the pots aside for 3 to 4 weeks. If we now observe the pot A, we will find that the plant wastes buried in it have been decomposed. The plant wastes (fruit and vegetable peels, fallen leaves, etc.) have been decomposed by the action of micro-organisms present in the soil and converted into manure. This manure contains the nutrients released from plant wastes. These nutrients can be used for growing new plants.

If, however, we look at the pot B, we will find that the polythene bag, glass bottle, and plastic toy did not get decomposed, and remained as such. This is because the micro-organisms present in soil are not able to decompose polythene bag, glass and plastic and convert them into manure. The micro-organisms present in soil can decompose only the organic matter present in dead plants, dead animals and animal wastes, etc.

**HARMFUL MICRO-ORGANISMS**

Micro-organisms can be harmful in many ways. For example, some of the micro-organisms cause diseases in human beings, other animals and plants. Those micro-organisms which cause diseases are called pathogens. Thus, pathogens are disease-causing micro-organisms. Pathogens can be bacteria, viruses, protozoa or fungi, etc. Micro-organisms cause diseases such as tuberculosis (TB), tetanus, diphtheria, whooping cough, cholera, typhoid, AIDS, food poisoning, malaria, smallpox and chickenpox, etc. Some micro-organisms spoil food, clothing and leather objects. We will now study some of the harmful activities of micro-organisms in detail.

**DISEASE-CAUSING MICRO-ORGANISMS IN HUMANS**

Disease-causing micro-organisms (or pathogens) enter our body through the air we breathe, the water we drink, or the food we eat. The disease-causing micro-organisms can also get transmitted by direct contact with an infected person or carried through an insect (or other animal). When pathogens (such as bacteria, viruses, protozoa, fungi, etc.) enter our body, they cause diseases.

A person who has disease-causing micro-organisms (or microbes) in his body is said to be an ‘infected person’. Those microbial diseases which can spread from an infected person to a healthy person through air, water, food or physical contact, etc., are called communicable diseases. In communicable diseases, the disease-causing germs (or infection) get transmitted from a human being, an animal or the environment to another human being. Some of the examples of communicable diseases are: Common cold, Cholera, Chickenpox, Tuberculosis (TB), Malaria, and AIDS. For example, the disease called ‘common cold’...
The disease ‘common cold’ spreads by breathing air containing micro-organisms. This happens as follows: The disease ‘common cold’ is caused by a virus. A person suffering from common cold is infected with ‘common cold virus’. When the person suffering from common cold sneezes, fine droplets of moisture carrying thousands of common cold viruses are spread in the air around him (or her) (see Figure 11). When a healthy person breathes in this contaminated air containing common cold virus, the virus enters his body and he also gets ‘common cold’ disease. The **communicable diseases can occur and spread in the following ways:**

(i) by breathing of air containing micro-organisms,
(ii) by taking infected food or water,
(iii) through insect bites (such as mosquito bites),
(iv) by sharing infected injection needles, and
(v) by physical contact with an infected person (or by using articles of an infected person such as towel, clothes, bed, utensils, etc.).

For example, the common cold disease spreads by breathing air containing micro-organisms; the disease called cholera spreads by taking infected food or water; the disease called malaria spreads through insect bites (mosquito bites); and the disease called AIDS spreads by sharing infected injection needles or through physical contact (sexual contact) with an infected person.

**Prevention of Communicable Diseases**

Some of the methods for preventing the occurrence and spreading of communicable diseases are given below:

(i) A person suffering from common cold should always cover his mouth and nose with a handkerchief while sneezing, so that micro-organisms do not get into the air. We should also keep a safe distance from a person having common cold.

(ii) We should keep our food covered to protect it from getting infected by flies. We should also drink clean and safe water.

(iii) We should protect ourselves from mosquito bites by using mosquito nets over our beds while sleeping, by putting fine wire mesh on doors and windows, or by using mosquito repellent creams and devices.

(iv) We should make sure that only disposable syringes and needles are used for giving us injections.

(v) We should avoid physical contact with an infected person, and not use his towel, clothes or bed. The towel, clothes and utensils used by an infected person should be washed and cleaned separately with soap and hot water.

(vi) Some of the diseases can be prevented by vaccination at proper time.

**Carriers of Disease-Causing Micro-Organisms**

There are some insects in our environment which transfer disease-causing microbes into our body (either by contaminating our food or by biting into our body), and spread diseases. The two most common insects which carry disease-causing micro-organisms (microbes or pathogens) are the housefly and mosquito. The **insect (or other animal) which transmits disease-causing micro-organisms to humans (without itself suffering from them) is called a ‘carrier’**. We can now say that there are some insects which act as carriers of disease-causing micro-organisms. The two most common carriers of disease-causing micro-organisms (or microbes) are:

(i) Housefly, and
(ii) Mosquito.

We will now describe the role of houseflies and mosquitoes in spreading diseases. Please note that houseflies breed and feed in filthy places (insanitary places) which contain a lot of disease-causing micro-organisms (microbes or pathogens). And mosquitoes breed in pools of stagnant water.
The Role of Housefly in Spreading Diseases

The houseflies lay eggs on garbage dumps. So, they breed on filth and refuse (kachra). The houseflies feed on garbage, animal excreta, dead organic matter and exposed human food (uncovered human food). The body and legs of housefly bear a lot of fine hair (see Figure 12). When the housefly sits on a garbage heap, human excreta or other filth and refuse, then millions of disease-causing micro-organisms (like bacteria) present in them stick to the hairy legs and other body parts of the housefly [see Figure 13(a)]. And when this housefly now sits on our uncovered food, then the micro-organisms sticking to the hair on its legs and other body parts are transferred to food [see Figure 13(b)]. In this way our food gets contaminated with disease-causing micro-organisms. When this contaminated food is consumed by a person, then the disease causing micro-organisms enter into his body and cause various diseases. The person gets sick. Thus, the housefly carries disease-causing micro-organisms (or germs) on the hair of its legs and other body parts. It is the habit of housefly of sitting on garbage and human food alternately which is responsible for the transmission of micro-organisms to our body and causing diseases. Some of the dangerous diseases spread by houseflies are: Cholera, Tuberculosis (TB), Typhoid and Diarrhoea.

Prevention of Diseases Spread by Houseflies

The spreading of diseases by houseflies can be prevented in the following ways:

(i) We should not leave household garbage here and there. The garbage should be put in the garbage bins which should be kept covered. This will prevent the houseflies from breeding because they will not be able to lay their eggs on garbage.

(ii) The food should always be kept covered so that flies cannot sit on it.

(iii) We should avoid eating uncovered food items from the road-side stalls.

(iv) The flies should be killed by using insecticide spray and baits.

(v) Some of the diseases spread by houseflies can be prevented by vaccination.

Role of Mosquitoes in Spreading Diseases

Mosquito is another insect which spreads diseases by transmitting disease-causing micro-organisms (or microbes) (see Figure 14). Mosquito acts as a carrier of disease-causing micro-organisms and spreads diseases from one person to another. Please note that housefly carries the disease-causing microbes on the hair (outside its body) but the mosquito carries microbes inside its body. Mosquitoes breed in stagnant water of ponds, dirty drains, pools, ditches, and shallow lakes, etc.

The most common disease spread by mosquitoes is ‘malaria’. Actually, it is the female *Anopheles* mosquito which carries the parasite of malaria. The malarial parasite (called *Plasmodium*)
causes malaria disease. It is called a parasite because it lives on the blood of a person as its food on entering his body. We will now describe how female *Anopheles* mosquito spreads malaria disease.

(i) When a female *Anopheles* mosquito bites a person suffering from malaria disease, it sucks the blood of that person which contains the malarial parasite microbes (see Figure 15) (Malarial parasite is a protozoan called *Plasmodium*).

(ii) And when this infected *Anopheles* mosquito now bites a healthy person to suck his blood, it transfers the malarial parasite microbes into his blood stream alongwith saliva.

(iii) By receiving malarial parasite microbes in blood, the healthy person also gets malaria disease.

Please note that only the female *Anopheles* mosquito sucks blood, so only the female *Anopheles* mosquito carries malarial parasite and spreads malaria. The male *Anopheles* mosquito does not suck blood of a person and hence does not spread malaria disease. Another disease spread by mosquitoes is ‘dengue’. Dengue is caused by a virus. The female *Aedes* mosquito acts as a carrier of dengue virus and spreads the dengue disease from person to person.

**Prevention of Diseases Spread by Mosquitoes**

We can prevent (or control) the spreading of diseases like malaria and dengue caused by mosquitoes in the following ways:

(i) All the mosquitoes breed in water. So, the pools of stagnant water around the houses should be drained out so that mosquitoes may not breed in them. We should not let water collect in coolers, tyres, flower pots, etc. By keeping our surroundings clean and dry, we can prevent mosquitoes from breeding. And when there are no mosquitoes, there will be no malaria or dengue.

(ii) The windows and doors of the house should have fine iron wire mesh so that mosquitoes cannot enter the house.

(iii) Insecticides should be sprayed in houses periodically to kill mosquitoes.

(iv) Oil should be sprayed on the surface of water in dirty water drains to kill the larvae of mosquitoes.

(v) Mosquito repellant cream should be applied on the exposed parts of the body before sleeping at night. Mosquito repellent devices can also be used.

(vi) Mosquito net should be used over beds while sleeping to prevent mosquito bites.

Please note that the micro-organism which causes a disease is known as causative micro-organism of that disease. For example, tuberculosis disease is caused by bacteria, so the causative micro-organisms of tuberculosis are bacteria. Some of the common human diseases, their causative micro-organisms, modes of transmission and general methods of prevention are given below.

**Some Common Human Diseases Caused by Micro-Organisms**

<table>
<thead>
<tr>
<th>Human disease</th>
<th>Causative micro-organism</th>
<th>Mode of transmission</th>
<th>General preventive measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tuberculosis</td>
<td>Bacteria</td>
<td>Air</td>
<td>(i) The patient should be kept in complete isolation.</td>
</tr>
<tr>
<td>2. Measles</td>
<td>Virus</td>
<td>Air</td>
<td>(ii) The personal belongings of the patient should be kept away from those of others.</td>
</tr>
<tr>
<td>3. Chickenpox</td>
<td>Virus</td>
<td>Air/Contact</td>
<td>(iii) Vaccination should be done at suitable age.</td>
</tr>
<tr>
<td>4. Polio</td>
<td>Virus</td>
<td>Air/Water</td>
<td></td>
</tr>
<tr>
<td>5. Cholera</td>
<td>Bacteria</td>
<td>Water/Food</td>
<td>(i) Maintain personal hygiene and good sanitary habits.</td>
</tr>
<tr>
<td>6. Typhoid</td>
<td>Bacteria</td>
<td>Water</td>
<td></td>
</tr>
</tbody>
</table>
7. Hepatitis B
- Virus
- Water
- (i) Eat properly cooked food.
- (ii) Drink clean and boiled drinking water.
- (iii) Vaccination should be done.
- (iv) Clean and boiled drinking water.

8. Malaria
- Protozoan
- Mosquito
- (i) Do not allow water to collect in surroundings to prevent breeding of mosquitoes.
- (ii) Spray insecticides in homes to kill mosquitoes.
- (iii) Put fine wire mesh on doors and windows to prevent mosquitoes from entering into house.
- (iv) Use mosquito nets over beds for sleeping.
- (v) Use mosquito repellent cream and devices.

9. Dengue
- Virus
- Mosquito
- (i) Spray insecticides in homes to kill mosquitoes.
- (ii) Put fine wire mesh on doors and windows to prevent mosquitoes from entering into house.
- (iii) Use mosquito nets over beds for sleeping.
- (iv) Use mosquito repellent cream and devices.

Disease-Causing Micro-Organisms in Animals

Just like human beings, several micro-organisms cause diseases in other animals (such as cow, buffalo, sheep, goat and poultry birds). Some of the examples of diseases caused in animals by the micro-organisms (or microbes) are: Foot and mouth disease; Anthrax and Aspergillosis.

(i) Foot and mouth disease of animals (like cattle) is caused by a virus. Thus, foot and mouth disease is a viral disease of animals. The causative micro-organism of foot and mouth disease is virus. The cattle suffering from this disease get blisters on feet and mouth.

(ii) Anthrax is a dangerous disease of animals (like cattle) which is caused by a bacterium. Thus, anthrax disease is a bacterial disease of animals. The causative micro-organism of anthrax disease is a bacterium (known as Bacillus anthracis). The bacterium Bacillus anthracis which causes anthrax disease in animals was discovered by Robert Koch in 1876.

(iii) Aspergillosis is a disease of animals (like poultry birds) which is caused by a fungus. Thus, aspergillosis is a fungal disease of animals. The causative micro-organism of aspergillosis disease is a fungus.

Disease-Causing Micro-Organisms in Plants

Just like human beings and other animals, micro-organisms also cause diseases in plants. For example, several micro-organisms (or microbes) cause diseases in plants like wheat, rice, potato, sugarcane, orange, apple, and others. Some of the common plant diseases caused by micro-organisms are: Rust of wheat; Citrus canker and Yellow vein mosaic of bhindi (Okra).

(i) The plant disease called ‘rust of wheat’ is caused by fungi. Thus, the causative micro-organism of ‘rust of wheat’ disease is fungus. The rust of wheat disease is transmitted through air and seeds. This means that the modes of transmission of the ‘rust of wheat’ disease are: Air and Seeds. As the name suggests, the rust of wheat disease occurs in wheat plants.

(ii) The plant disease called ‘citrus canker’ is caused by bacteria. So, the causative micro-organisms of ‘citrus canker’ disease are bacteria. The ‘citrus canker’ disease is transmitted through air. This means that the mode of transmission of citrus canker disease of plants is: Air. As the name suggests, the citrus canker disease occurs in citrus trees such as those of lemon, lime, orange, etc.

(iii) The plant disease called ‘yellow vein mosaic of bhindi (or Okra)’ is caused by a virus. So, the causative micro-organism of this plant disease is virus. The ‘yellow vein mosaic of bhindi’ disease is...
transmitted through insects. Thus, the mode of transmission of yellow vein mosaic of bhindi disease is: Insect.

The diseases of plants caused by micro-organisms reduce the yield and quality of various crops. The plant diseases can be controlled by the use of certain chemicals which kill the disease-causing micro-organisms (or insects). We will now discuss food poisoning and preservation of food.

**FOOD POISONING**

If the food is not covered properly, stored properly or preserved properly, then it gets spoiled by the action of micro-organisms (such as bacteria and fungi) on it. Micro-organisms that grow on our food sometimes produce toxic substances (poisonous substances). The food spoiled in this manner starts giving foul smell and bad taste. Its colour may also change (see Figure 16). If such a food is eaten, it will lead to food poisoning. The disease caused due to the presence of a large number of micro-organisms (like bacteria and fungi) in the food, or due to the presence of toxic substances in food formed by the action of micro-organisms, is called food poisoning. Thus, food poisoning occurs due to the consumption of food spoilt by some micro-organisms. The major symptoms of food poisoning are: Vomiting, Diarrhoea (Loose motions), Pain in abdomen, Headache and Fever. Food poisoning can cause serious illness and even death. The micro-organisms (like bacteria and fungi) which cause food poisoning come into food from the air, dirty hands, unclean food containers, flies, cockroaches, insects, rats, or sick farm animals. The two most common examples of bacteria which cause food poisoning are bacteria *Salmonella* and bacteria *Clostridium botulinum*. An example of fungus which causes food poisoning is *Aspergillus*. The Spoiling of food is a chemical change. Food is a very precious material. It should not be allowed to get spoiled, become useless, and cause food poisoning, etc. We ‘preserve’ food to prevent it from getting spoiled. We will now discuss the preservation of food.

**PRESERVATION OF FOOD**

The food materials like milk, fruits, vegetables, meat, fish and cooked food, etc., get spoiled easily. This is because they contain a lot of water due to which the food-spoiling micro-organisms can grow in them easily. We can prevent the spoilage and contamination of easily spoilable food materials like milk, fruits, vegetables, meat, fish and cooked food, etc., by proper methods (or techniques) of food preservation. The process in which the food materials are given a suitable physical or chemical treatment to prevent their spoilage is called food preservation. Some of the methods for preserving foods are: (i) Sun-drying (or Dehydration) (ii) Heating (iii) Cooling (or Refrigeration) (iv) Deep freezing (v) Addition of common salt (vi) Addition of sugar (vii) Addition of mustard oil and vinegar (viii) Use of special chemical preservatives (such as sodium metabisulphite, sodium benzoate and citric acid) (ix) Pasteurisation, and (x) Packing food in air-tight packets. The method to be used for preserving a particular food material depends on the nature of the food material. Different types of foods are preserved by using different methods of preservation. The preservation of food by different methods will become clear from the following examples.

1. **Preservation of Food by Sun-Drying (or Dehydration)**

Drying (or dehydration) means removal of water from food materials which are to be preserved. Sun-drying (or dehydration) reduces the water content (or moisture content) of food materials and makes them dry. In the absence of moisture, the food does not get spoiled because the micro-organisms which spoil food do not grow in dry food. The vegetables like Spinach (*Palak, Saag*), Methi leaves, Cauliflower and Peas (*Mutter*) are preserved in our homes by the sun-drying method. These dried vegetables can be
stored safely for a long time and used whenever required. Grapes are preserved by drying to make raisins (*kishmish*).

**2. Preservation of Food by Heating**

Heating kills many micro-organisms and prevents the food from spoilage. So, some foods can be preserved just by heating. For example, **we boil milk to prevent it from spoilage**. When we heat the milk during boiling, then the food-spoiling bacteria present in it get killed. So, the boiled milk remains good for a longer time. It does not get sour quickly.

**3. Preservation of Food by Cooling (or Refrigeration)**

Low temperature inhibits the growth of micro-organisms. So, the food-spoiling bacteria do not grow and multiply in cold conditions (having low temperature). Thus, when food is kept in a cold place (like that in a refrigerator), then the food does not get spoiled easily. It remains fresh for a much longer period. The food materials like milk, kneaded flour (dough), cooked food (like cooked vegetables and pulses), and fresh fruits and vegetables are kept in a cool place like refrigerator to prevent their spoilage.

**4. Preservation of Food by Deep Freezing**

Preservation of food by deep freezing means preservation of food by excessive cold (at temperatures much below 0°C). Deep freezing of food can be done by placing it in the ‘freezer compartment’ of our refrigerator or in special ‘deep freeze refrigerators’. When the food is kept in a deep freezer (whose temperature is much below 0°C), the food gets frozen. At the very low temperature in deep freezer, the growth of food-spoiling micro-organisms is prevented completely. Due to this, the frozen food remains unspoiled and fresh for long periods. Thus, food can be frozen in deep freezers and kept fresh even for months. This frozen food can be cooked and eaten whenever needed. **Deep freezing method is used for the preservation of foods like meat, fish and their products; fruits and vegetables.**

**5. Preservation of Food by Common Salt**

Common salt prevents the growth of food-spoiling micro-organisms due to which it is used to preserve a number of food materials. **Common salt has been used to preserve meat and fish for ages.** Meat and fish are covered with dry salt to prevent the growth of bacteria. Such meat and fish do not get spoiled easily. They remain good for a long time. **Common salt is also used to preserve fruits such as raw mangoes, lemon and *amla* (in the form of their pickles) and tamarind (in the form of *chutney*).** Common salt does not allow bacteria or fungus to grow on fruits and vegetables preserved in it. For example, if ripe mangoes are kept as such for some time, they rot and get spoiled but the raw mangoes preserved by using common salt in the form of pickle do not get spoiled for a long time.

**6. Preservation of Food by Sugar**

Sugar is used as a preservative in making jams and jellies from fruits (see Figure 17). Sugar reduces the moisture content from the fruits which inhibits the growth of micro-organisms like bacteria which spoil the fruits, etc. **The fruits which are preserved in the form of jams and jellies by using sugar as preservative are: Apple, Ripe mango, Orange, Strawberry, Pineapple and Guava, etc.** The fruits preserved in the form of food materials like jams and jellies can be stored safely for a considerable time and used later.
7. Preservation of Food by Mustard Oil and Vinegar

Mustard oil and vinegar (sirka) are widely used as preservatives for the preservation of fruits and vegetables in the form of pickles (achar) (see Figure 18). The use of mustard oil or vinegar prevents the spoilage of fruits and vegetables because food-spoiling bacteria cannot live in such an environment. Some of the fruits and vegetables which can be spoiled easily are preserved in the form of their pickles by using mustard oil or vinegar. **Mustard oil and vinegar are used as preservatives for preserving fruits such as raw mango, amla and lemon, etc., in the form of their pickles.**

8. Preservation of Food by Using Special Chemicals as Preservatives

The three special chemicals which are used as preservatives in the preservation of food are: Sodium metabisulphite, Sodium benzoate and Citric acid. **Sodium metabisulphite and sodium benzoate are used to preserve foods such as jams, jellies, juices and squashes so as to save them from spoilage. And citric acid is used as a preservative in confectionary (sweets).** These special chemicals kill the food-spoiling bacteria but they do not harm us.

9. Preservation of Food by Pasteurisation

A French scientist named Louis Pasteur has given an excellent method of preserving food. This method is called ‘pasteurisation’ after his name. **The method of pasteurisation is used for the preservation of milk in big milk dairies,** and it involves the process of heating, followed by quick cooling. Milk is preserved by the method of pasteurisation as follows: First the milk is heated to about 70°C for 15 to 30 seconds to kill most of the bacteria present in it. Next, this hot milk is cooled very quickly to a low temperature to prevent any remaining bacteria from growing further. And then this milk is stored in cold (in refrigerators). Pasteurised milk can be consumed without boiling because it is free from harmful micro-organisms. The milk that comes in packets also does not get spoiled for a fairly long time. This is because it is pasteurised milk.

10. Preservation of Food by Packing in Air-Tight Packets

These days, dry fruits and even vegetables are sold in sealed, air-tight packets to prevent the attack of micro-organisms on them. This helps the dry fruits and vegetables to remain unspoiled for a longer time.

**NITROGEN FIXATION**

Our atmosphere contains a lot of nitrogen gas. In fact, our atmosphere has 78 per cent nitrogen gas. The atmospheric nitrogen gas cannot be utilised directly by the plants or animals. In order that the nitrogen gas of atmosphere can be utilised by plants for their growth, it has first to be converted into nitrogen compounds (which can be absorbed by the roots of the plants). **The process of converting nitrogen gas of atmosphere (or air) into compounds of nitrogen (which can be used by the plants) is called nitrogen fixation.** The ‘nitrogen gas’ is the ‘free nitrogen’ whereas ‘nitrogen compounds’ (like nitrates) are said to be ‘fixed nitrogen’. The nitrogen gas of atmosphere (or air) can be ‘fixed’ (converted into nitrogen compounds) (i) by certain nitrogen-fixing bacteria present in the soil, (ii) by *Rhizobium* bacteria present in the root nodules of leguminous plants, (iii) by blue-green algae, and (iv) by lightning. The nitrogen fixing *Rhizobium* bacteria live in the root nodules of leguminous plants (such as peas, beans, etc.) (see Figure 19). *Rhizobium* bacteria have symbiotic relationship with leguminous plants. Thus, some nitrogen-fixing bacteria live freely in the soil whereas other nitrogen-fixing bacteria (*Rhizobium* bacteria) live in the root nodules of leguminous plants. **Nitrogen gas of atmosphere also**

Figure 19. The nodules on the roots of this pea plant (a leguminous plant) contain nitrogen-fixing *Rhizobium* bacteria which convert nitrogen gas of air into nitrogen compounds.
gets fixed through the action of lightning in the sky. This happens as follows: When lightning takes place in the sky during thunderstorm, a high temperature is produced in the atmosphere. At this high temperature, nitrogen gas of air combines with oxygen gas of air to form nitrogen compounds. These nitrogen compounds dissolve in rain water, fall to earth with rain water and go into the soil. Nitrogen of atmosphere can also be fixed by artificial methods. We will study the artificial fixation of nitrogen in higher classes.

**THE NITROGEN CYCLE**

Nitrogen is required by both, plants and animals for their growth and development. Nitrogen is an essential component of proteins which make up the bodies of plants and animals. Nitrogen is also present in chlorophyll, nucleic acids and vitamins. The same nitrogen element is circulated again and again through living things (like plants and animals) and non-living things (like air, soil and water). The circulation of nitrogen element through living things (plants and animals) and non-living environment (air, soil and water) is called nitrogen cycle in nature. A labelled diagram of nitrogen cycle in nature is given in Figure 20. We will now describe the nitrogen cycle in nature. The main steps in the nitrogen cycle in nature are as follows:

(i) The atmosphere (or air) contains nitrogen gas. The nitrogen-fixing bacteria (present in the soil and in the root nodules of leguminous plants), blue-green algae and lightning in the sky fix nitrogen gas from the atmosphere and convert it into compounds of nitrogen which go into soil.

(ii) The plants take compounds of nitrogen from the soil for their growth. The plants absorb the nitrogen compounds from the soil through their roots. The plants convert the compounds of nitrogen into plant proteins and other organic compounds which make up the body of plants.
(iii) The plants are eaten up by animals as food. Animals convert plant proteins into animal proteins and other organic compounds which make up their body. Some animals also eat other animals to obtain nitrogen compounds. Thus, animals obtain nitrogen compounds by eating plants as well as other animals.

(iv) When plants and animals die, the complex nitrogen compounds (like proteins, etc.) present in their dead bodies are decomposed and converted into simple compounds of nitrogen by certain bacteria and fungi present in the soil. Animal excretions (urine, etc.) are also converted into simple compounds of nitrogen. All the simple compounds of nitrogen formed in this way go into the soil. In this way, the compounds of nitrogen which were taken by the plants from the soil during their growth are returned to the soil. From the soil, these nitrogen compounds are again absorbed by the new plants for their growth and this part of nitrogen cycle is repeated endlessly.

(v) Some of the compounds of nitrogen (formed from the decay of dead plants and animals) are decomposed by denitrifying bacteria present in the soil to form nitrogen gas. This nitrogen gas goes back into the atmosphere (from where it initially came) (This process is the reverse of fixation of nitrogen). In this way, the nitrogen gas which was removed from the atmosphere during fixation is put back into the atmosphere.

From the atmosphere, nitrogen gas is used again during nitrogen fixation and the nitrogen cycle is repeated in nature again and again. As a result of nitrogen cycle in nature, the percentage of nitrogen gas in the atmosphere (or air) remains constant. We are now in a position to answer the following questions:

Very Short Answer Type Questions

1. Name the instrument (or device) which is needed to see the micro-organisms.
2. What is the name of micro-organisms which reproduce only inside the living cells of other organisms?
3. What are the major groups of micro-organisms?
4. Name any two human diseases caused by bacteria.
5. Name any two human diseases caused by viruses.
6. Name any two human diseases caused by protozoa.
7. Name any two human diseases caused by fungi.
8. Which micro-organism is utilised in making curd from milk?
9. Name the micro-organism which is used for the large scale production of alcohol.
10. Name any two antibiotics.
11. Name an antibiotic extracted from fungus (mould). Name the fungus.
12. Name any four diseases which can be prevented by vaccination.
13. Name the scientist who discovered the vaccine for smallpox.
14. Name the scientist who discovered ‘penicillin’.
15. State an important function performed by blue-green algae.
16. Name one ‘biological nitrogen-fixer’.
17. Name two common insects which act as carriers of disease-causing micro-organisms (or disease-causing microbes).
18. Name any two diseases spread by housefly.
19. Name the insect which is the carrier of parasite of malaria.
20. Name the insect which carries dengue virus.
21. Which of the two spreads dengue: mosquito or housefly?
22. Name two diseases spread by mosquitoes.
23. Name the microbe which causes malaria disease.
24. Name one disease which spreads by breathing in air containing micro-organisms.
25. Name one disease which spreads through insect bites.
26. Name one disease which spreads through infected food or water.
27. Name the causative micro-organisms of the following animal diseases:
   (a) Foot and mouth disease
   (b) Anthrax
28. Name two food materials which are preserved by sun-drying method in our homes.
29. Name two food materials which are preserved by using common salt.
30. Name two food materials which can be preserved by using sugar.
31. Name two food materials which are usually preserved by deep freezing.
32. Name some of the preservatives which are used in the preservation of fruits as jams and jellies.
33. Name some of the preservatives which are used in the preservation of fruits and vegetables as pickles.
34. Name two food materials which can be preserved by using oil or vinegar.
35. Name any two special chemicals which are used as food preservatives.
36. Name the micro-organisms which can fix atmospheric nitrogen in the soil.
37. What type of plants can fix nitrogen gas of the air into compounds of nitrogen?
38. Name the micro-organisms present in the soil and in the root nodules of leguminous plants which can fix atmospheric nitrogen.
39. Name two leguminous plants which can fix nitrogen.
40. Fill in the following blanks with suitable words:
   (a) Alcohol is produced with the help of ...............
   (b) Blue-green algae fix...............directly from air to enhance fertility of soil.
   (c) Micro-organisms can be seen with help of a.......... 
   (d) Cholera is caused by............
   (e) Common salt has been used to preserve.......... and .......... for ages.
   (f) The food material which is preserved by pasteurisation is ............
   (g) As a result of nitrogen cycle, the percentage of nitrogen in the atmosphere remains more or less...........

Short Answer Type Questions

41. How do viruses differ from other micro-organisms such as bacteria?
42. What are micro-organisms? Give any two examples of micro-organisms.
43. Can micro-organisms be seen with the naked eye? If not, how can they be seen?
44. (a) How do houseflies carry disease-causing microbes (or pathogens)?
   (b) State any two ways of preventing diseases spread by houseflies.
45. (a) How do mosquitoes carry disease-causing micro-organisms and spread diseases?
   (b) Mention any three ways of preventing diseases spread by mosquitoes.
46. (a) What is meant by fermentation? Name the scientist who discovered fermentation.
   (b) Which micro-organism converts sugar into alcohol during fermentation?
47. (a) How do micro-organisms help in increasing soil fertility?
   (b) How do micro-organisms help in cleaning the environment?
48. What are antibiotics? What precautions must be taken while taking antibiotics?
49. Why are antibiotics not effective against ‘common cold’ and ‘flu’?
50. What is the full form of HIV? Name the disease caused by HIV.
51. Describe how, curd is made from milk. Name the bacterium which converts milk into curd.
52. Name the micro-organism used in bread-making which makes the bread-dough rise. How does it make the dough rise?
53. What is food poisoning? How is food poisoning caused?
54. (a) What is meant by food preservation? Name any five methods of preserving food.
   (b) How do you preserve cooked food at home?
55. (a) Why should we not let water collect anywhere in the neighbourhood?
   (b) Name one animal disease each caused: (i) by virus (ii) by bacteria (iii) by fungus.
56. Where do Rhizobium bacteria live? What is their function?
57. Name any two (a) bacteria (b) viruses (c) protozoa (d) algae, and (e) fungi.
58. State the beneficial effects (or usefulness) of micro-organisms in our lives.
59. Describe the method of pasteurisation for the preservation of milk.
60. Name one plant disease each caused: (a) by fungi (b) by virus (c) by bacteria.
61. Which disease is spread by:
   (a) female Anopheles mosquito?
   (b) female Aedes mosquito?
62. Name two fruits which are preserved:
   (a) in the form of pickles.
   (b) in the form of jams.
63. What is the mode of transmission of the following diseases?
   (a) Rust of wheat (b) Citrus canker (c) Yellow vein mosaic of bhindi (Okra)
64. Name any two animal diseases and two plant diseases caused by micro-organisms.

65. State the causative micro-organisms and modes of transmission of the following human diseases:
   (i) Tuberculosis (ii) Measles (iii) Chickenpox (iv) Polio (v) Cholera
   (vi) Typhoid (vii) Hepatitis B (viii) Malaria (ix) Dengue

Long Answer Type Questions

66. (a) What is meant by communicable diseases? Name any two communicable diseases.

(b) What are the various ways in which communicable diseases can occur and spread?

67. (a) Name any five human diseases caused by micro-organisms. Also name the causative micro-organisms and mode of transmission for each of these diseases.

(b) State the various ways of preventing the occurrence and spreading of communicable diseases.

68. (a) What is a vaccine? How does a vaccine work?

(b) Why are children given vaccination?

69. What is meant by 'nitrogen fixation'? State two ways in which nitrogen gas of the atmosphere can be 'fixed' in nature to get nitrogen compounds in the soil.

70. Draw a neat, labelled diagram of nitrogen cycle in nature. Which natural phenomenon occurring in the sky is responsible for nitrogen fixation?

Multiple Choice Questions (MCQs)

71. The bread dough rises because of:
   (a) heat (b) grinding (c) growth of yeast cells (d) kneading

72. Yeast is used in the production of:
   (a) sugar (b) alcohol (c) hydrochloric acid (d) oxygen

73. The process of conversion of sugar into alcohol is called:
   (a) nitrogen fixation (b) moulding (c) fermentation (d) infection

74. Which of the following is an antibiotic?
   (a) sodium bicarbonate (b) streptomycin (c) alcohol (d) yeast

75. The most common carrier of communicable diseases is:
   (a) ant (b) housefly (c) dragonfly (d) spider

76. The carrier of malaria-causing protozoan is:
   (a) female Anopheles mosquito (b) cockroach (c) housefly (d) female Aedes mosquito

77. The vaccine for smallpox was discovered by:
   (a) Alexander Fleming (b) Edward Jenner (c) Louis Pasteur (d) Rober Koch

78. Alcohol can be converted into vinegar by the action of micro-organisms called:
   (a) viruses (b) yeast (c) protozoa (d) bacteria

79. The first antibiotic called penicillin was extracted from:
   (a) a bacterium (b) a protozoan (c) a fungus (d) an alga

80. Which of the following is not a communicable disease?
   (a) cholera (b) cancer (c) chickenpox (d) malaria

81. Which of the following increase the fertility of soil?
   A. Lactobacillus bacteria   B. Rhizobium bacteria   C. Spirogyra algae   D. Blue-green algae
   (a) A and B (b) B and C (c) A and D (d) B and D

82. Which of the following cannot be used as a food preservative?
   (a) sodium metabisulphite (b) sodium hydroxide (c) sodium benzoate (d) citric acid

83. Which of the following disease is not caused by bacteria?
   (a) cholera (b) typhoid (c) tuberculosis (d) measles

84. The micro-organisms which can reproduce and multiply only inside the cells of other organisms are:
   (a) protozoa (b) fungi (c) bacteria (d) viruses

85. The dengue disease spread by Aedes mosquito is caused by:
   (a) bacteria (b) virus (c) protozoan (d) fungus
86. Which of the following disease is not caused by viruses?
(a) measles  (b) smallpox  (c) cholera  (d) polio

87. The micro-organism which is capable of converting sugar into alcohol and carbon dioxide is:
(a) bacterium  (b) fungus  (c) alga  (d) protozoan

88. Which of the following is not a use of micro-organisms?
(a) preparation of medicines (or drugs)  (b) preparation of food by photosynthesis  (c) recycling of materials in nature  (d) increasing the fertility of soil

89. The malaria disease is caused by a:
(a) virus  (b) protozoan  (c) bacterium  (d) fungus

90. The parasite called *Plasmodium* causes a disease known as:
(a) measles  (b) polio  (c) malaria  (d) dengue

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

91. After consuming a dish of mutton, a person complained of nausea, vomiting, diarrhoea, and pain in the abdomen.
(a) What type of disease is he suffering from?
(b) What causes this disease?

92. Match the micro-organisms in column A with their action in column B:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Bacteria</td>
<td>(a) Fixing nitrogen</td>
</tr>
<tr>
<td>(ii) <em>Rhizobium</em></td>
<td>(b) Setting of curd</td>
</tr>
<tr>
<td>(iii) <em>Lactobacillus</em></td>
<td>(c) Baking of bread</td>
</tr>
<tr>
<td>(iv) Yeast</td>
<td>(d) Causing malaria</td>
</tr>
<tr>
<td>(v) A protozoan</td>
<td>(e) Causing cholera</td>
</tr>
<tr>
<td>(vi) A virus</td>
<td>(f) Causing AIDS</td>
</tr>
<tr>
<td>(vii) <em>Penicillium</em></td>
<td>(g) Producing antibiotics</td>
</tr>
</tbody>
</table>

93. To which category of micro-organisms do the following belong?
*Amoeba, Lactobacillus, Chlamydomonas, Penicillium, Yeast, HIV*

Name the causative micro-organisms of the following plant diseases:
(a) Rust of wheat  (b) Citrus canker  (c) Yellow vein mosaic of *bhindi* (Okra)

94. The mosquito P is a carrier of virus and spreads a disease Q. Another mosquito R is the carrier of protozoan S and spreads a disease called T.
(a) Name (i) mosquito P, and (ii) disease Q.
(b) Name (i) mosquito R (ii) protozoan S, and (iii) disease T.
(c) What is the sex of mosquito P?
(d) What is the sex of mosquito R?

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**ANSWERS**

40. (a) yeast  (b) nitrogen  (c) microscope  (d) bacteria  (e) meat; fish  (f) milk  (g) constant
71. (c)
72. (b) 73. (c) 74. (b) 75. (b) 76. (a) 77. (b) 78. (d) 79. (c) 80. (b) 81. (d) 82. (b) 83. (d) 84. (d)
85. (b) 86. (c) 87. (b) 88. (b) 89. (b) 90. (c) 91. (a) Food poisoning  (b) Micro-organisms (like bacteria and fungi) present in spoil dish of mutton
92. (i) e  (ii) a  (iii) b  (iv) c  (v) d  (vi) f  (vii) g
93. *Amoeba* : Protozoa; *Lactobacillus* : Bacteria; *Chlamydomonas* : Algae; *Penicillium* : Fungi; *Yeast* : Fungi; *HIV* : Viruses
94. (a) Fungus  (b) Bacteria  (c) Virus
95. (a) *Aedes* mosquito  (b) *Dengue*  (c) *Anopheles* mosquito
96. (i) *Plasmodium* (ii) *Malaria*  (c) Female  (d) Female

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**QR Codes**

- **Fungi and bacteria**
- **Preservation of food**
A very thin, thread-like strand from which cloth is made, is called a fibre. Fabric means cloth. Fabric is made by weaving or knitting long, twisted threads called ‘yarn’ made from fibres. The clothes which we wear are made of fabrics. Fabrics are made from fibres obtained from ‘natural’ or ‘artificial’ sources (synthetic sources). Thus, all the fibres can be divided into two groups:

(i) Natural fibres, and
(ii) Synthetic fibres.

The fibres obtained from plants and animals are called natural fibres. Cotton, flax, jute, wool and silk are natural fibres. Cotton, flax and jute fibres come from plants whereas wool and silk come from animals.

The synthetic fibres are made by human beings. Rayon, nylon, polyester and acrylic are synthetic fibres. We have studied the natural fibres in Classes VI and VII. In this Class we will study synthetic fibres. Before we go further and discuss synthetic fibres in detail, we should know the meaning of the term ‘polymer’. This is described below.

A polymer is a ‘very big molecule’ formed by the combination of a large number of small molecules. The small molecules (of chemical compounds) which join together to form a polymer are called ‘monomers’. The monomers which make a polymer may all be of the ‘same compound’ or of ‘two different compounds’ (see Figures 1 and 2). The word ‘polymer’ comes from two Greek words ‘poly’ meaning ‘many’ and ‘mer’ meaning ‘units’. So, a polymer is made of many small ‘repeating units’ (of chemical compounds) called monomers.

Polymers are of two types: Natural polymers and Synthetic polymers. Cotton, wool and silk are natural polymers. For example, cotton fibre is made of a natural polymer called cellulose. Cellulose is a polymer which is made up of a large number of small glucose molecules (or glucose units) joined one after the other (see Figure 1). The walls of all the plant cells are made up of cellulose. So, wood contains a large...
amount of cellulose polymer. Thus, polymers occur in nature too. Nylon, polyester, acrylic, polythene, polyvinyl chloride (PVC), bakelite, and melamine are synthetic polymers (or man-made polymers). For example, nylon fibre is made up of nylon polymer in which two different types of molecules (or monomer units) are combined alternately to form long chains (see Figure 2). Please note that the term ‘synthetic’ means made by humans in an industrial process (and not occurring naturally). We will now discuss synthetic fibres.

**SYNTHETIC FIBRES**

The man-made fibres produced from chemical substances are called synthetic fibres. Synthetic fibres are made in industry by the chemical process called ‘polymerisation’. A synthetic fibre is a long chain of small units joined together. Each small unit is a chemical compound (called organic compound). Many, many such small units join together one after the other to form a very large single unit called polymer. It is this man-made polymer which forms synthetic fibres. Thus, a synthetic fibre is a polymer made from the molecules of a monomer (or sometimes two monomers) joined together to form very long chains (see Figure 2). Synthetic fibres are also known as man-made fibres or artificial fibres.

**Types of Synthetic Fibres**

Depending upon the type of chemicals used for manufacturing synthetic fibres, there are four major types of synthetic fibres (or man-made fibres). These are:

(i) Rayon,
(ii) Nylon,
(iii) Polyester, and
(iv) Acrylic.

Rayon is a man-made fibre made from a natural material called cellulose (obtained from wood pulp). Nylon, polyester and acrylic are fully synthetic fibres which do not require a natural material (like cellulose) for their manufacture. These fully synthetic fibres are prepared by a number of processes by using raw materials (or chemical compounds) of petroleum origin, called petrochemicals. We will now study all these synthetic fibres, one by one. Let us start with rayon. Before we do that, we should know the meaning of the term ‘wood pulp’. Wood pulp is a soft, wet mass of fibres obtained from wood. Wood pulp contains a large amount of natural polymer called ‘cellulose’.

1. **RAYON**

We have studied in Class VII that silk is a natural fibre obtained from silkworms. The fabric (or cloth) made from natural silk fibres is very costly. But the beautiful texture (feel, appearance, shine) of natural silk
fabrics fascinated everyone. So, attempts were made to make silk artificially which would be cheaper than natural silk. Towards the end of 19th century, scientists were successful in obtaining fibres having properties similar to that of silk. This fibre was called rayon. **Rayon is often regarded as artificial silk.**

Rayon is a man-made fibre prepared from a natural raw material (called cellulose) by chemical treatment. The cellulose required for making rayon is obtained from ‘wood pulp’. So, we can also say that rayon is obtained by the chemical treatment of wood pulp (which contains cellulose). Rayon is produced as follows :

(i) Wood pulp is dissolved in an alkaline solution (sodium hydroxide solution) to form a sticky liquid called ‘viscose’.

(ii) Viscose is forced to pass through the tiny holes of a metal cylinder (called spinneret) into a solution of sulphuric acid when a silk like thread of rayon is formed.

Since rayon is made from naturally occurring polymer (cellulose) present in wood pulp, therefore, rayon is neither a fully synthetic fibre nor a fully natural fibre. It is a semi-synthetic fibre. **Rayon is different from truly synthetic fibres because it is obtained from a natural material (wood pulp).** Although rayon is obtained from a natural resource called wood pulp, yet it is said to be a man-made fibre. This is because it is obtained by the chemical treatment of wood pulp in factories. Rayon fibre is chemically identical to cotton but it has shine like silk. Since rayon resembles silk in appearance, therefore, **rayon is also called artificial silk.** Rayon is cheaper than natural silk and can be woven like silk fibres. Rayon can also be dyed in a variety of colours.

**Uses of Rayon**

(i) Rayon is used in textile industry for making clothing like sarees, blouses, dresses, socks, etc.

(ii) Rayon (mixed with cotton) is used to make furnishings such as bed-sheets, curtains, blankets, etc.

(iii) Rayon (mixed with wool) is used to make carpets.

(iv) Rayon is used in medical field for making bandages and surgical dressings.

(v) Rayon is used in tyre industry for the manufacture of tyre cord.

2. **NYLON**

Nylon is a synthetic fibre. In fact, nylon is the first fully synthetic fibre made by man without using any natural raw materials (from plants or animals). It was made in the year 1931. The chemical compounds (or monomers) used in making nylon are now obtained from petroleum products called petrochemicals. Actually, nylon is made up of the repeating units of a chemical called an ‘amide’. So, **nylon is a polyamide** (which is a polymer). The name **NYLON** comes from the fact that it was developed in New York (NY) and London (LON). Nylon is a thermoplastic polymer (which can be melted by heating). Molten nylon is forced through the tiny holes in a spinneret to make nylon fibres (or nylon threads), or cast into desired shapes.

Some of the important properties of nylon fibres are as follows : Nylon fibres are very strong, fairly elastic, lightweight and lustrous. Nylon fibres absorb very little water, so clothes made of nylon are easy to wash and dry. Nylon is wrinkle resistant. Nylon fibres have high abrasion resistance (high wear and tear resistance), so they are very durable (long lasting). Nylon is not attacked by moths and ordinary chemicals. Due to all these properties, nylon fibres have become very popular for making clothes.

**Uses of Nylon**

(i) Nylon is used for making textiles (fabrics) like sarees, shirts, neck-ties, tights, socks and other garments.

(ii) Nylon is used in making curtains, sleeping bags and tents.

(iii) Nylon is used in making ropes, car seat-belts, fishing nets, tyre cord, strings for sports rackets and musical instruments, bristles for toothbrushes and paint brushes. Nylon is used for making parachutes and ropes for rock climbing. All these uses of nylon are due to the high strength of nylon fibres. A nylon thread is actually stronger than a steel wire of similar thickness.
(iv) Nylon is used as a plastic for making machine parts.

(a) Socks  (b) Toothbrush bristles  (c) Parachute  (d) Climbing ropes

**Figure 3.** Some of the uses of nylon fibres.

**POLYESTER**

Polyester is another synthetic fibre. Actually, polyester is the general name of synthetic fibres which contain many ester groups. Polyester (poly + ester) is made up of the repeating units of a chemical called an ‘ester’ (Esters are the organic chemical substances which give fruits their sweet smell). We can now say that polyester is a synthetic fibre in which the polymer units are linked by ester groups. Terylene is a popular polyester fibre. The chemical compounds (or monomers) used in making polyester fibres are made from petroleum products called petrochemicals. Like nylon, polyester is also a thermoplastic polymer. When molten polyester is forced through the tiny holes of a spinneret, then thin polyester fibres (or polyester threads) are formed. The polyester yarn can be woven to make fabrics.

Most of the properties of polyester fibres (like terylene) are similar to those of nylon. Polyester fibres are, however, stronger than nylon fibres. Polyester fibres are also softer than nylon fibres. Since polyester fabric is strong, wrinkle resistant, easy to wash and dry, not attacked by moths and ordinary chemicals, and has high abrasion resistance, it is quite suitable for making dress materials. This is why we see many people around us wearing polyester shirts and other dresses. Sometimes, natural fibres (such as cotton or wool) are mixed with polyester or terrycot to make blended fabrics. Blended fabrics are sold by the names like polycot (or terrycot) and polywool (or terrywool), etc. As the name suggests, these fabrics are made by mixing (or blending) two types of fibres. For example, polycot is a mixture of polyester and cotton. Similarly, polywool is a mixture of polyester and wool.

**Uses of Polyester Fibres**

(i) The most important use of polyester (like terylene) is in making fabrics for sarees, dress materials and curtains. Polyester mixed with cotton (called polycot or terrycot) is used for making shirts, trousers and other dresses. Polyester mixed with wool (called polywool or terrywool) is used for making suits.

(ii) Polyester is used for making sails of sail-boats. The polyester sails are light, strong, do not stretch and do not rot in contact with water.

(iii) Polyester is used for making water hoses for fire-fighting operations.

(iv) Polyester is used for making conveyer belts.

From the above discussion we conclude that synthetic fibres have become very popular. The synthetic fibres have become very popular because they are strong and elastic, and have low water absorption. Synthetic fibres are lightweight, long lasting and extremely fine. They are wrinkle resistant, chemically unreactive and not attacked by moths or common chemicals. Due to these properties, synthetic fibres are much more superior to natural fibres like cotton, wool and silk.

**PET**

PET is a very familiar form of polyester. PET is the abbreviation of the synthetic polymer called ‘Poly-Ethylene Terephthalate’. PET can be made into a fibre or a plastic. In discussing synthetic fibres, PET is
generally referred to as ‘polyester’ while the term PET is usually used for the plastic form. PET as a plastic is very lightweight. It is naturally colourless with high transparency. PET is strong and impact-resistant. As a plastic, PET is replacing materials like glass. Unlike glass, PET is shatterproof. PET is used for making bottles, jars and utensils. For example, PET bottles are used for fizzy drinks and PET jars are used for storing sugar, salt, spices and rice, etc., in our homes (see Figure 4). PET is also used for making thin films and many other useful products. It is clear that polyester fibres and PET bottles and jars are made of the same material.

**ACRYLIC**

Acrylic is a synthetic fibre. Acrylic fibre is made from a chemical called ‘acrylonitrile’ by the process of polymerisation. Acrylic is lightweight, soft and warm with a wool-like feel. Acrylic retains its shape, resists shrinkage and wrinkles. It can be dyed very well. Acrylic fibres are strong and durable. Acrylic absorbs very little water so it has ‘quick-dry’ quality. Acrylic fibres are resistant to moths and most chemicals.

**Due to its wool-like feel, acrylic fibre is often used as a substitute for wool.** The wool obtained from natural sources (like sheep) is quite expensive. Acrylic offers a less expensive alternative to natural wool. So, the clothes made from acrylic are relatively cheaper but more durable than those made from natural wool. Many of the sweaters which the people wear in winter, and the shawls and blankets which people use, are actually not made from natural wool, though they appear to be made from wool. They are made from synthetic fibre called acrylic. Acrylic fibre is used for making sweaters, shawls, blankets, jackets, sportswear, socks, furnishing fabrics, carpets and as lining for boots and gloves.

**Characteristics of Synthetic Fibres**

Synthetic fibres have unique characteristics which make them popular dress materials. The important characteristics (or properties) of synthetic fibres are given below:

1. **Synthetic fibres are very strong.** On the other hand, natural fibres like cotton, wool and silk have low strength.

2. **Synthetic fibres are more durable.** Synthetic fibres have high resistance to abrasion (wear and tear). Due to this, the clothes made of synthetic fibres are very durable (long lasting). On the other hand, natural fibres like cotton, wool and silk have low abrasion resistance due to which the clothes made of natural fibres are not much durable. They do not last long.

3. **Synthetic fibres absorb very little water.** Due to this, the clothes made of synthetic fibres dry up quickly. On the other hand, natural fibres like cotton, wool and silk absorb a lot of water. So, the clothes made of natural fibres do not dry up quickly.

4. **Synthetic fibres are wrinkle resistant.** Due to this, the clothes made of synthetic fibres do not get crumpled easily during washing or wear. They keep permanent creases. On the other hand, natural fibres like cotton, wool and silk are not wrinkle resistant. So, the clothes made of natural fibres get crumpled easily during washing and wear.

5. **Synthetic fibres are quite lightweight.** On the other hand, natural fibres are comparatively heavy.

6. **Synthetic fibres are extremely fine.** So, the fabrics made from synthetic fibres have a very smooth texture. On the other hand, natural fibres are not so fine. Due to this, the fabrics made from natural fibres do not have a very smooth texture.

7. **Synthetic fibres are not attacked by moths.** On the other hand, natural fibres are damaged by moths.
8. **Synthetic fibres do not shrink.** So, the clothes made of synthetic fibres retain their original size even after washing. On the other hand, natural fibres shrink after washing.

9. **Synthetic fibres are less expensive and readily available** as compared to natural fibres.

10. **Clothes made from synthetic fibres are easier to maintain** as compared to those made from natural fibres.

We will now describe an **activity to compare the strengths of synthetic fibres with those of natural fibres.** For this activity, we require threads of natural fibres (such as wool, cotton and silk) and of synthetic fibres (like nylon and polyester) which are of nearly the same thickness and of the same length.

**ACTIVITY**

Take an iron stand with a clamp. Take a woollen thread of about 50 cm length. Tie one end of the woollen thread to the clamp so that it hangs freely. Tie a pan to the lower end of the woollen thread (as shown in Figure 5) so that weights can be placed in it. Put a weight in the pan. Go on adding more and more weights in the pan till the woollen thread breaks. Note down the total weight required to break the woollen thread. This weight indicates the strength of the woollen thread. Repeat this activity by using similar threads of cotton, silk, nylon and polyester. Note down the weights required to break all these threads, one by one. We will find that:

(i) Minimum weight is required to break the woollen thread showing that woollen thread has the minimum strength.

(ii) More weight is required to break the cotton thread showing that the strength of cotton thread is greater than that of woollen thread.

(iii) Still more weight is needed to break the silk thread, indicating that silk thread is stronger than the cotton thread.

(iv) Much more weight is required to break the nylon thread showing that nylon thread has a greater strength than the silk thread.

(v) Maximum weight is needed to break the polyester thread indicating that the polyester thread is even stronger than the nylon thread.

Based on this activity, we can now arrange the natural fibres and synthetic fibres in the order of their increasing strengths as: Wool, Cotton, Silk, Nylon, Polyester. This activity tells us that the synthetic fibres (like nylon and polyester) are stronger than the natural fibres (like wool, cotton and silk).

We will now describe an **activity to demonstrate the difference in the ‘water absorption’ property of synthetic fibres and natural fibres.**

**ACTIVITY**

(i) Take a piece of cloth made of a synthetic fibre (like polyester cloth) of about half a square metre size. Also take another piece of cloth made of a natural fibre (like cotton cloth) of exactly the same size.

(ii) Take two mugs and put 500 mL of water in each mug. Soak the piece of polyester cloth in water taken in one mug for about 5 minutes. Soak the piece of cotton cloth in water taken in the other mug for an equal time.

(iii) Take out the soaked pieces of polyester cloth and cotton cloth from the two mugs and compare the volume of water which remains behind in each mug. We will find that more water is left behind in the mug in which polyester cloth was soaked. This shows that polyester cloth absorbs less water. Much less water is left behind in the mug in which cotton cloth was soaked, showing that cotton cloth absorbs much more water. From these observations we conclude that synthetic fibres (like polyester) absorb much less water than natural fibres (like cotton).
(iv) Spread the wet piece of polyester cloth and the wet piece of cotton cloth in sunshine so as to dry them. We will find that the wet piece of polyester cloth dries up rapidly but the wet piece of cotton cloth takes much longer time to get dried. From these observations we conclude that the wet synthetic fibres (like polyester) dry up quickly but the wet natural fibres (like cotton) do not dry up quickly.

So far we have described the advantages of synthetic fibres. We will now describe some disadvantages of synthetic fibres (over the natural fibres).

**A disadvantage of synthetic fibres is that they melt on heating.** If a person is wearing clothes made of synthetic fibres and his clothes catch fire accidentally, then the synthetic fibres of clothes melt and stick to the body of the person causing severe burns. This can be disastrous for the person concerned. We should, therefore, not wear synthetic clothes (made of nylon, polyester, etc.) while working in the kitchen or in a science laboratory. The natural fibres (like cotton, wool, etc.) do not melt on heating. So, it is quite safe to wear clothes made of natural fibres while working in the kitchen or in a science laboratory.

**Another disadvantage of synthetic fibres is that the clothes made of synthetic fibres are not suitable for wearing during hot summer weather.** This can be explained as follows: Synthetic fibres are extremely fine, so the clothes made of synthetic fibres do not have sufficient pores for the sweat to come out, evaporate and cool our body. Due to this, clothes made of synthetic fibres make us feel hot and uncomfortable during summer. Clothes made of natural fibres (like cotton) are more comfortable during summer. This is because the large pores of cotton clothes allow the body sweat to come out through them, evaporate and make us feel cool and comfortable. So, if we want to buy shirts for summer, we should buy cotton shirts and not the shirts made from synthetic materials (like polyester).

**The manufacturing of fully synthetic fibres (like nylon, polyester and acrylic, etc.) is helping in the conservation of forests.** This is because the fully synthetic fibres are manufactured from petrochemicals (obtained from crude oil ‘petroleum’), so no trees have to be cut down for making them. On the other hand, semi-synthetic fibres like rayon are made from wood pulp which requires cutting down of forest trees. We will now discuss plastics.

**PLASTICS**

We use a large number of articles (or things) made of plastics in our everyday life. Some of the articles made of plastics which are used by us in our everyday life are plastic bags (polythene bags), water bottles, buckets, mugs, water tanks, water pipes, ballpoint pens, combs, toothbrushes, toys, shoes, tea-strainers, cups, plates, chairs, tables, insulation of electric wires, covers of electric switches, plugs, sockets and bulb-holders, etc. (see Figure 6). Some of the parts of radio, television, refrigerator, cars, buses, trucks, scooters,
trains, aeroplanes, ships and spacecrafts are also made of various types of plastics. The list of things made of plastics and used in homes, transport and industry is endless. Plastic articles are available in all possible shapes and sizes.

A plastic is a synthetic material which can be moulded (or set) into desired shape when soft and then hardened to produce a durable article (the term ‘plastic’ means ‘easy to mould’). Like synthetic fibres, plastics are also polymers. This means that plastics consist of very long molecules made by joining many small molecules together. The starting materials for plastics are obtained from petroleum products called ‘petrochemicals’. Some of the examples of plastics are: Polythene, Poly-Vinyl Chloride (PVC), Bakelite, Melamine and Teflon. Nylon is also a plastic. The major properties and uses of some of the plastics are given below.

**Polythene (poly + ethene = polythene).** Polythene is a plastic obtained by the polymerisation of a chemical compound known as ethene. Polythene is tough and durable. Polythene is used in making polythene bags (plastic bags), waterproof plastic sheets, bottles, buckets and dustbins. Polythene is also used for packaging.

**Polyvinyl chloride** (commonly known as PVC) is a strong and hard plastic. It is not as flexible as polythene. PVC is used for making insulation for electric wires, pipes, garden hoses, raincoats, seat covers, etc.

**Bakelite** is a very hard and tough plastic. Bakelite is a poor conductor of heat and electricity. Bakelite is used for making the handles of various cooking utensils (such as frying pans and pressure cookers, etc.). Bakelite is used for making handles of cooking utensils because (i) it is a poor conductor of heat, and (ii) it does not become soft on getting heated (It is a thermosetting plastic). Bakelite is also used for making electrical fittings such as electric switches, plugs and sockets, etc. Bakelite is used for making electric switches, plugs and sockets, etc., because (i) it does not conduct electricity, and (ii) it does not become soft on getting heated.

**Melamine** is a plastic which can tolerate heat better than other plastics and resists fire. Melamine is used for making floor tiles, unbreakable kitchenware (cups, plates, etc.), ashtrays and fire-resistant fabrics. Melamine is a fire-resistant plastic. The uniforms of fire-men have a coating of melamine plastic to make them fire-resistant. Special plastic cookware made of melamine is used in microwave ovens for cooking food. In microwave ovens, the heat cooks the food but does not affect the plastic vessel.

**Teflon** is a special plastic on which oil and water do not stick. Oil and water do not stick on teflon plastic because it has a slippery surface. Teflon also withstands high temperatures. Teflon is used for giving non-stick coating on cookwares (like non-stick frying pans). Teflon is also used for making soles (bottoms) of electric irons.

Plastics are used extensively in the health care industry. For example, plastics are used in the packing of tablets, for making syringes, doctor’s gloves, threads for stitching wounds, and a number of medical instruments.

**Types of Plastics**

Plastics are of two types: Thermoplastics and Thermosetting plastics. We will now discuss these two types of plastics in detail, one by one. Let us start with thermoplastics.

1. **Thermoplastics**

Some plastics get soft (or melt) when heated, and hard again when they are cooled. Such plastics can be made soft and hard again and again. A plastic which can be softened repeatedly by heating and can be moulded into different shapes again and again, is called a thermoplastic. Thermoplastics are flexible so they can be bent easily (without breaking). Thermoplastics are also known as ‘thermosoftening’ plastics. Some of the examples of thermoplastics are: Polythene and Polyvinyl chloride (PVC).
If we take a plastic bottle (polythene bottle) and add quite hot water in it, the plastic bottle gets deformed—its shape changes and becomes irregular. This happens because the bottle is made of a thermoplastic (like polythene) which becomes soft on getting heated by hot water and changes shape. This activity shows that the articles made of thermoplastics become soft on heating. Let us now take a plastic bottle and press it by applying the force of our hands. We will find that the plastic bottle bends easily. This shows that the articles made of thermoplastics bend easily. In other words, we can say that thermoplastics are flexible. In fact, **thermoplastics are used for making those articles which do not get too hot, and are flexible**. Thermoplastics are used for making insulation of electric wires and cables, various types of plastic containers (plastic bottles, plastic jars, etc.), combs, toys, plastic bags, raincoats, seat covers, bristles of brushes, packaging materials and chairs. Thermoplastics are used for making the insulation of electric wires because (i) they do not conduct electricity, and (ii) they are flexible. Some of the articles (or objects) made of thermoplastics are shown in Figure 7.

**2. Thermosetting Plastics**

There are some plastics which get soft only once—the first time they are heated after being made. When such plastics are heated for the first time, they become soft (or melt) and can be moulded to make an article of any desired shape. On cooling, this article becomes very hard and rigid. When this plastic article is heated again, it does not become soft at all. **A plastic which once set, does not become soft on heating and cannot be moulded a second time, is called a thermosetting plastic.** Once set in a given shape and solidified, a thermosetting plastic cannot be re-softened or re-moulded. Thus, an article (or object) made of thermosetting plastic will retain its original shape permanently, even on heating. Thermosetting plastics are also known as thermosets. **Some of the examples of thermosetting plastics are: Bakelite and Melamine.** Thermosetting plastics are hard and rigid. Thermosetting plastics are not flexible. Due to this, thermosetting plastics cannot bend. When an article made of thermosetting plastic is forced to bend, it breaks.

If we take a discarded electric switch and put it in hot water for some time, we will find that the electric switch does not become soft. This is because an electric switch is made of a thermosetting plastic (called bakelite). This activity shows that thermosetting plastics do not become soft on heating. If we try to bend an electric switch by applying the force of our hands, we find that it does not bend at all. This shows that the articles made of thermosetting plastics are hard and rigid. The articles made of thermosetting plastics are not flexible. They do not bend at all. **Thermosetting plastics are used for making those articles which
may get too hot during use and are hard and rigid (so that they do not bend at all). Thermosetting plastics are used for making handles of cooking utensils (such as frying pans, pressure cookers, etc.), plates, cups, floor tiles, electrical fittings (such as electric switches, plugs and sockets), ballpoint pens and telephone instruments. Some of the articles made of thermosetting plastics are shown in Figure 8.

Thermosetting plastics are used for making handles of cooking utensils (such as frying pan handles and pressure cooker handles) because (i) they do not soften on getting heated, and (ii) they are poor conductors of heat. Thermosetting plastics are used for making electrical fittings such as electric switches, plugs and sockets, etc., because (i) they do not become soft on getting heated, and (ii) they do not conduct electricity. Please note that the handle and bristles of a toothbrush cannot be made of the same plastic because the handle of a toothbrush has to be hard and rigid whereas the bristles of a toothbrush have to be soft and flexible. This means that the handle of a toothbrush should be made of a thermosetting plastic whereas its bristles should be made of a thermoplastic.

We can tell whether a given plastic is thermoplastic or thermosetting plastic from the way it behaves on heating. If a given plastic article softens on heating, then it will be a thermoplastic. On the other hand, if the given plastic article does not become soft on heating, then it will be a thermosetting plastic. Moreover, thermoplastics are flexible and can be bent whereas thermosetting plastics are very hard and rigid which cannot be bent at all. Please note that the articles made of thermoplastics can be recycled whereas the articles made of thermosetting plastics cannot be recycled.

**Thermoplastics and Thermosetting Plastics Differ in Structure**

We will now discuss why thermoplastics can be softened by heat but thermosetting plastics cannot be softened by heat. This is due to the difference in their structure. It can be explained as follows: Both, thermoplastics and thermosetting plastics are made up of long chain molecules called polymers. In thermoplastics, the long polymer chains are not cross-linked with one another [see Figure 9(a)]. Due to

![Figure 9. Arrangement of polymer chains in thermoplastics and thermosetting plastics.](image-url)
this, on heating, the individual polymer chains can slide over one another and thermoplastic material becomes soft and ultimately melts. On the other hand, in thermosetting plastics, the long polymer chains are cross linked with one another [see Figure 9(b)]. These cross-links prevent the displacement (or sliding) of individual polymer chains on being heated. Due to this, thermosetting plastics do not become soft on heating (or change their shape on heating) once they have been set into a particular shape. For example, polythene is a thermoplastic having linear polymer chains with no cross-linkages, so it becomes soft on heating. On the other hand, bakelite is a thermosetting plastic having long polymer chains connected through cross-links (or held strongly through cross-links), due to which it does not become soft on heating.

**USEFUL PROPERTIES OF PLASTICS**

Plastics have many useful properties which make them materials of choice for all sorts of uses. Due to these special properties, plastics have many advantages over the traditional materials like metals, wood, etc., for making various articles. The important properties of plastics which make them very useful materials are given below.

(i) **Plastic is Chemically Unreactive**

We know that metals like iron get rusted (or corroded) when left exposed to air and water (moisture). This is because metals are chemically reactive. Plastics are chemically unreactive. Plastics do not react with air and water. Due to this, plastics are resistant to corrosion. In other words, plastics are not affected by the weather. Plastics are also often unaffected by various chemicals (including acids and bases). Since plastics are unreactive and resist corrosion, the plastic containers are used to store various kinds of materials, including many chemicals.

(ii) **Plastics are Poor Conductors of Heat and Electricity**

Plastics do not conduct heat or electricity, so they can be used as ‘insulators’. Plastics, being poor conductors of heat, are used where heat is to be kept away from reaching our hands. For example, the handles of cooking utensils (like frying pans and pressure cookers) are made of plastic so that we can hold the hot cooking utensil safely (without getting our hands burnt). Since plastics are poor conductors of electricity, they are used as electrical insulators. For example, electric wires have plastic covering as insulation so as to protect us from electric current passing through them. The handles of screw drivers used by electricians are also made of plastic because it is an electrical insulator. Electric switches, plugs and sockets also have plastic covers.

(iii) **Plastics Can be Moulded into Different Shapes**

Since plastics can be easily moulded, they are used to make a large variety of articles (or objects) having different shapes and sizes such as buckets, mugs, furniture (chairs, tables, etc.), bags, sheets, slippers, electrical fittings, toys, combs, toothbrushes, etc. The list is endless.

(iv) **Plastics are Quite Cheap and Easily Made**

Plastics are generally cheaper than metals. Plastics can also be made much more easily than metals. Due to these properties, plastics are now widely used for making many of the household and industrial articles which were earlier made from metals. For example, the buckets used in our homes were earlier made from iron metal sheet but these days most of the buckets are made of plastics.

(v) **Plastic is Light, Strong and Durable**

Plastics have low density, so they are lighter than metals. Plastics also have good strength and they are durable (long lasting). It is because of the lower price, easy availability, lightweight, good strength, durability and corrosion-resistance of plastic that the plastic containers are preferred for storing food, water, milk, jams, juices, pickles, squashes and soft drinks, etc. Being lighter than metals, plastics are also used in cars, aircrafts and spacecrafts.
BIODEGRADABLE AND NON-BIODEGRADABLE MATERIALS

A material which gets decomposed through natural processes (such as the action of bacteria) is called biodegradable. Plant wastes (such as peels of vegetables and fruits, fallen leaves, left-over food stuffs, etc.), animal wastes, paper, cotton cloth, woollen cloth, jute and wood, are all biodegradable materials. Biodegradable materials rot away with time and hence do not cause pollution in the environment. Thus, biodegradable materials are environment friendly.

A material which is not easily decomposed by natural processes (such as the action of bacteria) is called non-biodegradable. Plastics, glass, tin, aluminium cans, and other metal objects are non-biodegradable. Non-biodegradable materials do not rot away on their own and hence cause pollution in the environment. So, non-biodegradable materials are not environment friendly.

From the above discussion we conclude that two types of waste materials are produced in our day to day life: biodegradable wastes and non-biodegradable wastes. The biodegradable wastes and non-biodegradable wastes in our homes should be collected separately and disposed of separately.

PLASTICS AND THE ENVIRONMENT

When we go to the market, we usually get things put in plastic bags (polythene bags), or wrapped in plastic sheets or packed in plastic cartons. After we reach home, the plastic bags (polythene bags), plastic sheets and plastic cartons are no longer needed and become a waste. This is just one way in which the plastic wastes keep on getting accumulated in our homes. Ultimately the plastic wastes are dumped along with the household garbage. The use of plastics has a bad effect on the environment. The use of plastic materials affects the environment because of the following reasons:

(i) Plastic is non-biodegradable. So, the articles made of plastics (such as plastic bags, bottles and cartons) do not rot when they are thrown away after use. The waste plastic articles keep on accumulating in the surroundings and pollute the environment (see Figure 10). Thus, plastics are not environment friendly.

(ii) The waste plastic articles (like polythene bags, etc.) thrown here and there carelessly get into dirty water drains and sewers, and clog them (block them). This makes the dirty drain water (or sewer water) to flow over the streets and roads causing unhygienic conditions.

(iii) Sometimes the animals (like cows) eat up the used polythene bags or plastic wrappers along with the left-over food and vegetable wastes thrown on garbage dumps. The plastic wastes can choke the respiratory system of these animals or form a plastic lining in their stomach. This can cause the death of these animals.

(iv) When the plastic waste materials are burnt, they produce poisonous gases which pollute the air.

The Disposal of Plastic Wastes is a Major Problem. This is because of the following two big disadvantages of plastics:

(i) The articles made of plastics are non-biodegradable. They do not decompose (or rot) easily. This causes a great problem in the disposal of plastic wastes. So, plastic wastes cannot be disposed of easily.

(ii) The burning of plastic wastes gives out harmful gases which pollute the air. So, it is not advisable to dispose of the used plastic articles by burning.

How to Save the Environment From Excessive Plastic Wastes

Since the use of plastic articles is not good for the environment, we should take some steps to save the environment from the harmful effects of excessive use of plastics. Please note that plastics are very useful
materials for us, so it is not possible to stop the use of plastic articles altogether. We can take steps only to minimise the use of plastics, wherever possible. **Some of the steps which can be taken to save the environment from plastic wastes are as follows:**

(i) We should try to reduce (or minimise) the use of plastics by using other materials in their place. For example, we should use bags made of cotton cloth or jute for shopping instead of polythene bags (plastic bags). Paper bags can also be used. Similarly, a stainless steel lunch box can be used instead of a plastic lunch box.

(ii) We should not throw polythene bags (plastic bags), wrappers of chips, biscuits and other eatables in water bodies, on the roads, in parks or picnic places. The used plastic materials should be put in the dustbins provided at various public places. This will keep our surroundings clean and also prevent the blockage of dirty water drains and sewers.

(iii) We should reuse the plastic containers which come with jams, pickles, oils and other packed food materials for storing salt, spices, tea-leaves, and sugar, etc., in the kitchen. We can also reuse the plastic carry bags for shopping purposes instead of throwing them as a waste.

(iv) Plastic wastes should be recycled. All the plastic wastes in the homes, shops and industry should be collected and sent for recycling to plastic making factories. In plastic factory, the waste plastic articles are melted and used to make new plastic articles. During recycling of used plastic articles, certain colours are added. This is to tell the buyers that it is a recycled plastic product, and to avoid its use for the storage of food. Most of the articles made of thermoplastics can be recycled. The articles made of thermosetting plastics cannot be recycled.

We should remember the 3R’s to save the environment from the harmful effects of the excessive use of plastics. **The three R’s stand for: Reduce, Reuse and Recycle.** This means that we should reduce the use of plastic articles by using articles made of other suitable materials; we should reuse plastic articles wherever possible; and we should recycle old and discarded plastic articles, if possible. We are now in a position to **answer the following questions:**

### Very Short Answer Type Questions

1. Name the units of which cellulose polymer is made.
2. Name the man-made fibre prepared from natural materials.
3. Name the man-made fibre which is regarded as artificial silk.
4. Name the fibre obtained by the chemical treatment of wood pulp (or cellulose).
5. Name the first fully synthetic fibre.
6. Name the fibre used for making parachutes and rock climbing ropes.
7. Which synthetic fibre contains the organic group similar to those which give fruits their sweet smell?
8. Which synthetic fibre feels like wool and used as a substitute for wool?
9. To which kind of synthetic fibres does terylene belong?
10. State one disadvantage of using synthetic fibres for making clothes.
11. Name the form of polyester which is replacing materials like glass and used for making bottles and jars.
12. Name four different plastics.
13. Give one use of teflon.
14. Which of the two is a thermosetting plastic: PVC or bakelite?
15. Fill in the following blanks with suitable words:
   (a) Synthetic fibres are also called............or............fibres.
   (b) Synthetic fibres are made from raw materials called............
   (c) Like synthetic fibres, plastic is also a ..............
   (d) The use of plastics can be reduced by using bags made of ............or ...............instead of polythene bags.

### Short Answer Type Questions

16. What is a polymer? Name the natural polymer of which cotton is made.
17. State the characteristics of synthetic fibres.
18. What is nylon? State the important properties of nylon.
19. Give the important uses of nylon.
20. What is polyester? Name a popular polyester.
21. Arrange the following fibres in the order of increasing strength (keeping the fibre of least strength first):
   Nylon, Cotton, Wool, Polyester, Silk
22. What is PET? State the uses of PET.
23. What is acrylic? State one important property of acrylic.
24. Write the uses of acrylic fibres.
25. Why should we not wear clothes made of synthetic fibres (like nylon or polyester) while working in the kitchen?
26. What type of shirts should we buy for summer: cotton shirts or shirts made from synthetic materials (like polyester)? Give reason for your answer.
27. Explain how, manufacturing of synthetic fibres is actually helping in the conservation of forests.
28. What are plastics? Name any five commonly used articles made of plastics.
29. What are the various types of plastics? Give two examples of each type of plastics.
30. Why are thermoplastics not used for making frying pan handles?
31. Explain why, frying pan handles are made of thermosetting plastics.
32. Why are electric switches, plugs and sockets made of thermosetting plastics?
33. Explain the difference between thermoplastics and thermosetting plastics.
34. Should the handle and bristles of a toothbrush be made of the same type of plastic material? Explain your answer.
35. Explain why, plastic containers are preferred for storing food.
36. Choose the thermoplastics and thermosetting plastics from the following:
   Melamine, Polythene, Bakelite, Polyvinyl chloride
37. State two uses of polythene.
38. Write the full form of PVC. Is it thermoplastic or thermosetting plastic?
39. Write two uses of bakelite.
40. State two uses of melamine.
41. Give two uses of PVC.
42. Write some of the uses of plastics in healthcare industry.
43. Classify the following as biodegradable and non-biodegradable materials:
   Woollen clothes, Polythene bags, Paper, Aluminium cans, Toothbrush, Peels of vegetables and fruits, Cotton cloth, Jute bag, Electric switch, Frying pan handle
44. State whether plastic is biodegradable or non-biodegradable? Give reasons for your answer.
45. Explain how, the use of plastics has a bad effect on the environment.
46. Explain why, the disposal of plastic wastes is a major problem. Give two reasons only.
47. What are the various ways to save the environment from excessive plastic wastes?
48. How do carelessly thrown plastic bags (polythene bags) affect:
   (a) dirty water drains and sewers?
   (b) animals (such as cows)?
49. What is meant by the 3R’s principle in the context of use of plastics?
50. State the various ways in which we can avoid (or minimise) the use of plastics.

**Long Answer Type Questions**

51. (a) What is rayon? How is rayon made?
    (b) Give any two uses of rayon.
52. (a) What are synthetic fibres? Name any two synthetic fibres.
    (b) Why have synthetic fibres become more popular than natural fibres?
53. (a) What are thermoplastics? Give two examples of thermoplastics.
    (b) What are thermosetting plastics? Give two examples of thermosetting plastics.
54. Explain why, thermoplastics become soft on heating but thermosetting plastics do not become soft on heating. Draw labelled diagrams to illustrate your answer.
55. What is meant by biodegradable and non-biodegradable materials? Give examples of two biodegradable and two non-biodegradable materials.
Multiple Choice Questions (MCQs)

56. Rayon is different from truly synthetic fibres because:
   (a) it has a silk-like appearance.
   (b) it is obtained from wood pulp.
   (c) its fibres can be woven like those of natural fibres.
   (d) it can be dyed in a wide variety of colours.

57. The synthetic material which can be used for making fabrics as well as shatterproof bottles and jars is:
   (a) nylon
   (b) rayon
   (c) polyester
   (d) acrylic

58. Which of the following has cross-linked polymer chains?
   (a) bakelite
   (b) polyester
   (c) PVC
   (d) nylon

59. The man-made fibre made from the cellulose polymer is:
   (a) nylon
   (b) acrylic
   (c) rayon
   (d) polyester

60. Which of the following is not a thermoplastic polymer?
   (a) polyester
   (b) melamine
   (c) nylon
   (d) polyvinyl chloride

61. The synthetic polymer which can be used as a substitute for wool for making sweaters and shawls, etc., is:
   (a) nylon
   (b) polyester
   (c) terylene
   (d) acrylic

62. Which of the following is not a synthetic fibre?
   (a) nylon
   (b) flax
   (c) acrylic
   (d) polyester

63. The synthetic fibre which contains the organic groups similar to those which give fruits their ‘sweet smell’ is:
   (a) nylon
   (b) acrylic
   (c) terylene
   (d) rayon

64. The man-made fibre rayon is chemically identical to:
   (a) wool
   (b) silk
   (c) jute
   (d) cotton

65. One of the following man-made fibre is not prepared from raw materials obtained from petrochemicals. This one is:
   (a) polyester
   (b) rayon
   (c) terylene
   (d) acrylic

66. Which of the following plastics do not have cross-links between their polymer chains?
   A. Nylon  B. Melamine  C. Terylene  D. Bakelite
   (a) A and B
   (b) B and C
   (c) A and C
   (d) C and D

67. The clothes of a person working in the kitchen catch fire accidentally causing severe burns. The person is most likely wearing clothes made of:
   (a) flax
   (b) rayon
   (c) terylene
   (d) cotton

68. The plastic which is coated on the uniforms of firemen to make them fire-resistant is:
   (a) bakelite
   (b) polythene
   (c) teflon
   (d) melamine

69. Which of the following is a man-made fibre prepared from wood-pulp?
   (a) flax
   (b) nylon
   (c) acrylic
   (d) rayon

70. The manufacture of one of the following artificial fibres contributes to deforestation. This fibre is:
   (a) nylon
   (b) rayon
   (c) terylene
   (d) acrylic

71. The non-stick coating on frying pans is that of a plastic called:
   (a) polyvinyl chloride
   (b) melamine
   (c) bakelite
   (d) teflon

72. Which of the following plastics is used for making electric switches?
   (a) teflon
   (b) melamine
   (c) PET
   (d) bakelite

73. Which of the following are thermo-setting polymers?
   A. Melamine  B. Terylene  C. Polythene  D. Bakelite
   (a) A and B
   (b) B and C
   (c) A and D
   (d) B and D

74. The similarity between artificial silk and cotton is that:
   (a) both are non-biodegradable
   (b) both melt on heating
   (c) both are amide polymers
   (d) both are cellulose polymers

75. Which of the following plastic objects can be recycled?
   A. Electric socket  B. Polythene bag  C. PVC pipe  D. Ashtray
   (a) A and B
   (b) B and C
   (c) A and D
   (d) C and D
76. Match the terms of column A correctly with the phrases given in column B:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Polyester</td>
<td>(a) Prepared by using wood pulp</td>
</tr>
<tr>
<td>(ii) Teflon</td>
<td>(b) Used for making parachutes</td>
</tr>
<tr>
<td>(iii) Rayon</td>
<td>(c) Used to make non-stick cookware</td>
</tr>
<tr>
<td>(iv) Nylon</td>
<td>(d) Fabrics do not wrinkle easily</td>
</tr>
</tbody>
</table>

77. Which plastic is used:
(a) for making uniforms of fire-men fire resistant?
(b) for giving non-stick coating on frying pans?
(c) for making handles of frying pans?
(d) for making insulation (covering) of electric wires?
(e) for making electric switches?
(f) for making flexible water bottles?

78. Which of the following articles made of plastics ‘can be recycled’ and which ‘cannot be recycled’? Give reasons for your choice.
- Telephone instruments, Plastic toys, Cooker handles, Plastic covering on electrical wires, Electric switches, Ballpoint pens, Carry bags, Plastic bottles, Plastic chairs

79. Out of the following materials:
- Cotton, Nylon, Terylene, Wool, PET, Acrylic
(a) Which materials are polyesters?
(b) Which material is a polyamide?
(c) Which material is used as a substitute for wool?
(d) Which material is used as a substitute for glass?

80. The synthetic fibre A is chemically a polyamide whereas the synthetic fibre B contains a large number of ester groups. Another synthetic fibre C is made of a polymer D which consists of a number of glucose units joined one after the other.
(a) Which fibre could (i) terylene (ii) rayon, and (iii) nylon?
(b) Name the polymer D.
(c) Which fibre (A, B or C) is prepared from a natural raw material?
(d) Which fibre (A, B or C) contains the same type of groups as those in a PET jar?

ANSWERS

7. Polyester 9. Polyester 11. PET (Poly-Ethylene Terephthalate) 14. Bakelite 15. (a) man-made ; artificial (b) petrochemicals (c) polymer (d) cotton; jute 56. (b) 57. (c) 58. (a) 59. (c) 60. (b) 61. (d) 62. (b) 63. (c) 64. (d) 65. (c) 66. (c) 67. (c) 68. (d) 69. (d) 70. (b) 71. (d) 72. (d) 73. (c) 74. (d) 75. (b) 76. (i) d (ii) c (iii) a (iv) b 77. (a) Melamine (b) Teflon (c) Bakelite (d) PVC (Poly-Vinyl Chloride) (e) Bakelite (f) Polythene 78. Can be recycled: Plastic toys, Plastic covering on electrical wires, Carry bags, Plastic bottles, Plastic chairs — All these are made of thermoplastics; Cannot be recycled: Telephone instruments, Cooker handles, Electric switches, Ballpoint pens — All these are made of thermosetting plastics 79. (a) Terylene; PET (b) Nylon (c) Acrylic (d) PET 80. (a) (i) B (ii) C (iii) A (b) Cellulose (c) C (Rayon) (d) B (Terylene)
A substance which cannot be broken down into two (or more) simpler substances by chemical reactions (by applying heat, light or electricity) is called an element. For example, iron is an element because it cannot be broken down into two or more simpler substances by the usual methods of carrying out chemical reactions such as by applying heat, light or electricity. Please note that the elements themselves are the simplest substances. That is why they cannot be broken down (or split up) into any more simpler substances. Some of the common elements are: Hydrogen, Helium, Carbon, Nitrogen, Oxygen, Sulphur, Phosphorus, Silicon, Chlorine, Bromine, Iodine, Sodium, Potassium, Magnesium, Calcium, Aluminium, Iron, Zinc, Copper, Silver, Gold and Mercury. Every element is represented by a ‘symbol’. All the elements have separate symbols. No two elements can have the same symbol. A symbol is the short way to write an element. For example, the symbol of Hydrogen is H whereas the symbol of Magnesium is Mg. The symbol of an element also represents ‘one atom’ of that element. We will discuss the symbols of elements in detail in higher classes.

The smallest particle of an element is called ‘atom’. A sample of an element contains only one kind of atoms. This gives us another definition of element which can be written as: An element is a substance which is made up of only one kind of atoms. There are as many type of atoms as are elements. So, different elements are made up of different kinds of atoms. For example, sulphur element is made up of only sulphur atoms whereas iron element is made up of only iron atoms. The atoms of an element remain unaffected by the physical changes in the element. For example, an atom of liquid sulphur (molten sulphur) or vapour forms of sulphur would be exactly the same as that of solid sulphur. Although there is an enormous variety of substances in the universe but the number of elements forming these substances is limited. There are only 92 naturally occurring elements known to us at present. An important classification of elements is in terms of metals and non-metals. This is discussed on the next page.
**METALS AND NON-METALS**

On the basis of their properties, all the elements can be divided into two main groups: metals and non-metals. Iron, copper and aluminium are examples of metals whereas carbon, oxygen and sulphur are examples of non-metals. All the metals have similar properties. All the non-metals have also similar properties. But the properties of non-metals are opposite to those of metals. Both, metals as well as non-metals are used in our daily life. We also use a large number of compounds of metals and non-metals.

Before we go further and give the characteristics (identifying properties) of metals and non-metals, we should know the meaning of some new terms such as malleable, ductile, brittle and lustrous. **Malleable** means which can be beaten with a hammer to form thin sheets (without breaking). **Ductile** means which can be stretched (or drawn) to form thin wires. **Brittle** means which breaks into pieces on hammering or stretching. **Lustrous** means shiny (chamakdar). Keeping these points in mind, we will now give the characteristics of metals and non-metals.

**Characteristics of Metals**

The important characteristics of metals are as follows. **Metals are malleable and ductile elements which are good conductors of heat and electricity.** Metals are lustrous or shiny. Metals are usually hard and strong. They cannot be cut easily. All the metals are solids except mercury which is a liquid metal. Metals have high melting points and boiling points. Metals have high densities which means they are heavy. Metals are sonorous which means that metals make a ringing sound when we strike them with a hard object.

![Figure 1](image-url)

**Figure 1.** Iron, copper, silver and gold are metals.

Some of the examples of metals are: Iron, Copper, Aluminium, Zinc, Silver, Gold, Platinum, Chromium, Sodium, Potassium, Magnesium, Nickel, Cobalt, Tin, Calcium, Lead, Cadmium, Mercury, Antimony, Tungsten, Manganese and Uranium. Out of 92 naturally occurring elements, 70 elements are metals. All these metals are solids except one metal mercury which is a liquid.

**Characteristics of Non-Metals**

The important characteristics of non-metals are as follows. **Non-metals are the elements which are neither malleable nor ductile, they are brittle. Non-metals do not conduct heat and electricity.** Non-metals are not lustrous or shiny, they are dull in appearance. Solid non-metals are usually neither hard nor strong. They can be cut easily. Non-metals can be solid, liquid or gases at the room temperature. Non-metals have usually low melting points and boiling points. Non-metals have low densities which means they are light. Non-metals are not sonorous, which means non-metals do not make a ringing sound when we strike them with a hard object.

Some of the examples of non-metals are: Carbon, Sulphur, Phosphorus, Hydrogen, Oxygen, Nitrogen, Fluorine, Chlorine, Bromine, Iodine, Helium, Neon, Argon, Krypton and Xenon. Of the 92 naturally occurring elements, 22 elements are non-metals. Out of these, 10 non-metals are solids, 1 non-metal (bromine) is a liquid whereas the remaining 11 non-metals are gases.
Metalloids

There are some elements which show some properties of metals and the other properties of non-metals. The elements whose properties are intermediate between those of metals and non-metals are known as metalloids. For example, metals are good conductors of electricity whereas non-metals do not conduct electricity at all but metalloids conduct electricity to a small extent. Thus, metalloids are semiconductors. The examples of metalloids are: Silicon, Germanium, Arsenic and Tellurium. We will learn more about metalloids in higher classes. We will now discuss the properties of metals and non-metals in detail.

PHYSICAL PROPERTIES OF METALS AND NON-METALS

Metals and non-metals show different physical properties. The important physical properties of metals and non-metals are given below.

1. Malleability

(i) Metals are Malleable. This means that metals can be beaten into thin sheets with a hammer.

If we take a piece of aluminium metal, place it on a block of iron and beat it with a hammer, we will find that the piece of aluminium metal turns into a thin aluminium sheet, without breaking. And we say that aluminium metal is malleable or it shows malleability. The property which allows the metals to be hammered into thin sheets is called malleability. Malleability is an important characteristic property of metals. Most of the metals are malleable. Gold and silver are the best malleable metals and can be hammered into very fine sheets or foils. Aluminium and copper are also highly malleable metals. For example, aluminium metal can be hammered to form thin aluminium foils. Copper metal can also be hammered to form copper sheets. Iron is also a quite malleable metal which can be hammered to form iron sheets. It is due to the property of malleability that metals can be bent to form objects of different shapes by beating with a hammer. For example, it is because of the property of malleability of iron that an ironsmith can change the shape of a block of iron metal by hammering to make different iron objects such as an axe, a spade or a shovel, etc.

(ii) Non-Metals are Not Malleable. Non-Metals are Brittle. This means that non-metals cannot be beaten into thin sheets with a hammer. Non-metals break into small pieces when hammered.
Carbon is a non-metal. Carbon is found in many forms such as charcoal, coke, graphite and diamond, etc. Coal is also mainly carbon. The pencil lead is a form of carbon called graphite (see Figure 4). If we take a piece of carbon (say, a pencil lead or charcoal) and beat it with a hammer, it will break into pieces. We cannot hammer carbon (without breaking) to obtain thin sheets of carbon. Thus, carbon is a non-metal which is not malleable. Carbon is brittle. Sulphur is also a non-metal. If we hammer a piece of sulphur, it will break into smaller pieces. We cannot hammer sulphur to obtain thin sheets of sulphur. Thus, sulphur is a non-metal which is not malleable, it is brittle. From this discussion we conclude that we cannot obtain thin sheets by beating non-metals. When beaten with a hammer, solid non-metals break into pieces. The **property due to which non-metals break on hammering is called brittleness.** Brittleness is a characteristic property of solid non-metals.

2. Ductility

**(i)** **Metals are Ductile.** This means that metals can be drawn (or stretched) into thin wires.

Most of the metals are ductile. Gold and silver are among the best ductile metals. Copper and aluminium metals are also very ductile and can be drawn into thin copper wires and aluminium wires (which are used as electric wires). Iron, magnesium, and tungsten metals are also quite ductile and can be drawn into wires. Iron wires are used for making wire gauzes. Magnesium wires are used in science experiments in the laboratory. And thin wires of tungsten metal are used for making the filaments of electric bulbs. The **property which allows the metals to be drawn into wires is called ductility.** Ductility is another characteristic property of metals. From the above discussion we conclude that: **Generally, metals are malleable and ductile.**

**(ii)** **Non-Metals are Not Ductile.** This means that non-metals cannot be drawn into wires. They are easily snapped on stretching.

For example, sulphur and phosphorus are non-metals and they are not ductile. When stretched, sulphur and phosphorus break into pieces and do not form wires. Thus, we cannot get wires from non-metals. From the above discussion we conclude that: **Non-metals are neither malleable nor ductile.** Non-metals are brittle.

3. Conductivity

**(i)** **Metals are Good Conductors of Heat and Electricity.**

This means that metals allow heat and electricity to pass through them easily.

If we hold one end of a metal spoon (like an aluminium spoon) in hot water, then its other end becomes hot very soon. This is because the metal of spoon conducts heat (or carries heat) from one end to the other end quickly. And we say that the metal spoon is a good conductor of heat. **Copper, silver, gold, aluminium and iron metals are good conductors of heat.** Though all the metals are good conductors of heat, **silver metal is the best conductor of heat.** Copper metal is a better conductor of heat than aluminium metal. The cooking utensils
Like a frying pan, etc.) are made of metals because metals are good conductors of heat (see Figure 6). Being a good conductor of heat, the metallic bottom of cooking utensils transfers the heat of the gas stove quickly to the food kept inside it. We cannot hold a hot metal pan directly because it will conduct the heat quickly to our hand causing burns. We have to hold a hot metal pan from its handle made of plastic or wood (because plastic and wood do not conduct heat).

ACTIVITY

Let us now show the conduction of electricity by metals. We take a cell, a torch bulb fitted in a holder and some connecting wires (copper wires) with crocodile clips, and connect them to make an electric circuit as shown in Figure 7. Let us insert a piece of aluminium foil between the ends of crocodile clips A and B. We will see that the torch bulb lights up at once (see Figure 7). This means that aluminium foil allows electric current to pass through it. In other words, aluminium metal is a good conductor of electricity. Let us now remove the aluminium foil and insert an iron nail between the two ends of crocodile clips A and B. The bulb will light up again showing that iron metal is also a good conductor of electricity. The connecting wires used in making the circuit shown in Figure 7 are made of copper metal. Since the copper connecting wires allow electric current to pass through them, therefore, copper metal is also a good conductor of electricity. From this activity we conclude that metals are good conductors of electricity. Copper wires are used in household electric wiring because copper metal is a very good conductor of electricity. Copper metal is a better conductor of electricity than aluminium. Silver metal is the best conductor of electricity.

(ii) Non-Metals are Poor Conductors of Heat and Electricity. This means that non-metals do not allow heat and electricity to pass through them.

For example, sulphur is a non-metal which does not conduct heat or electricity. Similarly, a piece of coal (which is mainly carbon non-metal) also does not conduct heat or electricity. Many of the non-metals are, in fact, very good insulators. There are, however, some exceptions. A form of the carbon element, diamond is a non-metal which is a good conductor of heat. And another form of carbon element, graphite is a non-metal which is a good conductor of electricity. Being a good conductor of electricity, graphite is used for making electrodes (as that in dry cells).

4. Lustre

(i) Metals are Lustrous (or Shiny). This means that metals have a shiny appearance.

If we observe the freshly cut surfaces of metals, we will find that they have a shiny appearance. This is called metallic lustre (or chamak). The shiny appearance of metals makes them useful in making jewellery and decoration pieces. For example, gold and silver are used for making jewellery because they are bright and shiny.

(ii) Non-Metals are Not Lustrous. They are Dull. This means that non-metals are not shiny, they are dull in appearance.

For example, sulphur and phosphorus are solid non-metals which do not have lustre (or shine). They are dull in appearance. There is, however, one exception. Iodine is a non-metal having lustre (or chamak). Iodine has a shining surface like that of metals.

Figure 7. Metals conduct electricity. Here an aluminium foil is conducting electricity.

Figure 8. Metals are lustrous (or shiny). These bangles are made of gold because it is a highly lustrous (or shiny) metal.
5. Strength

(i) **Metals are Usually Strong. They have High Tensile Strength.**

This means that metals can hold large weights without snapping (without breaking).

For example, iron metal (in the form of steel) is very strong having a high tensile strength. Due to this iron metal is used in the construction of bridges, buildings, railway lines, girders, machines, vehicles and chains, etc. Though most of the metals are strong but some of the metals are not strong. For example, sodium and potassium metals are not strong. They have low tensile strength.

(ii) **Non-Metals are Not Strong. They have Low Tensile Strength.**

This means that non-metals cannot hold large weights. They are easily snapped.

For example, graphite is a non-metal which is not strong. It has a low tensile strength. So, when a large weight is placed on a graphite sheet, it gets snapped (breaks).

6. Sonorousness

(i) **Metals are Sonorous.** This means that metals make a ringing sound when we strike them.

Sonorous means capable of producing a ringing sound. If we drop a metal coin or a metal utensil on the floor of our house, we hear a ringing sound. And when the clapper (or hammer) of an electric bell strikes the metal gong, even then a ringing sound is produced. So, the metal objects make a ringing sound when we drop them on a hard floor or strike them with a hard object. We say that the metals are sonorous (or capable of producing a ringing sound). Suppose we have two boxes, one box made of metal and the other box made of wood, which are similar in appearance. We can tell which box is made of metal by striking them with a small hammer. The box which produces a ringing sound on being struck by the hammer will be the one made of metal. Metal sheets are used for making bells (like the bicycle bells and temple bells). The use of metals for making bells is based on their property of being sonorous.

(ii) **Non-Metals are Not Sonorous.** This means that solid non-metals do not make a ringing sound when we strike them.

If we drop a piece of carbon (say, a piece of charcoal) or a lump of sulphur on the floor or strike them with a hammer, we do not hear any ringing sound. This means that carbon and sulphur non-metals are not sonorous. They are not capable of producing a ringing sound when struck.

7. Hardness

(i) **Metals are Generally Hard.** This means that most of the metals cannot be cut easily.

Though most of the metals are hard but their hardness varies from one metal to another. For example, if we try to cut a thin sheet of iron metal with a pair of scissors, we will find that it is very, very difficult to cut the sheet of iron. This is because iron
metal is very hard. On the other hand, a thin sheet of aluminium metal can be cut easily by using scissors. This means that aluminium metal is less hard. There are, however, some exceptions to this property of hardness of metals. **Sodium and potassium metals are soft and can be easily cut with a knife.** For example, if we try to cut a lump of sodium metal with a dry knife, we will find that it can be easily cut into small pieces (just like wax). This shows that sodium metal is soft. Magnesium metal can also be cut easily.

**(ii) Most of the Solid Non-Metals are Quite Soft.** This means that most of the solid non-metals can be cut easily.

For example, sulphur and phosphorus are soft non-metals which can be easily cut into pieces with a knife. Only one non-metal, diamond, is very hard. In fact, diamond is the hardest natural substance known.

**Comparison Between the Physical Properties of Metals and Non-Metals**

We will now compare the physical properties of metals and non-metals in tabular form. These physical properties can be used to distinguish between metals and non-metals.

<table>
<thead>
<tr>
<th>Differences in Physical Properties of Metals and Non-Metals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metals</strong></td>
</tr>
<tr>
<td>1. Metals are malleable and ductile.</td>
</tr>
<tr>
<td>2. Metals are good conductors of heat and electricity.</td>
</tr>
<tr>
<td>3. Metals are lustrous (or shiny).</td>
</tr>
<tr>
<td>4. Metals are strong. They have high tensile strength (except sodium and potassium which are not strong and have low tensile strength).</td>
</tr>
<tr>
<td>5. Metals are sonorous. They make a ringing sound when struck.</td>
</tr>
<tr>
<td>6. Metals are generally hard (except sodium and potassium which are soft metals).</td>
</tr>
</tbody>
</table>

An element can be identified as being a metal or a non-metal by comparing its properties with the general properties of metals and non-metals. While doing so we should, however, keep the various exceptions to the general properties of metals and non-metals in mind. We will now answer one question based on metals and non-metals.

**Sample Problem.** State two reasons for believing that copper is a metal and sulphur is a non-metal.

**Answer.** The two properties which tell us that copper is a metal and sulphur is a non-metal are given below.

<table>
<thead>
<tr>
<th>Copper</th>
<th>Sulphur</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Copper is malleable and ductile. It can be hammered into thin sheets and drawn into wires.</td>
<td>1. Sulphur is neither malleable nor ductile. It is brittle. Sulphur breaks into pieces when hammered or stretched.</td>
</tr>
<tr>
<td>2. Copper is a good conductor of heat and electricity.</td>
<td>2. Sulphur is a poor conductor of heat and electricity.</td>
</tr>
</tbody>
</table>
**CHEMICAL PROPERTIES OF METALS AND NON-METALS**

Metals and non-metals show different chemical properties. Some of the important chemical properties of metals and non-metals are given below.

1. **Reaction with Oxygen**
   
   *(i)* Metals react with oxygen to form metal oxides. Metal oxides are basic in nature.

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

   Thus, on burning, metals react with oxygen to form basic oxides. **The basic metal oxides turn red litmus to blue.** This property will become clear from the following activity.

   **ACTIVITY**

   Magnesium is a metal. We take a magnesium wire, hold it with a pair of tongs and heat it over a flame. Magnesium wire burns vigorously producing a bright white light to form an ash (which is magnesium oxide). We put this magnesium oxide ash in a boiling tube, add a little water in the boiling tube and shake it. We will find that magnesium oxide dissolves in water partially. We now add some red litmus solution to the boiling tube and observe the change in colour. We will see that red litmus solution turns blue. This shows that magnesium oxide is basic in nature (because only basic substances turn red litmus to blue). From this activity we conclude that magnesium is a metal which forms a basic oxide (magnesium oxide) on burning in air. This basic magnesium oxide turns red litmus blue.

   The chemical reactions involved in the above activity are given below:

   *(a)* When magnesium burns in air, it combines with the oxygen of air to form magnesium oxide (which is a basic oxide):

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

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

   *(b)* Magnesium oxide dissolves partially in water to form magnesium hydroxide solution:

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

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

   Magnesium hydroxide turns red litmus to blue showing that it is a base and that magnesium oxide is a basic oxide.

   Similarly, sodium is a metal which forms a basic oxide, sodium oxide (Na\(_2\)O). A solution of sodium oxide in water turns red litmus blue. Please note that when we want to react a metal with oxygen, we usually burn the metal in air. It is the oxygen present in air which combines with the metal on burning to form a metal oxide.

   **We will now discuss the reaction of iron metal with oxygen of air which takes place in nature.** We have studied the rusting of iron in Class VII. During the rusting of iron, iron metal combines slowly with the oxygen of air in the presence of water (moisture) to form a compound called ‘iron oxide’. This iron oxide is rust. The reaction of iron metal with oxygen in the presence of water can be written as follows:

   \[
   \text{Iron} + \text{Oxygen} + \text{Water} \rightarrow \text{Iron oxide}
   \]

   \[
   (\text{Fe}) + (\text{O}_2) + (\text{H}_2\text{O}) \rightarrow (\text{Fe}_2\text{O}_3)
   \]

   Rust (A basic oxide)
**ACTIVITY**

We will now describe an activity to show that iron oxide (or rust) is basic in nature. Take a spoonful of rust (from any rusted iron object) in a test-tube, add a little of water and shake it well. In this way, we will get a suspension of iron oxide in water. Test this suspension of iron oxide (or rust) with blue litmus paper and red litmus paper, one by one. We will find that the red litmus paper turns blue. This shows that iron oxide suspension is basic in nature (because only basic substances turn red litmus paper to blue). From this activity we conclude that iron metal forms a basic oxide (iron oxide) on reaction with oxygen of air. In other words, rust is basic in nature.

We will now describe the reaction of copper metal with moist air which takes place in nature. When a copper object is exposed to moist air for a long time, then copper reacts with water, carbon dioxide and oxygen present in moist air to form a green coating on the copper object. The green coating (or green material) is a mixture of copper hydroxide \([\text{Cu(OH)}_2]\) and copper carbonate \((\text{CuCO}_3)\) which is formed by the action of moist air on copper object. This reaction can be written as:

\[
\begin{align*}
2 \text{Cu} & + \text{H}_2\text{O} + \text{CO}_2 + \text{O}_2 \rightarrow \text{Cu(OH)}_2 + \text{CuCO}_3 \\
\text{Copper} & \quad \text{Water} \quad \text{Carbon} \quad \text{Oxygen} \quad \text{Copper} \quad \text{Copper} \\
\text{From moist air} & \quad \text{dioxide} \quad \text{hydroxide} \quad \text{carbonate} \quad \text{Green coating}
\end{align*}
\]

Thus, when a copper vessel is exposed to moist air for a long time, it acquires a green coating on its surface. The mixture of copper hydroxide and copper carbonate which forms the green coating is commonly known as ‘basic copper carbonate’ (because it is basic in nature). If we make a suspension of a little of green coating (from a copper vessel) in water and test it with litmus papers, we will find that it turns red litmus paper to blue. This shows that the green coating formed on a copper vessel (or any other copper object) is basic in nature. **The formation of green coating of basic copper carbonate on the surface of copper objects on exposure to moist air is called corrosion of copper.** While iron rusts, other metals corrode.

**(ii) Non-metals react with oxygen to form non-metal oxides. Non-metal oxides are acidic in nature.**

\[
\begin{align*}
\text{Non-metal} & + \text{Oxygen} \rightarrow \text{Non-metal oxide} \\
& \quad \text{(From air)} \quad \text{(Acidic oxide)}
\end{align*}
\]

Thus, non-metals react with oxygen to form acidic oxides. The acidic non-metal oxides turn blue litmus to red. This property will become more clear from the following activity.

**ACTIVITY**

Sulphur is a non-metal. We take a small amount of sulphur powder in a deflagrating spoon and heat it over a flame [Figure 13(a)]. As soon as sulphur starts burning with a blue flame, we introduce the deflagrating spoon in a gas jar and allow the sulphur to burn inside the gas jar [Figure 13(b)]. Cover the gas jar with a lid to prevent the gas being formed from escaping. Sulphur burns in the air of gas jar to form a pungent smelling gas (sulphur dioxide) [Figure 13(c)]. Remove the deflagrating spoon from the gas jar. We now put some water in the gas jar, cover it with a lid and shake it to dissolve sulphur dioxide gas. Add some blue litmus solution to the gas jar. We will see that the blue litmus solution turns red. This shows that sulphur dioxide gas is acidic in nature (because only acidic substances turn blue litmus to red). From this activity we conclude that **sulphur is a non-metal which forms an acidic oxide (sulphur dioxide) on burning in air.**
The chemical reactions involved in this activity are given below:

(i) When sulphur burns in air, it combines with the oxygen of air to form sulphur dioxide (which is an acidic oxide):

\[
\text{Sulphur} + \text{Oxygen} \rightarrow \text{Sulphur dioxide}
\]

\[
\text{(S)} + \text{(O}_2\text{)} \rightarrow \text{(SO}_2\text{)}
\]

(ii) Sulphur dioxide dissolves in water to form sulphurous acid solution:

\[
\text{Sulphur dioxide} + \text{Water} \rightarrow \text{Sulphurous acid}
\]

\[
\text{(SO}_2\text{)} + \text{(H}_2\text{O)} \rightarrow \text{(H}_2\text{SO}_3\text{)}
\]

This sulphurous acid turns blue litmus to red showing that it is an acid and that sulphur dioxide is acidic in nature. Similarly, carbon is a non-metal which forms an acidic oxide, carbon dioxide (CO\textsubscript{2}). A solution of carbon dioxide in water turns blue litmus red. From the above discussions we conclude that:

(i) Metals form metal oxides on burning in air. **Metal oxides are basic in nature and turn red litmus to blue.**

(ii) Non-metals form non-metal oxides on burning in air. **Non-metal oxides are acidic in nature and turn blue litmus to red.**

This property of the nature of oxides can be used to identify whether a given element is a metal or a non-metal. This is because:

(a) If an element forms a basic oxide (which turns red litmus blue), then the element will be a metal.

(b) If an element forms an acidic oxide (which turns blue litmus red), then the element will be a non-metal.

We have studied acids and bases in Class VII. We can now understand that **metal oxides are basic in nature and form bases on dissolving in water.** On the other hand, **non-metal oxides are acidic and form acids on dissolving in water.** Some of the bases and acids, and the metals and non-metals present in them (from whose oxides they are formed) are given below:

<table>
<thead>
<tr>
<th>Metals in Bases</th>
<th>Non-Metals in Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name of base</strong></td>
<td><strong>Name of metal</strong></td>
</tr>
<tr>
<td>1. Magnesium hydroxide</td>
<td>Magnesium</td>
</tr>
<tr>
<td>2. Calcium hydroxide</td>
<td>Calcium</td>
</tr>
<tr>
<td>3. Sodium hydroxide</td>
<td>Sodium</td>
</tr>
<tr>
<td>4. Potassium hydroxide</td>
<td>Potassium</td>
</tr>
</tbody>
</table>
Please note that most of the non-metals form acidic oxides but there are some exceptions. This is because some of the non-metals form neutral oxides (which are neither acidic nor basic). For example, hydrogen is a non-metal which forms a neutral oxide \( \text{H}_2\text{O} \) (which is commonly known as water).

2. Reaction with Water

(i) When a metal reacts with water, then a metal hydroxide and hydrogen gas are formed.

\[
\text{Metal + Water} \rightarrow \text{Metal hydroxide + Hydrogen}
\]

The vigour (or intensity) of reaction of a metal with water depends on its chemical reactivity. Some metals react vigorously even with cold water, some metals react with hot water, some metals react with steam whereas some metals do not react even with steam. For example, sodium is a very reactive metal, therefore, sodium metal reacts violently even with cold water. Magnesium is a comparatively less reactive metal so it reacts slowly with cold water, it reacts rapidly only with hot boiling water or steam. The metals like zinc and iron are less reactive which react slowly even with steam. And the metals like copper, silver and gold are so unreactive that they do not react with water or even with steam. The reaction of sodium metal with water is described below.

Sodium metal reacts violently (explosively) with cold water forming sodium hydroxide solution and hydrogen gas:

\[
\text{Sodium} + \text{Water} \rightarrow \text{Sodium hydroxide} + \text{Hydrogen}
\]

Thus, the gas liberated when sodium metal (or any other metal) reacts with water is hydrogen. The reaction of sodium metal with water can be studied as follows.

**ACTIVITY**

We cut a small piece of sodium metal carefully and dry it by using a filter paper. This piece of sodium metal is placed in water filled in a beaker. We will find that the piece of sodium metal starts moving in water making a hissing sound due to formation of bubbles of a gas and reacts with water causing little explosions. Soon the piece of sodium metal catches fire (see Figure 14). When the reaction stops, touch the beaker, We will feel the beaker to be somewhat hot. This is because heat is produced in this reaction. If we test the solution in the beaker with red and blue litmus papers one by one, we will find that it turns red litmus paper blue. This shows that the solution formed by the reaction of sodium and water is basic in nature. These observations can be explained as follows: Sodium metal reacts with water to form sodium hydroxide and hydrogen gas. A lot of heat is also produced in this reaction. This heat burns the hydrogen gas as well as sodium metal. The burning of hydrogen gas causes little explosions. The formation of sodium hydroxide makes the solution basic. And this basic solution turns red litmus paper blue.

Sodium is a very reactive metal. It reacts with the moisture (water), oxygen and other gases present in air. So, if sodium metal is kept exposed to air, it will react with the various components of air and get spoiled. In order to prevent its reaction with the moisture and other gases of air, sodium metal is always stored under kerosene. Potassium metal is also highly reactive. So, potassium metal is also stored in kerosene.

(ii) Non-metals do not react with water.

Sulphur is a non-metal. Sulphur does not react with water. In fact, some of the reactive non-metals are kept under water to protect them from the action of air. For example, phosphorus is a very reactive non-
metal element. If phosphorus is kept open in the air, it reacts with the oxygen of air and catches fire. So, in order to protect phosphorus from atmospheric air, it is stored in a bottle containing water.

3. Reaction with Acids

(i) Most of the metals react with dilute acids to form salts and hydrogen gas.

\[ \text{Metal} + \text{Acid} \rightarrow \text{Salt} + \text{Hydrogen} \]

Only the less reactive metals like copper, silver and gold do not react with dilute acids. The vigour of reaction of a metal with dilute acid depends on the chemical reactivity of the metal. Depending on their reactivity, some metals react violently (explosively) with dilute acids, some metals react rapidly with dilute acids, some metals react with dilute acids only on heating whereas some metals do not react with dilute acids at all. The reaction of magnesium metal with dilute hydrochloric acid is given below.

Magnesium metal reacts with *dilute* hydrochloric acid to form magnesium chloride and hydrogen gas. This reaction can be written as:

\[ \text{Mg} + \text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2 \]

Aluminium, iron and zinc metals also react with dilute hydrochloric acid to form the corresponding metal chlorides and hydrogen gas. This hydrogen gas burns with a ‘pop’ sound when a lighted matchstick is brought near the mouth of test-tube (containing metal and dilute hydrochloric acid). The less reactive metals like copper, silver and gold do not react with dilute acids (like dilute hydrochloric acid or dilute sulphuric acid). Thus, copper, silver and gold do not produce hydrogen gas with dilute acids.

**ACTIVITY**

We will now describe a simple activity to show that when a metal reacts with a dilute acid, then hydrogen gas is produced. We take four test-tubes. Put a small piece of magnesium ribbon in the first test-tube, a piece of aluminium foil in the second test-tube, some iron filings in the third test-tube and a piece of uncovered copper wire in the fourth test-tube. Add 10 mL of dilute hydrochloric acid in each test-tube and warm them gently. Test the gas produced in each test-tube by bringing a lighted matchstick (or burning matchstick) near the mouth of each test-tube.

(i) When we bring a lighted matchstick near the mouth of the first test-tube containing a piece of magnesium ribbon and dilute hydrochloric acid, the gas produced burns with a ‘pop’ sound, showing that it is hydrogen gas.

(ii) When we bring a lighted matchstick near the mouth of the second test-tube containing a piece of aluminium foil and dilute hydrochloric acid, the gas burns with a ‘pop’ sound showing that it is hydrogen gas.

(iii) When we bring a lighted matchstick near the mouth of the third test-tube containing iron filings and dilute hydrochloric acid, the gas burns with a ‘pop’ sound showing that it is hydrogen gas.

(iv) When we bring a lighted matchstick near the mouth of the fourth test-tube containing a piece of copper wire and dilute hydrochloric acid, nothing happens showing that no hydrogen gas is produced in this case.

This activity shows that though magnesium, aluminium and iron metals react with dilute hydrochloric acid to produce hydrogen gas but copper metal does not react with dilute hydrochloric acid to form hydrogen gas. Dilute sulphuric acid reacts with these metals in a similar way.

Copper metal also does not react with dilute sulphuric acid to produce hydrogen gas. Copper metal, however, reacts with hot and concentrated sulphuric acid but no hydrogen gas is produced. We will study these reactions in higher classes.

The reactions of metals with acids have some important implications in our daily life. Certain foodstuffs like citrus fruit juices (say, orange juice), pickles, *chutney* and curd, etc., contain acids. When foodstuffs containing acids are kept in iron, aluminium or copper containers, the acids present in them
react with the metal of the container slowly to form toxic salts (or poisonous salts). And these toxic salts can make us sick and damage our health. So, iron, aluminium and copper containers (or utensils) should not be used to store acidic foods like citrus fruit juices (such as orange juice), pickles, chutney and curd, etc. For example, we cannot store lemon pickle in an aluminium vessel. This is because the acid present in lemons will react with aluminium metal of vessel to form toxic salts which can make us sick and damage our health.

(ii) Non-metals do not react with dilute acids.
Non-metals do not react with dilute acids to form salts and hydrogen gas. For example, if we take some sulphur powder (or charcoal powder) in a test-tube and add dilute hydrochloric acid, then no reaction takes place even on heating. This shows that sulphur and carbon non-metals do not react with dilute acids and hence no hydrogen gas is produced. Some of the non-metals, however, react with hot and concentrated sulphuric acid and nitric acid but no hydrogen gas is produced in such cases. We will study these reactions in higher classes.

4. Reaction with Bases

(i) Some metals react with bases to form salts and hydrogen gas.

\[
\text{Metal} + \text{Base} \rightarrow \text{Salt} + \text{Hydrogen}
\]

Aluminium is a metal and sodium hydroxide is a base. When aluminium is heated with sodium hydroxide solution, then sodium aluminate (salt) and hydrogen gas are formed:

\[
\text{Sodium hydroxide} + \text{Aluminium} \rightarrow \text{Sodium aluminate} + \text{Hydrogen}
\]

\[
(\text{NaOH}) \quad (\text{Al}) \quad (\text{NaAlO}_2) \quad \text{H}_2
\]

**ACTIVITY**
We can demonstrate the formation of hydrogen gas in the reaction of aluminium metal with sodium hydroxide as follows: Take 5 mL of freshly prepared sodium hydroxide solution in a boiling tube. Drop a piece of aluminium foil in the sodium hydroxide solution and heat the boiling tube over a burner. Bring a lighted matchstick near the mouth of boiling tube. We will find that the gas produced burns with a 'pop' sound showing that it is hydrogen gas.

Zinc metal also reacts with sodium hydroxide solution to form hydrogen gas. Thus, **aluminium and zinc are the two common metals which react with bases (like sodium hydroxide) to produce hydrogen gas.** In general we can say that: Some metals react with sodium hydroxide to produce hydrogen gas. Please note that **all the metals do not react with bases (like sodium hydroxide) to produce hydrogen gas.**

(ii) Some non-metals react with bases (like sodium hydroxide) but no hydrogen gas is produced. The reactions of non-metals with bases are complex. We will study these reactions in higher classes.

Before we go further and study the displacement reactions of metals, we should know the reactivity series of metals. This is described below.

**REACTIVITY SERIES OF METALS.** Some metals are chemically very reactive whereas other metals are less reactive or unreactive. On the basis of vigour of reactions of various metals with oxygen, water and acids, as well as the displacement reactions, the metals have been arranged in a group (or series) according to their chemical reactivities. **The arrangement of metals in a vertical column in the order of decreasing reactivities is called the reactivity series of metals** (or activity series of metals). In reactivity series, the most reactive metal is placed at the top whereas the least reactive metal is placed at the bottom. The reactivity series of some common metals is given on the next page.
**Reactivity Series of Metals**

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium</td>
<td>(K)</td>
</tr>
<tr>
<td>Sodium</td>
<td>(Na)</td>
</tr>
<tr>
<td>Calcium</td>
<td>(Ca)</td>
</tr>
<tr>
<td>Magnesium</td>
<td>(Mg)</td>
</tr>
<tr>
<td>Aluminium</td>
<td>(Al)</td>
</tr>
<tr>
<td>Zinc</td>
<td>(Zn)</td>
</tr>
<tr>
<td>Iron</td>
<td>(Fe)</td>
</tr>
<tr>
<td>Lead</td>
<td>(Pb)</td>
</tr>
<tr>
<td>Copper</td>
<td>(Cu)</td>
</tr>
<tr>
<td>Silver</td>
<td>(Ag)</td>
</tr>
<tr>
<td>Gold</td>
<td>(Au)</td>
</tr>
</tbody>
</table>

Please note that **potassium is the most reactive metal, so it has been placed at the top of the reactivity series.** As we come down in the reactivity series, the chemical reactivity of metals decreases gradually. For example, sodium is less reactive than potassium; calcium is less reactive than sodium; magnesium is less reactive than calcium; aluminium is less reactive than magnesium; zinc is less reactive than aluminium; iron is less reactive than zinc, copper is less reactive than iron and silver is less reactive than copper. **Gold being the least reactive metal here has been placed at the bottom of the reactivity series.** We should remember the reactivity series of metals because it will help us in understanding the displacement reactions of metals.

**5. Displacement Reactions**

(i) **A more reactive metal displaces a less reactive metal from its salt solution.** This means that when a more reactive metal is placed in the salt solution of a less reactive metal, then the more reactive metal displaces (pushes out) the less reactive metal from its salt solution. The more reactive metal becomes a part of the salt whereas the less reactive metal is set free. Let us take some examples to make this point more clear.

(a) **Reaction of Iron Metal with Copper Sulphate Solution.** When a strip of iron metal (or an iron nail) is placed in copper sulphate solution for some time, then the blue colour of copper sulphate solution fades and a red-brown coating of copper metal is deposited on the iron strip (or iron nail). This reaction can be written as:

\[
\text{Copper sulphate} + \text{Iron} \rightarrow \text{Iron sulphate} + \text{Copper} \\
(CuSO}_4 \quad (Fe) \quad (FeSO}_4 \quad (Cu) \\
(\text{Blue solution}) \quad (Grey) \quad (Greenish solution) \quad (\text{Red-brown})
\]

In this case the solution turns greenish due to the formation of iron sulphate. We know that iron metal is more reactive than copper metal. So, **in this reaction, a more reactive metal ‘iron’ is displacing a less reactive metal ‘copper’ from its salt solution, copper sulphate solution.** The products of this displacement reaction are ‘iron sulphate solution’ and ‘copper metal’. Please note that the blue colour of copper sulphate solution changes to greenish due to the formation of iron sulphate (which is green in colour). The copper metal produced in this displacement reaction forms a red-brown coating over the iron strip (or iron nail). In the above displacement reaction, **iron metal displaces copper from copper sulphate solution.** This displacement reaction takes place because iron is more reactive than copper. The displacement reaction between iron metal and copper sulphate solution can be performed as follows.
**ACTIVITY**

We take about 50 mL of water in a beaker and dissolve 5 grams of copper sulphate in it to obtain copper sulphate solution (which is blue in colour). Put a clean iron nail in copper sulphate solution in the beaker and keep the beaker undisturbed for some time. We will find that the blue colour of copper sulphate solution starts fading gradually. And the iron nail gets covered with a red-brown layer of copper metal. This change takes place because iron metal displaces copper metal from its compound copper sulphate. It is the copper metal set free from its compound which forms a red-brown layer on the surface of iron nail.

We will now discuss the reverse case in which a copper strip is placed in iron sulphate solution. A less reactive metal cannot displace a more reactive metal from its salt solution. For example, if we place a strip of copper metal in iron sulphate solution for some time, then no displacement reaction takes place. That is:

\[
\text{Iron sulphate } + \text{ Copper } \rightarrow \text{ No displacement reaction}
\]

\[
(\text{FeSO}_4) + (\text{Cu}) \rightarrow \text{No reaction}
\]

This displacement reaction does not occur because copper metal is less reactive than iron metal. So, a less reactive metal ‘copper’ cannot displace a more reactive metal ‘iron’ from its salt solution, iron sulphate solution. Thus, copper metal cannot displace iron from iron sulphate solution.

**\(b\)** **Reaction of Zinc Metal with Copper Sulphate Solution.** When a strip of zinc metal is placed in copper sulphate solution for some time, then the blue colour of copper sulphate solution fades gradually and red-brown copper metal is deposited on the zinc strip. This reaction can be written as:

\[
\text{Copper sulphate } + \text{ Zinc } \rightarrow \text{ Zinc sulphate } + \text{ Copper}
\]

\[
(\text{CuSO}_4) + (\text{Zn}) \rightarrow (\text{ZnSO}_4) + (\text{Cu})
\]

We know that zinc metal is more reactive than copper metal. So, in this reaction, a more reactive metal ‘zinc’ is displacing a less reactive metal ‘copper’ from its salt solution, copper sulphate solution. The products of this displacement reaction are ‘zinc sulphate solution’ and ‘copper metal’. Please note that the blue colour of the copper sulphate solution gradually disappears due to the formation of colourless zinc sulphate solution. The copper metal which is formed in this displacement reaction deposits on the zinc strip in the form of a red-brown coating. In the above displacement reaction, **zinc metal displaces copper metal from copper sulphate solution.** This displacement reaction between zinc and copper sulphate solution occurs because zinc is more reactive than copper. Let us now discuss the reverse case in which a copper strip is placed in zinc sulphate solution.

If we place a strip of copper metal in zinc sulphate solution, then no displacement reaction will take place. That is:

\[
\text{Zinc sulphate } + \text{ Copper } \rightarrow \text{ No displacement reaction}
\]

\[
(\text{ZnSO}_4) + (\text{Cu}) \rightarrow \text{No reaction}
\]
This displacement reaction does not take place because copper metal is less reactive than zinc metal. So, a less reactive metal ‘copper’ cannot displace a more reactive metal ‘zinc’ from its salt solution, zinc sulphate solution. Thus, copper cannot displace zinc from zinc sulphate solution.

(c) Reaction of Zinc Metal with Iron Sulphate Solution. When a strip of zinc metal is placed in iron sulphate solution, then a displacement reaction takes place to form zinc sulphate solution and iron metal. This reaction can be written as:

\[
\text{FeSO}_4 + \text{Zn} \rightarrow \text{ZnSO}_4 + \text{Fe}
\]

(Greenish solution) (Silvery white) (Colourless solution) (Grey)

In this reaction, zinc metal displaces iron metal from iron sulphate solution. This displacement reaction takes place because zinc is more reactive than iron. Let us now discuss the reverse case in which an iron nail is placed in zinc sulphate solution.

If we place an iron nail in zinc sulphate solution, then no displacement reaction takes place. That is:

\[
\text{ZnSO}_4 + \text{Fe} \rightarrow \text{No displacement reaction}
\]

This displacement reaction does not occur because iron metal is less reactive than zinc metal. So, a less reactive metal iron cannot displace a more reactive metal zinc from zinc sulphate solution.

Please note that magnesium metal is more reactive than zinc, iron and copper. So, magnesium metal can displace zinc, iron and copper metals from their salt solutions.

(ii) A more reactive non-metal displaces a less reactive non-metal from its salt solution. We will study these displacement reactions in higher classes.

Comparison Between the Chemical Properties of Metals and Non-Metals

We will now compare the important chemical properties of metals and non-metals in tabular form. Alongwith physical properties, the chemical properties can be used to distinguish between metals and non-metals.

Differences in Chemical Properties of Metals and Non-Metals

<table>
<thead>
<tr>
<th>Metals</th>
<th>Non-Metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Metals react with water (or steam) to</td>
<td>2. Non-metals do not react with water (or steam).</td>
</tr>
<tr>
<td>produce hydrogen gas (except copper, silver</td>
<td>3. Non-metals do not react with dilute acids.</td>
</tr>
<tr>
<td>and gold which do not react with water or</td>
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<tr>
<td>steam).</td>
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<tr>
<td>which do not react with dilute acids).</td>
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</tbody>
</table>

We will now answer some questions based on the properties of metals and non-metals.

Sample Problem 1. An element reacts with oxygen to form an oxide. An aqueous solution of this oxide turns red litmus paper blue. Is the element a metal or a non-metal? Give reason for your answer.

Answer. We know that basic substances turn red litmus to blue. Since an aqueous solution of this oxide turns red litmus to blue, it means that the oxide is basic in nature. Now, basic oxides are formed by metal elements. So, the given element is a metal.

Sample Problem 2. Why is iron not deposited over a copper plate when the copper plate is dipped in iron sulphate solution?

Answer. Copper is less reactive than iron, so copper is not able to displace iron from iron sulphate solution to form free iron metal. Since no iron metal is formed, it is not deposited over copper plate.
Sample Problem 3. Consider the following displacement reactions:

(i) Copper sulphate + Iron $\rightarrow$ Iron sulphate + Copper

(ii) Iron sulphate + Zinc $\rightarrow$ Zinc sulphate + Iron

On the basis of these two displacement reactions, find out which is the most reactive metal and which is the least reactive metal out of copper, iron and zinc.

**Answer.**

(i) In the first reaction, iron metal displaces copper metal from copper sulphate solution, therefore, iron is more reactive than copper.

(ii) In the second reaction, zinc metal displaces iron metal from iron sulphate solution, so zinc is more reactive than iron.

Now, since zinc is more reactive than iron, and iron is more reactive than copper, therefore, in this case: zinc is the most reactive metal whereas copper is the least reactive metal.

Sample Problem 4: Saloni took a piece of burning charcoal and collected the gas evolved in a test-tube.

(a) How will she find the nature of the gas?

(b) Write down word equations of all the reactions taking place in this process.

**Answer.** Charcoal is a form of carbon (which is a non-metal). When carbon (charcoal) burns in air, it forms an acidic oxide called carbon dioxide (which is a gas).

(a) To find the nature of carbon dioxide gas, dissolve it in water. Test the aqueous solution of carbon dioxide gas with blue litmus paper and red litmus paper. The aqueous solution of carbon dioxide gas will turn blue litmus paper to red showing that carbon dioxide is acidic in nature.

(b) When carbon (or charcoal) burns in air, it combines with the oxygen of air to form carbon dioxide. The word equation for this reaction is:

\[
\text{Carbon + Oxygen $\rightarrow$ Carbon dioxide} \hspace{1cm} \text{(Charcoal)}
\]

Carbon dioxide dissolves in water to form carbonic acid (which turns blue litmus paper to red). The word equation for this reaction is:

\[
\text{Carbon dioxide + Water $\rightarrow$ Carbonic acid}
\]

**USES OF METALS**

Metals are used in our everyday life for a large number of purposes. Metals are used in making nails, screws, utensils, water boilers, electric wires, office furniture, cars, buses, trains, aeroplanes, satellites, various types of machines, and many, more things used by us. **Some of the important uses of metals are given below**:

1. Iron, copper and aluminium metals are used to make cooking utensils, and water boilers for factories.
2. Copper metal is used for making electric wires for household wiring, electric motors, armature of dynamos, and many other electrical appliances. Aluminium metal is used for making electric cables (thick wires) and over-head electric transmission lines.
3. Aluminium foils are used for packaging medicines, chocolates, food items and many other materials.
4. Aluminium metal (in the form of alloys) is used to make aeroplanes.
5. Iron metal (in the form of steel) is used to make nails, screws, nut-bolts, pipes, railings, gas cylinders, stoves, water tanks, office furniture, industrial tools and machines, buildings and bridges, railway lines, transport vehicles such as cars, buses and trains, household goods and agricultural implements.
6. Zinc metal is used for galvanising iron to protect it from rusting.
7. Silver and gold metals are used to make jewellery.
8. Mercury metal is used in making thermometers.

In our body, iron is present in the pigment of red blood cells called ‘haemoglobin’ (which transports oxygen from the lungs to all the tissues of our body). If there is deficiency of iron in our body, then there will be less haemoglobin in our blood. Lower level of haemoglobin in the blood will cause shortage of oxygen in the body leading to tiredness and weakness.

**USES OF NON-METALS**

All the living things around us like plants and animals (including human beings) are made up mainly of compounds of non-metals like carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus, etc. Non-metals are used in our day to day life for a large number of purposes. Some of the important uses of the common non-metals like oxygen, nitrogen, chlorine, iodine, sulphur, phosphorus and carbon are given below:

1. Oxygen is a non-metal which is used by plants and animals (including human beings) for breathing. Thus, oxygen non-metal is essential for maintaining our life. Oxygen non-metal is also used in the process of burning (or combustion) of fuels in homes, factories and transport vehicles.
2. Nitrogen is a non-metal which is used in making fertilisers to enhance the growth of plants. Nitrogen gas (being inert) is used in food packaging instead of air, to keep the food fresh.
3. Chlorine is a non-metal which is used in the water purification process. Chlorine has the ability to kill germs, so chlorine makes the drinking water supply germ-free.
4. Iodine is a non-metal which is used to make purple-coloured solution called ‘tincture iodine’ which is applied on cuts and wounds as an antiseptic.
5. Sulphur and phosphorus are the non-metals which are used in fireworks (crackers, etc.)
6. Sulphur is a non-metal which is used in the vulcanisation of rubber (or hardening of rubber).
7. Carbon is a non-metal which is used as a fuel. The forms of carbon used as a fuel are charcoal, coke and coal.

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

**Very Short Answer Type Questions**

1. What is the general name of the elements whose properties are intermediate between those of metals and non-metals?
2. Name one metal and one non-metal which exist in liquid state at room temperature.
3. Name the property:
   (a) which allows metals to be hammered into thin sheets.
   (b) which enables metals to be drawn into wires.
4. Name two metals which are soft and can be easily cut with a knife.
5. If a metal coin is dropped on hard floor, it produces a ringing sound. What is this property of metals known as?
6. Name the property of iron metal due to which it can be hammered to make objects of different shapes such as an axe, a spade or a shovel.
7. Name a non-metal which is very hard.
8. Name a non-metal which is a good conductor of electricity.
9. State one chemical property which can be used to distinguish a metal from a non-metal.
10. How do metal oxides differ from non-metal oxides?
11. An element forms an oxide which is acidic in nature. Is the element a metal or a non-metal?
12. An element forms an oxide which is basic in nature. State whether the element is a metal or a non-metal?
13. Write a word equation for the reaction of magnesium with oxygen.
14. Iron metal reacts slowly with the oxygen and moisture of damp air to form rust. State whether the rust
formed is acidic, basic or neutral.

15. Name the gas evolved when a metal reacts with water.
16. Name the gas evolved when a metal reacts with a dilute acid.
17. (a) Name one metal which reacts with dilute hydrochloric acid to produce hydrogen gas.
   (b) Name one metal which does not react with dilute hydrochloric acid.
18. Which metal is more reactive: iron or zinc?
19. Which metal is less reactive: copper or iron?
20. Name any five objects used in our everyday life which are made of metals.
21. Name two metals which are used for making cooking utensils and water boilers for factories.
22. Name two metals which are used for making electric wires.
23. Name the metal which is used in making thermometers.
24. Which metal is used to galvanise iron to protect it from rusting?
25. Name the metal which is used to make thin foils for packaging medicines, chocolates, and food items, etc.
26. Name two metals which are used to make jewellery.
27. Where is iron present in our body?
28. Name the non-metal which is essential for maintaining life and inhaled during breathing.
29. Name one non-metal used for making fertilisers.
30. Which non-metal is used in water purification process to make drinking water supply germ-free?
31. Name the non-metal used to make purple coloured solution which is applied on cuts and wounds as an antiseptic.
32. Name two non-metals which are used in fireworks (crackers, etc.).
33. Which non-metal is used as a fuel?
34. State whether the following statements are true or false:
   (a) All metals exist in solid form at room temperature.
   (b) Coal can be drawn into wires.
   (c) Non-metals react with dilute acids to produce hydrogen gas.
   (d) Sodium is a very reactive metal.
   (e) Copper displaces zinc from zinc sulphate solution.
   (f) Rust formed on iron objects is basic in nature.
   (g) Non-metals react with water to form a gas which burns with a ‘pop’ sound.
35. Fill in the following blanks with suitable words:
   (a) Metals are .................. conductors of heat and .................. .
   (b) Most non-metals are .................. conductors of heat and electricity.
   (c) Phosphorus is a very .................. non-metal.
   (d) Metals react with acids to produce ............. gas.
   (e) Iron is more ............. than copper.
   (f) Metals form ............. oxides whereas non-metals form ............. oxides.
   (g) Sulphur forms ............. oxide whereas magnesium forms ............. oxide.
   (h) A non-metal is used to make an antiseptic solution called tincture ..........

**Short Answer Type Questions**

36. State two physical properties on the basis of which metals can be distinguished from non-metals.
37. Name the gas produced when aluminium foil reacts with:
   (a) dilute hydrochloric acid.
   (b) sodium hydroxide solution.
38. State any two physical properties for believing that aluminium is a metal.
39. Compare the properties of metals and non-metals with respect to:
   (i) malleability
   (ii) ductility,
   (iii) conduction of heat and electricity.
40. Give reason why:
   (a) copper metal is used for making electric wires.
   (b) graphite is used for making electrode in a cell.
   (c) immersion rods for heating liquids are made of metallic substances.
41. Define (a) malleability, and (b) ductility.

42. What is meant by saying that metals are: (i) malleable (ii) ductile (iii) lustrous, and (iv) sonorous?

43. There are two boxes, one made of metal and the other made of wood, which are similar in appearance. How will you find out which box is made of metal?

44. Consider the following materials:
Copper, Sulphur, Phosphorus, Carbon (such as pencil lead), Gold, Silver.
Which of these materials are: (i) malleable and ductile, and (ii) brittle?

45. Can you hold a hot metallic pan which is without a plastic or a wooden handle? Give reason for your answer.

46. The screw driver used by an electrician has a plastic or a wooden handle. Why?

47. What is the nature (acidic/basic) of the following oxides?
(a) Magnesium oxide (b) Sulphur dioxide
Given reason for your choice.

48. What type of oxides are formed:
(a) when metals combine with oxygen?
(b) when non-metals combine with oxygen?

49. Element A is soft, brittle and does not conduct electricity. Element B is hard, malleable and ductile, and also conducts electricity. Which of the two elements, A or B, is a non-metal?

50. Consider the following elements:
Sodium, Sulphur, Carbon, Magnesium
Which of these elements will form:
(a) acidic oxides?
(b) basic oxides?

51. What happens when a copper vessel is exposed to moist air for a long time?

52. When a copper object is exposed to moist air for a long time, then a green coating is formed on its surface.
(a) What is the material of the green coating?
(b) State whether the green coating is acidic or basic.

53. Sodium metal reacts vigorously with water.
(a) Name the gas evolved when sodium reacts with water.
(b) State whether the solution formed by the reaction of sodium with water is acidic or basic.

54. How do metals react with dilute acids? Explain with the help of an example.

55. What would you observe when a strip of zinc is placed in copper sulphate solution? Write a word equation of the reaction which takes place.

56. Can copper displace iron from iron sulphate solution? Give reason for your answer.

57. (a) Name one metal which can displace iron from iron sulphate solution.
(b) Name one metal which cannot displace iron from iron sulphate solution.


59. Why should the foodstuffs like orange juice, pickles, chutney and curd not be kept in iron or aluminium containers?

60. Give reasons for the following:
(a) Sodium and potassium are stored in kerosene.
(b) Copper cannot displace zinc from its salt solution (zinc sulphate solution).

61. (a) Why are metals used for making bells?
(b) Why is phosphorus kept under water?

62. Which of the following can be beaten into thin sheets? Why?
(a) Zinc (b) Phosphorus (c) Sulphur (d) Oxygen

63. Match the substances given in column A with their uses given in column B:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Gold</td>
<td>(a) Thermometers</td>
</tr>
<tr>
<td>(ii) Iron</td>
<td>(b) Electric wires</td>
</tr>
<tr>
<td>(iii) Aluminium</td>
<td>(c) Wrapping food</td>
</tr>
<tr>
<td>(iv) Carbon</td>
<td>(d) Jewellery</td>
</tr>
<tr>
<td>(v) Copper</td>
<td>(e) Machinery</td>
</tr>
<tr>
<td>(vi) Mercury</td>
<td>(f) Fuel</td>
</tr>
</tbody>
</table>
64. Give one use each of the following metals:
(a) Iron (b) Copper (c) Aluminium (d) Zinc (e) Mercury
65. State one use each of the following non-metals:
(a) Oxygen (b) Nitrogen (c) Sulphur (d) Chlorine (e) Iodine

Long Answer Type Questions
66. (a) What are metals? Name five metals.
(b) What are non-metals? Name five non-metals.
67. (a) What are metalloids? Name two metalloids.
(b) Classify the following elements into metals, non-metals and metalloids:
   Copper, Sulphur, Aluminium, Oxygen, Silicon, Nitrogen, Germanium, Mercury, Chlorine, Sodium.
68. (a) What happens when sulphur dioxide is dissolved in water? Write a word equation for the reaction which takes place.
(b) What happens when an iron nail is placed in copper sulphate solution? Write word equation of the reaction involved.
69. (a) State five characteristics of metals and five characteristics of non-metals.
(b) State five uses of metals and five uses of non-metals.
70. Compare the chemical properties of metals and non-metals in tabular form.

Multiple Choice Questions (MCQs)
71. An element is soft and can be cut easily with a knife. It is very reactive and cannot be kept open in the air. It reacts vigorously with water. This element is most likely to be:
(a) magnesium (b) potassium (c) phosphorus (d) aluminium
72. Which one of the following four metals would be displaced from the solution of its salt by the other three metals?
(a) zinc (b) silver (c) copper (d) magnesium
73. Sulphur element is said to be:
(a) ductile (b) hard (c) malleable (d) brittle
74. An element X reacts with water to from a solution which turns phenolphthalein indicator pink. The element X is most likely to be:
(a) sulphur (b) sodium (c) carbon (d) silicon
75. The non-metal which exists in the liquid state at room temperature is:
(a) fluorine (b) chlorine (c) bromine (d) iodine
76. A basic oxide will be formed by the element:
(a) sulphur (b) phosphorus (c) potassium (d) carbon
77. “Is malleable and ductile”. This best describes:
(a) a metal (b) a compound (c) a non-metal (d) a mixture
78. The metal which will not produce hydrogen gas on reacting with dilute sulphuric acid is:
(a) sodium (b) silver (c) iron (d) zinc
79. The element which is stored under kerosene is:
(a) sulphur (b) phosphorus (c) sodium (d) silicon
80. Which of the following pairs cannot undergo displacement reaction?
(a) iron sulphate solution and magnesium
(b) zinc sulphate solution and iron
(c) zinc sulphate solution and calcium
(d) silver nitrate solution and copper
81. Which of the following metals exists in the liquid state at room temperature?
(a) magnesium (b) manganese (c) mercury (d) sodium
82. The element Z burns in air to form an oxide. The aqueous solution of this oxide turns blue litmus to red. The element Z is most likely to be:
(a) carbon (b) calcium (c) iron (d) magnesium
83. Which of the following elements is a metalloid?
(a) sodium (b) sulphur (c) silicon (d) silver
84. Which of the following elements will produce an oxide that will dissolve in water to form an acid?
   (a) carbon  (b) calcium  (c) chromium  (d) copper

85. The least reactive metal among the following is:
   (a) magnesium  (b) lead  (c) silver  (d) sodium

86. You are given a solution of iron sulphate. Which of the following do you think cannot displace iron from iron sulphate?
   (a) magnesium  (b) calcium  (c) copper  (d) zinc

87. When a vessel is exposed to moist air for a long time, then a green coating is formed on its surface. The vessel must be made of:
   (a) zinc  (b) magnesium  (c) iron  (d) copper

88. Which among the following is the most reactive metal?
   (a) copper  (b) calcium  (c) iron  (d) magnesium

89. The element whose oxide will turn red litmus solution to blue will be:
   (a) sodium  (b) sulphur  (c) carbon  (d) phosphorus

90. Which of the following is not a characteristic property of iron?
   (a) malleability  (b) brittleness  (c) ductility  (d) sonorousness

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

91. Which of the following reactions will not occur? Why not?
   (a) Zinc sulphate + Copper → Copper sulphate + Zinc
      (solution)  (solution)
   (b) Copper sulphate + Iron → Iron sulphate + Copper
      (solution)  (solution)

92. One day Reeta went to a jeweller’s shop with her mother. Her mother gave an old gold jewellery to
    goldsmith to polish. Next day when they brought the jewellery back, they found that there was a slight
    loss in its weight. Can you suggest a reason for the loss in weight? (NCERT Book Question)

93. An element burns in air to form an oxide. The aqueous solution of this oxide turns blue litmus paper red.
    State whether the element is a metal or a non-metal. Name one such element.

94. An element burns in air to form an oxide. The aqueous solution of this oxide turns turmeric paper red.
    State whether the element is a metal or non-metal. Name one such element.

95. The metal X reacts with dilute hydrochloric acid to form a gas Y. The metal X also reacts with sodium
    hydroxide solution (on heating) to form the same gas Y. When a lighted matchstick is applied, this gas
    burns by producing a ‘pop’ sound.
    (a) Name two metals which could behave like X.
    (b) Name the gas Y.

### ANSWERS

14. Basic  17. (a) Zinc (b) Copper  18. Zinc  19. Copper  34. (a) False (b) False (c) False (d) True (e) False
   (f) True (g) False / 35. (a) good ; electricity (b) poor (c) reactive (d) hydrogen (e) reactive (f) basic ; acidic
   (g) acidic ; basic (h) iodine  37. (a) Hydrogen (b) Hydrogen  49. Element A  57. (a) Zinc (b) Copper
   63. (i) d (ii) e (iii) c (iv) f (v) b  (vi) a  71. (b)  72. (b)  73. (d)  74. (b)  75. (c)  76. (c)  77. (a)  78. (b)  79. (c)
80. (b)  81. (c)  82. (a)  83. (c)  84. (a)  85. (c)  86. (c)  87. (d)  88. (b)  89. (a)  90. (b)  91. Reaction (a) will
   not occur because copper is less reactive than zinc  92. While polishing old gold jewellery, a thin, outer dull
   layer of gold is removed by treatment with a chemical. This leads to a slight loss in the weight of jewellery
   93. Non-metal ; Sulphur  94. Metal ; Magnesium  95. (a) Aluminium ; Zinc (b) Hydrogen

Physical properties of metals and non-metals - hardness, malleability, heat and electrical conductivity

Chemical properties of metals and non-metals - Reactivity with oxygen
In our everyday life, we use a large number of materials for our basic needs. Some of these materials are found in nature whereas others are man-made. Air, water, soil, sunlight, coal, petroleum, natural gas and minerals are obtained from nature, so they are called natural resources. On the other hand, plastics, synthetic fibres, paints, drugs, explosives, etc., are all man-made materials.

Inexhaustible and Exhaustible Natural Resources

Anything in the environment 'which can be used' is called a 'resource'. All the natural resources can be classified into two main groups:

(i) Inexhaustible natural resources, and
(ii) Exhaustible natural resources.

The term 'inexhaustible' means something 'which cannot be used up completely'. Those natural resources which are present in unlimited quantity in nature and are not likely to be exhausted by human activities are called inexhaustible natural resources. The examples of inexhaustible natural resources are: Sunlight, Air and Water. There is a never ending supply of inexhaustible resources in nature. The inexhaustible resources can be used again and again. They last forever.

The term 'exhaustible' means 'something which can be used up completely' (so that nothing is left behind). Those resources which are present in a limited quantity in nature and can be exhausted by human activities, are called exhaustible natural resources. The examples of exhaustible natural resources are: Coal, Petroleum, Natural gas, Minerals, Forests and Wildlife, etc. The exhaustible natural resources do not last forever.

In this Chapter we will study some exhaustible sources of energy like coal, petroleum and natural gas. Coal, petroleum and natural gas are also called non-renewable sources of energy. This is because when all the coal, petroleum and natural gas present under the earth will get used up (or exhausted), no more supply of these fuels will be available in the near future. Before we go further, we should know the meaning of the term 'fossil'. Fossils are the remains of the pre-historic plants or animals, buried under the earth millions of years ago.
FOSSIL FUELS

The natural fuels formed from the remains of living organisms buried under the earth long, long ago, are called fossil fuels. Coal, petroleum and natural gas are fossil fuels. Coal, petroleum and natural gas are called fossil fuels because they were formed by the decomposition of the remains of pre-historic plants and animals (fossils) buried under the earth long, long ago. Fossil fuels are exhaustible natural resources because once all the fossil fuels are used up, they will be gone forever.

How Fossil Fuels were Formed

Fossil fuels were formed from the dead remains of living organisms (plants and animals) buried under the earth millions of years ago. This happened as follows: The plants and animals which died millions of years ago, were gradually buried deep in the earth and got covered with sediments like mud and sand, away from the reach of air. In the absence of air, the chemical effects of heat, pressure and bacteria, converted the buried remains of plants and animals into fossil fuels like coal, petroleum and natural gas. Please note that the buried remains of large land plants were converted into coal whereas those of tiny marine plants and animals were converted into petroleum and natural gas.

COAL

Coal is a hard, black combustible mineral that consists mainly of carbon (see Figure 1). Coal is found in deep coal mines under the surface of the earth. In India, coal is found mainly in Bihar, West Bengal, Orissa and Madhya Pradesh. Coal is found in abundance in our country and it is the most important source of energy in our country.

How Coal was Formed

Coal was formed by the decomposition of large land plants and trees buried under the earth about 300 million years ago. This happened as follows: About 300 million years ago, the earth had dense forests in low-lying wet land areas. Due to natural processes like earthquakes, volcanoes and floods, etc., these forests were buried under the surface of earth. As more soil deposited over them, they were compressed. The temperature also rose as they sank deeper and deeper. Due to high pressure and high temperature inside the earth, and in the absence of air, the wood of buried forest plants and trees was slowly converted into coal. The slow process by which the dead plants buried deep under the earth have become coal is called carbonisation. Since coal was formed from the remains of plants, therefore, coal is called a fossil fuel.

Coal is a Source of Energy

Coal is mainly carbon. When heated in air, coal burns and produces mainly carbon dioxide gas. A lot of heat energy is also produced during the burning of coal. This can be written as:

\[
\text{Carbon} + \text{Oxygen} \rightarrow \text{Carbon dioxide} + \text{Heat}
\]

(Coal) (From air)

Coal is important because it can be used as a source of heat energy as such (just by burning it), or it can be converted into other forms of energy such as coal gas, coke or electricity. The real source of energy of coal is the solar energy (or sun’s energy). This is because the plants and trees which decomposed to form coal grew on the earth by absorbing sunlight energy during the process of photosynthesis.

Uses of Coal

(i) Coal is used as a fuel in homes and industry.
(ii) Coal is used as a fuel at Thermal Power Plants for generating electricity.
(iii) Coal is used to make coal gas which is an important industrial fuel.
(iv) Coal is used to make coke.
(v) Earlier, coal was used as a fuel to make ‘steam’ to run steam engines of trains.
(vi) Coal was also used as a source of organic chemicals.

**Products of Coal**

When coal is heated strongly in closed retorts in the absence of air, a number of useful products are obtained. The various useful products obtained by processing the coal by heating in the absence of air are:

(i) Coal gas,
(ii) Coal tar,
(iii) Coke.

Coal gas, coal tar and coke are called products of coal. Please note that these products are obtained when coal is heated in the absence of air. This is because if coal is heated in the presence of air, then coal burns to produce mainly carbon dioxide gas and no other useful products are obtained. The strong heating of coal in the absence of air is called destructive distillation of coal. We will now describe the various products of coal in somewhat detail.

**Coal Gas**

Coal gas is a gaseous fuel which is obtained by the strong heating of coal in the absence of air during the processing of coal to get coke. Coal gas is mainly a mixture of methane and hydrogen, with some carbon monoxide. All the gases present in coal gas can burn to produce heat, due to which coal gas is an excellent fuel (having high calorific value). Coal gas is used as a fuel in industries (which are situated near the coal processing plants). When coal gas burns, it also produces a good amount of light. So, in the past, coal gas has also been used for lighting purposes (or illumination purposes). Coal gas was used for street lighting for the first time in London in the year 1810. It was used for street lighting in New York around 1820. These days, however, coal gas is used as a source of heat rather than light.

**Coal Tar**

Coal tar is a thick, black liquid having an unpleasant smell which is obtained by heating coal in the absence of air (see Figure 2). Coal tar is not a single compound. Coal tar is a mixture of about 200 carbon compounds (or organic compounds). The useful carbon compounds (or organic compounds) present in coal tar include benzene, toluene, naphthalene, anthracene, phenol and aniline. Thus, the naphthalene balls used to repel moths and other insects (in stored clothes, etc.) are obtained from coal tar. The various compounds present in coal tar are separated by the process of fractional distillation. The compounds (or products) obtained from coal tar are used as starting materials for manufacturing a large number of substances used in everyday life and industry. For example, the products of coal tar are used to make synthetic fibres, drugs (medicines), plastics, synthetic dyes, perfumes, paints, varnishes, pesticides, photographic materials, roofing materials and explosives, etc. Coal tar has been traditionally used for metalling the roads. These days, however, bitumen (a petroleum product) is being used increasingly for metalling the road surfaces (in place of coal tar).

**Coke**

Coke is a tough and porous black solid substance (see Figure 3). Coke is prepared by heating coal in the absence of air. When coal is heated in the absence of air, then coal gas and coal tar are eliminated, and coke is left behind as a black residue. Thus, coal minus volatile constituents is coke. Coke is an almost pure form of carbon. It is 98 per cent carbon.
Coke is mainly used as a reducing agent in the extraction of metals (like iron, zinc, etc.) Coke is used in the manufacture of steel. Coke is also used as a fuel. Coke is a better fuel than coal because it produces more heat on burning than an equal amount of coal. Moreover, coke burns without producing any smoke whereas coal produces a lot of smoke on burning.

**PETROLEUM**

Petroleum is a dark coloured, thick crude oil found deep below the ground in certain areas. It has an unpleasant odour. The name ‘petroleum’ means ‘rock oil’ (petra = rock ; oleum = oil). It is called petroleum because it is found under the crust of earth trapped in rocks. Petroleum is not a single chemical compound. Petroleum is a complex mixture of compounds known as hydrocarbons (Hydrocarbons are compounds which are made up of only two elements : carbon and hydrogen). Petroleum is insoluble in water. Petroleum is a natural resource obtained from deep oil wells which are dug in certain areas of the earth. Just like coal, petroleum is also a fossil fuel. Please note that petroleum is also called ‘crude oil’ or ‘mineral oil’.

**How Petroleum was Formed**

Petroleum (oil) was formed by the decomposition of the remains of tiny plants and animals buried under the sea millions of years ago. It is believed that millions of years ago, the tiny plants and animals which lived in the sea, died. Their dead bodies sank to the bottom of sea and were soon covered with mud and sand. Due to high pressure, heat, action of bacteria, and in the absence of air, the dead remains of tiny plants and animals were slowly converted into petroleum. The petroleum thus formed got trapped between two layers of impervious rocks (non-porous rocks), forming an oil deposit.

**Occurrence and Extraction of Petroleum**

Petroleum occurs deep under the surface of earth between two layers of impervious rocks (see Figure 5). Petroleum is lighter than water, so it floats over water. Petroleum oil deposits are usually found mixed with water, salt and earth particles (sand, etc.). Petroleum does not occur in all the places of earth. It is found in only certain areas of the earth. Natural gas occurs above the petroleum oil trapped under the rocks (see Figure 5).

Petroleum is extracted by drilling holes (called oil wells) in the earth’s crust, where the presence of oil has been predicted by survey. The oil wells are drilled by using ‘drilling rigs’ (A drilling rig is a large structure with equipment for drilling an oil well). When an oil well is drilled through the rocks, natural gas comes out first with a great pressure and for a time, the crude petroleum oil comes out by itself due to gas pressure. After the gas pressure has subsided, petroleum is pumped out of the oil well. Some wells dig into the earth yield both petroleum and natural gas but some wells yield only natural gas but no oil. Early drilling of oil wells for getting petroleum was done only on land. Later on, oil wells were also drilled under the sea-bed by using new techniques. Thus, some of the oil wells are now drilled under the sea for the extraction of petroleum.
The world’s first oil well was drilled in Pennsylvania (USA) in 1859. Eight years later in 1867, oil was struck at Makum in Assam. In India, petroleum (oil) is found in Assam, Gujarat, Mumbai High (off-shore area), and near the basins of Godavari and Krishna rivers. The off-shore oil bearing area called Mumbai High is located in high seas at a distance of about 150 kilometres west of Mumbai city. The oil deposits of Mumbai High are buried at a depth of about 1000 metres below the sea-bed. A special platform of steel has been erected in the Mumbai High sea to pump out petroleum from under the sea-bed.

**Refining of Petroleum**

The crude petroleum oil is a complex mixture of solid, liquid and gaseous hydrocarbons. It is not very useful to us as such. So, before petroleum can be used for specific purposes, it has to be refined (or purified). The process of separating crude petroleum oil into more useful fractions is called refining. The refining of petroleum (or separation of petroleum) into different fractions is based on the fact that the different fractions of petroleum have different boiling point ranges. The refining of petroleum is carried out in an oil refinery (see Figure 6). The crude petroleum oil extracted from oil wells is taken to the ‘oil refinery’ through pipes. In the oil refinery, crude petroleum oil is refined (or separated) into different useful fractions. The separation of petroleum into different fractions is done by the process of ‘fractional distillation’. Fractional distillation is a process in which fractions of petroleum having different boiling point ranges are collected separately. The various useful fractions obtained by the refining of petroleum are: Petroleum gas, Petrol, Kerosene, Diesel, Lubricating oil, Paraffin wax and Bitumen.

**The Various Fractions of Petroleum and Their Uses**

The refining of petroleum gives the fractions (or products) such as petroleum gas, petrol, kerosene, diesel, lubricating oil, paraffin wax and bitumen. The important uses of the various fractions of petroleum are given below.

(i) **PETROLEUM GAS.** Petroleum gas is used as a fuel in homes and industry. Petroleum gas is used as a fuel as such or in the form of Liquefied Petroleum Gas (LPG).

(ii) **PETROL.** Petrol is used as a fuel in light motor vehicles (such as cars, motorcycles, and scooters, etc.). Petrol is also used as a solvent for drycleaning.

(iii) **KEROSENE.** Kerosene is used as a fuel in wick stoves and pressure stoves to cook food. Kerosene is also used in lanterns for lighting purposes (see Figure 7). A special grade of kerosene oil is used as aviation fuel in jet aeroplanes.

(iv) **DIESEL.** Diesel is used as a fuel in heavy motor vehicles (such as buses, trucks, tractors, and diesel train engines). Diesel is also used to run pump sets for irrigation in agriculture and in electric generators (to produce electricity on a small scale).

(v) **LUBRICATING OIL.** Lubricating oil is used for lubrication in machines and engines (like car engines).
(vi) **PARAFFIN WAX.** Paraffin wax is used for making candles, vaseline, ointments, wax paper, and grease.

(vii) **BITUMEN.** Bitumen is used for road surfacing. It is also used for water-proofing the roofs of buildings. Bitumen is used in making black paints.

Please note that the fuels such as petroleum gas, petrol, kerosene, and diesel are also fossil fuels (because they are obtained from a major fossil fuel called petroleum).

The most common fuel used in homes is liquified petroleum gas (or LPG). The petroleum gas which has been liquefied under pressure is called **liquefied petroleum gas.** The liquefied petroleum gas (or LPG) consists mainly of butane \((C_4H_{10})\) (which has been liquefied by applying pressure). Thus, the domestic gas cylinders like 'Indane' contain mainly 'butane' (see Figure 8). The gas used for domestic cooking is called liquefied petroleum gas because it is obtained from petroleum and it is liquefied by compression before filling into the gas cylinders. When we turn on the knob of the gas cylinder, the pressure is released, due to which the highly volatile LPG is converted into gas. This gas goes into the burner of LPG stove. When a lighted matchstick is applied to the burner, the gas burns with a blue flame producing a lot of heat. This heat is used for cooking food. Liquefied petroleum gas (LPG) is a good fuel because of its following advantages:

(i) LPG burns easily.
(ii) LPG has a high calorific value. Due to this, a given amount of LPG produces a lot of heat.
(iii) LPG burns with a smokeless flame and hence does not cause air pollution.
(iv) LPG does not produce any poisonous gases on burning.
(v) LPG does not leave behind any solid residue on burning.

We will now discuss natural gas.

**NATURAL GAS**

Natural gas consists mainly of methane with small quantities of ethane and propane. In fact, natural gas contains about 95% methane, the remaining being ethane and propane. Natural gas occurs deep under the crust of earth either alone or along with oil above the petroleum deposits. Thus, some wells dug into the earth produce only natural gas whereas others produce natural gas as well as petroleum oil. Natural gas is formed under the earth by the decomposition of vegetable matter lying under water. This decomposition is carried out by anaerobic bacteria in the absence of air. Just like coal and petroleum, natural gas is also a fossil fuel.

India has vast reserves of natural gas. In India, natural gas has been found in Tripura, Rajasthan, Maharashtra, and in Krishna-Godavari delta. **When natural gas is compressed by applying pressure, it is called Compressed Natural Gas (which is written in short form as CNG).** In fact, natural gas is stored under high pressure as compressed natural gas (or CNG). It becomes easier to store, transport and use natural gas in the form of CNG. Natural gas is called a clean fuel because it burns without producing any smoke and does not cause air pollution.

**Advantages of Using Natural Gas (or Compressed Natural Gas, CNG)**

1. Natural gas (or CNG) is a good fuel because it burns easily and produces a lot of heat. Moreover, natural gas burns with a smokeless flame and causes no air pollution. It also does not produce any poisonous gases on burning. Natural gas does not leave behind any solid residue on burning. Natural gas is, therefore, a clean fuel (as compared to other fossil fuels).

2. Natural gas (or CNG) is a complete fuel in itself and can be used directly for heating purposes in homes and industry. There is no need to add anything else to it.
3. A great advantage of natural gas is that it can be supplied to homes and factories through a network of underground pipes and this eliminates the need for additional storage and transport. Such a network of pipelines for the supply of natural gas exists in Vadodara (in Gujarat), in some parts of Delhi and a few other places.

**Uses of Natural Gas (or CNG)**

1. Natural gas is used as a domestic and industrial fuel.
2. Natural gas is used as a fuel in Thermal Power Stations for generating electricity.
3. Compressed natural gas (CNG) is being used increasingly as a fuel in transport vehicles (like cars, buses, etc.) in place of petrol and diesel. CNG is a good alternative to petrol and diesel in vehicles because it is a cleaner fuel and does not cause much air pollution. In fact, CNG is being used in many vehicles these days to reduce air pollution in cities. CNG which is used in vehicles is filled in cylinders. These cylinders can be refilled at CNG Filling Stations (see Figure 9).
4. Natural gas is used as a source of hydrogen gas needed to manufacture fertilisers. When natural gas is heated strongly, the methane present in it decomposes to form carbon and hydrogen. This hydrogen is then used to manufacture fertilisers.
5. Natural gas is used as a starting material for the manufacture of a number of chemicals (which are called petrochemicals).

**PETROCHEMICALS**

Many useful chemicals (or substances) are obtained from petroleum and natural gas. **Those chemicals which are obtained from petroleum and natural gas are called petrochemicals.** Some examples of petrochemicals are: methyl alcohol, ethyl alcohol, formaldehyde, acetone, acetic acid, ethylene, benzene, toluene, vinyl chloride and hydrogen. Petrochemicals are very important because they are used to manufacture a wide range of useful materials such as: Detergents, Synthetic fibres (like Polyester, Nylon, Acrylic, etc.), Plastics (such as Polythene, Polyvinyl chloride, Bakelite, etc.), Synthetic rubber, Drugs, Dyes, Perfumes, Fertilisers, Insecticides and Explosives, etc. Hydrogen gas is obtained as a petrochemical from natural gas. Hydrogen gas obtained from natural gas is used in the manufacture of fertilisers (such as ammonium nitrate and urea). Thus, petroleum is not only a source of fuels but also provides raw materials (in the form of petrochemicals) to manufacture a large number of useful substances. Due to its great commercial importance, petroleum is also called “black gold”.

**Energy Resources of Earth are Limited**

Most of the energy that we use today mainly comes from the three exhaustible resources of the earth: coal, petroleum and natural gas. **The amount of coal, petroleum and natural gas present in the earth is limited.** The known reserves of coal, petroleum and natural gas will last only for about 100 years. Once the present stock of coal, petroleum and natural gas present in the earth gets exhausted, no new supplies of these fossil fuels will be available to us in the near future (because it takes millions of years to convert the dead organisms into fossil fuels in nature). So, fossil fuels should be used with care and caution, and not wasted at all so that the existing reserves of fossil fuels can be used over as long a period as possible. Moreover, the burning of fossil fuels is a major source of air pollution. The use of fossil fuels is also linked to global warming (because they produce a lot of greenhouse gas ‘carbon dioxide’ on burning). So, the use of lesser fossil fuels will lead to cleaner environment and smaller risk of global warming. From the above discussion we conclude that we should use fossil fuels only when absolutely necessary because:
(i) it will ensure the availability of fossil fuels for a longer period of time.
(ii) it will reduce air pollution and lead to a cleaner environment.
(iii) it will reduce the risk of global warming.

Please note that the fossil fuels such as coal, petroleum and natural gas cannot be prepared in the laboratory from dead organisms (dead plants and animals). This is because the formation of fossil fuels is a very, very slow process and the conditions for their formation cannot be created in the laboratory.

How to Save Petrol and Diesel

Petrol and diesel are the two main fuels which are used for driving vehicles. We should make every effort to avoid the wastage of these precious fuels. In India, the Petroleum Conservation Research Association (PCRA) advises people on how to save petrol (or diesel) while driving vehicles. The various tips for minimising the wastage of petrol and diesel while driving vehicles are as follows:

(i) Drive the vehicle at a constant and moderate speed as far as possible.
(ii) Switch off the vehicle’s engine at traffic lights or at a place where a person has to wait.
(iii) Ensure correct air pressure in the tyres of the vehicle. Low tyre pressure consumes more fuel.
(iv) Ensure regular maintenance of the vehicle (including engine tuning).

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

**Very Short Answer Type Questions**

1. Name three useful products of coal.
2. Which product of coal is used as a reducing agent in the extraction of metals?
3. Name the process by which plant material (or vegetation) buried deep under the earth was slowly converted into coal.
4. Name the product of coal which is thick black liquid having an unpleasant smell.
5. Name any five substances used in everyday life which are manufactured starting from the products of coal tar.
6. Name an important source from which naphthalene balls are obtained.
7. Which substance is used for metallising the roads these days in place of coal tar?
8. Name the most common fuel used in light motor vehicles.
9. Name the fuel which is used in jet aircraft engines.
10. Name the petroleum product used to drive heavy vehicles.
11. Name the petroleum product which is commonly used for electric generators.
12. What is the full form of LPG?
13. Is it possible to extract petroleum from under the sea-bed?
14. What is the full form of CNG?
15. Name the major component of natural gas.
16. Name any two places in India where natural gas is found.
17. Name a fossil fuel other than coal and petroleum.
18. Name two places in India where coal is found.
19. Name the petroleum product used for surfacing of roads.
20. Name any four places in India where petroleum is found.
21. Write the full form of PCRA.
22. State whether the following statements are true or false:
   (a) Coke is almost pure form of carbon.
   (b) Coal tar is a mixture of various substances.
   (c) Kerosene is not a fossil fuel.
   (d) CNG is more polluting than petrol.
   (e) Fossil fuels can be made in the laboratory.
23. Fill in the following blanks with suitable words:
   (a) Fossil fuels are ..........., ........... and ...........
   (b) Coal contains mainly...........
(c) The slow process of conversion of dead vegetation into coal is called ..........
(d) The process of separation of different constituents from petroleum is called .......
(e) The least polluting fuel for vehicles is ............
(f) The burning of fossil fuels causes air.............and also leads to global.............

Short Answer Type Questions

24. Explain why, fossil fuels are exhaustible natural resources.
25. Describe how coal was formed. What is this process called?
26. What happens when coal is heated in air? State the uses of coal.
27. State the uses of coke.
28. What are the constituents of coal gas? State one use of coal gas.
29. What are the major products (or fractions) of petroleum refining? Give one use of each petroleum product.
30. What are the advantages of using natural gas (or CNG) as a fuel?
31. State the various uses of natural gas.
32. What is CNG? State its one use.
33. Where is natural gas found? Why is natural gas called a clean fuel?
34. What are the advantages of using LPG as fuel?
35. Name any five useful substances which are manufactured from petrochemicals.
36. Which material is called ‘black gold’? Why?
37. (a) Where and when was the world’s first oil well drilled?
    (b) Where and when was oil first struck in India?
38. State one use each of the following products of petroleum:
    (a) Petroleum gas (b) Petrol (c) Diesel (d) Lubricating oil (e) Bitumen
39. What is the major cause of air pollution? Write the various tips for minimising the wastage of petrol/diesel while driving vehicles.
40. Why should we use fossil fuels only when absolutely necessary?
41. State (a) two uses of kerosene, and (b) two uses of paraffin wax.

Long Answer Type Questions

42. (a) What is meant by inexhaustible natural resources? Name two inexhaustible natural resources.
    (b) What is meant by exhaustible natural resources? Name any two exhaustible natural resources.
43. (a) What are fossil fuels? Name three fossil fuels.
    (b) Describe how, fossil fuels were formed.
44. (a) What is petroleum? Where does petroleum occur?
    (b) Describe the process of formation of petroleum.
45. (a) What are petrochemicals? Name any two petrochemicals.
    (b) Why are petrochemicals so important?

Multiple Choice Questions (MCQs)

46. Which one of the following is not a fossil fuel?
    (a) petrol (b) coke (c) charcoal (d) coal
47. The major component of LPG is:
    (a) hydrogen (b) carbon monoxide (c) methane (d) butane
48. Which is the major component of CNG?
    (a) ethane (b) propane (c) methane (d) butane
49. The gas which occurs above the petroleum oil trapped under the rocks is called:
    (a) biogas (b) petroleum gas (c) natural gas (d) coal gas
50. Which of the following is being used as a source of hydrogen gas needed to manufacture fertilisers?
    (a) biogas (b) natural gas (c) coal gas (d) petroleum gas
51. One of the following is not an exhaustible source of energy. This one is:
    (a) natural gas (b) petroleum gas (c) coal gas (d) biogas
52. The slow process by which the large land plants and trees buried deep under the earth have become coal is called:
   (a) carbonation  (b) carburation  (c) carbonisation  (d) carbocation

53. Which of the following is used as a reducing agent in the extraction of iron metal?
   (a) coal  (b) bitumen  (c) charcoal  (d) coke

54. Which of the following is usually referred to as ‘black gold’?
   (a) coke  (b) coal tar  (c) petroleum  (d) coal

55. The various compounds present in coal tar are separated by the process of:
   (a) simple distillation  (b) destructive distillation  (c) fractional distillation  (d) fractional crystallisation

56. Which of the following is not obtained as a fraction during the refining of petroleum?
   (a) kerosene  (b) natural gas  (c) lubricating oil  (d) bitumen

57. Which one of the following is an inexhaustible natural resource?
   (a) coal  (b) petroleum  (c) water  (d) forests

Questions Based on High Order Thinking Skills (HOTS)

58. The substance W is a fossil fuel. It occurs deep below the ground in certain areas of the earth. Another fossil fuel X is found trapped above the deposits of W. When W is subjected to a process called Y, then a number of different products are collected at different temperature ranges which are put to different uses. A special grade of product Z obtained in this way is used as aviation fuel in jet aeroplanes.
   (a) What are (i) W, and (ii) X ?
   (b) What is (i) physical state, and (ii) colour, of A ?
   (c) Name the process Y.
   (d) Name the product Z.

59. The material A is a fossil fuel which is extracted from the earth. It is said to be formed from the buried, large land plants by a very slow process B. When A is heated in the absence of air in a process called C, then it gives three products D, E and F. The product D is used as a reducing agent in the extraction of metals, the product E is used as an industrial fuel whereas the product F has been traditionally used for metalling the roads.
   (a) What could material A be ?
   (b) What is (i) physical state, and (ii) colour, of A ?
   (c) Name the processes (i) B, and (ii) C.
   (d) What are (i) D, (ii) E, and (iii) F ?

60. The fossil fuel P is formed under the earth by the decomposition of vegetable matter lying under water by the action of anaerobic bacteria. The major component of fuel P is Q. The fossil fuel P is used as a source of gas R needed to manufacture nitrogenous fertilisers. When P is filled in metal cylinders and used as a fuel in motor vehicles, it is called S. What are P, Q, R and S ?

ANSWERS

2. Coke  22. (a) True (b) True (c) False (d) False (e) False  23. (a) coal ; petroleum ; natural gas (b) carbon (c) carbonisation (d) refining (e) CNG (f) pollution ; warming  46. (c)  47. (d)  48. (c)  49. (c)  50. (b)  51. (d)  52. (c)  53. (d)  54. (c)  55. (c)  56. (b)  57. (c)  58. (a)  59. (a)  60. (i) Petroleum (ii) Natural gas (b) (i) Thick liquid (ii) Destructive distillation (d) (i) Coke (ii) Coal gas (iii) Coal tar  60. P : Natural gas ; Q : Methane ; R : Hydrogen ; S : Compressed natural gas (CNG).
The burning of a substance in the oxygen of air in which heat and light are produced, is called combustion. So, in most simple words, ‘combustion’ means ‘burning’. In this Chapter we will study the chemical process of combustion (or burning) and the types of flames produced during this process.

**COMBUSTION**

A chemical process in which a substance reacts with the oxygen (of air) to give heat and light is called combustion. The light which is given off during combustion can be in the form of a ‘flame’ or as a ‘glow’. For example, wood burns by producing a flame (see Figure 1). But charcoal burns by producing light in the form of glow. The substance which undergoes combustion is said to be combustible. It is also called a fuel. We will now give some examples of combustion.

(i) **Combustion of Magnesium.** If a magnesium ribbon is heated, it starts burning (or undergoes combustion). When a magnesium ribbon burns, it combines with the oxygen of air to form magnesium oxide, and liberates heat and light. The combustion of magnesium can be written as follows:

\[
\text{Magnesium} + \text{Oxygen} \xrightarrow{\text{Combustion}} \text{Magnesium oxide} + \text{Heat} + \text{Light}
\]

(From air)

Thus, the burning of magnesium in air to produce heat and light is a combustion process. In this reaction, magnesium is a combustible substance.

(ii) **Combustion of Charcoal.** Charcoal is mainly carbon. If we hold a piece of charcoal with a pair of tongs and heat it on the flame of a burner, it starts burning (or undergoes combustion). When charcoal burns, then the carbon of charcoal combines with the oxygen of air to form carbon dioxide. A lot of heat is produced.
produced in this combustion reaction but only a little light is produced (which makes the charcoal glow). The combustion of charcoal can be written as follows:

\[
\text{Carbon} + \text{Oxygen} \xrightarrow{\text{Combustion}} \text{Carbon dioxide} + \text{Heat} + \text{Light}
\]

(From air)

Coal also contains a lot of carbon. So, coal also burns in air producing carbon dioxide, heat and light. Thus, charcoal and coal are combustible substances.

In both the examples of combustion given above, we find that oxygen is necessary for combustion (or burning) to take place. Actually, oxygen is a supporter of combustion. In most of the cases of combustion, oxygen is provided by the air around us. So, in a way, air is also a supporter of combustion. This is because air contains oxygen. So, whether we write oxygen as supporter of combustion or air as supporter of combustion, it will mean the same thing.

Food is a fuel for our body. During respiration, the digested food (like glucose) is broken down by reaction with oxygen in the body cells to produce carbon dioxide, water and heat energy. This heat energy is utilised by our body. Thus, respiration is a kind of slow combustion of food which takes place in the body to produce heat energy.

We have all seen the brown rust present on iron nails and other iron objects. The rust is formed when iron slowly combines with the oxygen present in air (in the presence of moisture) to form iron oxide. The process of rusting of iron is an example of slow combustion. The rusting liberates very little heat but no light.

The sun produces heat and light. The heat and light produced in the sun are not due to ordinary combustion (which takes place in the presence of oxygen of air). In the sun, heat and light are produced due to nuclear reactions (in which hydrogen is converted into helium with the release of heat and light).

**Combustible and Non-Combustible Substances**

Take a piece of paper. Apply a lighted matchstick to this piece of paper. We will find that the piece of paper starts burning. We say that the piece of paper burns (or the piece of paper undergoes combustion). We now take a piece of stone and apply a lighted matchstick to it. We will find that the piece of stone does not burn. We say that the piece of stone does not undergo combustion. This means that all the substances around us do not burn (or do not undergo combustion). So, there are two types of substances around us:

(i) Combustible substances, and

(ii) Non-combustible substances.

Those substances which can burn are called combustible substances. In other words, those substances which undergo combustion are called combustible substances. Some of the combustible substances are: Paper, Cloth (Fabrics), Straw (Dry grass), Cooking gas (LPG), CNG, Kerosene oil, Wood, Charcoal, Coal, Cow-dung cakes, Petrol, Diesel, Alcohol, Matchstick and Magnesium ribbon, etc. A combustible substance is also called a fuel.

Those substances which do not burn are called non-combustible substances. In other words, those substances which do not undergo combustion are called non-combustible substances. Some of the non-combustible substances are: Stone, Glass, Cement, Bricks, Soil, Sand, Water, Iron nails, Copper objects and Asbestos, etc. From this discussion we conclude that some of the substances around us are combustible whereas others are non-combustible.

We will now learn the various conditions which are necessary for combustion (or burning) of a substance to take place. These can also be considered to be the conditions necessary to start a fire.

**CONDITIONS NECESSARY FOR COMBUSTION**

There are three conditions which are necessary for combustion to take place. These are:

1. Presence of a combustible substance (A substance which can burn)
2. Presence of a supporter of combustion (like air or oxygen)
3. Heating the combustible substance to its ignition temperature
We will now discuss these three conditions required for combustion (or burning) of substances in detail.

1. **Combustible Substance**

The presence of a combustible substance is necessary for combustion to take place. So, when fire starts in a room, we remove all the combustible substances like wooden furniture, clothes, books and papers, etc., quickly from the room so that the fire may not spread due to the presence of a large number of combustible substances. A combustible substance is actually the ‘food for fire’.

2. **Supporter of Combustion**

The most common supporter of combustion which we have around us is air. So, we can say that air is necessary for combustion. We can demonstrate that air is necessary for combustion by performing a simple activity as follows.

**ACTIVITY**

Light a candle with a burning matchstick and fix it on a table. We will see that this candle keeps on burning [see Figure 2(a)]. This uncovered candle keeps burning because it is getting continuous supply of fresh air from the surroundings. Let us now cover the burning candle with an inverted gas jar. We will see that the candle stops burning after some time. In other words, the candle gets extinguished [see Figure 2(b)]. The candle stops burning (or gets extinguished) because the supply of fresh air to the burning candle is cut off by the gas jar cover. Since no fresh air is available to the burning candle, it stops burning (or gets extinguished). This observation shows that air is necessary for combustion (or burning) to take place.

We will now give some examples from our everyday life which will tell us that a supporter of combustion like air is necessary for combustion to take place.

(i) If burning charcoal is covered with a vessel, it stops burning after some time, that is, the charcoal fire gets extinguished after some time. Actually, when we cover the burning charcoal with a vessel, the supply of supporter of combustion (air) to the burning charcoal is cut off and hence the charcoal fire stops.

(ii) When the clothes of a person catch fire, the person is covered with a blanket to extinguish the fire. This is because when the burning clothes of a person are covered with a blanket, the supply of air to the burning clothes is cut off due to which the clothes stop burning – the fire gets extinguished.

From all the above examples we find that when the supply of supporter of combustion (air) to a burning substance is cut off, then the process of burning (or combustion) also stops. Thus, a supporter of combustion (like air) is necessary for combustion to take place. If, however, there is no supporter of combustion (like air), then a combustible substance cannot burn even if it is heated to its ignition temperature.

3. **Ignition Temperature**

Before a combustible substance can catch fire and burn, it must be heated to a certain minimum temperature by supplying heat from outside. The lowest temperature at which a substance catches fire and starts burning, is called its ignition temperature. It is necessary to heat a combustible substance to its ignition temperature so that it may undergo combustion (or burn). The ignition temperature of paper is 233°C. This means that a piece of paper has to be heated at least to a temperature of 233°C so that it may catch fire and start burning. A combustible substance cannot catch fire (or burn) as long as its temperature is lower than its ignition temperature.
We usually apply a burning matchstick (or lighter) to make a substance burn. This burning matchstick supplies heat to raise the temperature of the substance to its ignition temperature and make it burn. This will become more clear from the following example: A piece of paper does not catch fire (or does not burn) at the room temperature because the ignition temperature of paper is much higher than the room temperature. When we apply a burning matchstick to the piece of paper, it starts burning (see Figure 3). This is because the heat produced by burning matchstick heats the piece of paper to its ignition temperature and makes it burn (or undergo combustion).

The ignition temperatures of different substances are different. So, different substances catch fire and burn at different temperatures. Some substances have low ignition temperatures whereas other substances have comparatively high ignition temperatures.

(i) Some of the substances having low ignition temperatures are: Paper, Splinters of wood, Dry grass (Straw), White phosphorus, Cloth (Fabrics), Alcohol, Kerosene, Petrol, LPG, CNG and Biogas. The lower the ignition temperature, the more easily the substance will catch fire. The substances which have very low ignition temperatures and can easily catch fire with a flame are called inflammable substances. In other words, a substance which is easily set on fire is called inflammable. Some of the examples of inflammable substances are: Petrol, Alcohol, Liquefied petroleum gas (LPG), Compressed natural gas (CNG) and Biogas. All these inflammable substances have very low ignition temperatures.

The fuels having very low ignition temperatures are very dangerous to use. For example, petrol has a much lower ignition temperature than that of kerosene. Due to its very low ignition temperature, a can full of petrol catches fire very easily on being lighted with a matchstick and burns explosively. This is why, petrol is not used in stoves. On the other hand, kerosene has a comparatively higher ignition temperature due to which it burns smoothly in a kerosene stove.

(ii) Some of the substances having high ignition temperatures are: Coal, Charcoal, Log of wood and Cow-dung cakes (Uple). The substances having high ignition temperatures catch fire with difficulty. The substances having high ignition temperatures burn only on strong heating. They cannot be burnt directly by a lighted matchstick.

We will now describe how a matchstick is lighted. A matchstick does not catch fire and burn on its own at room temperature because the ignition temperature of matchstick is much higher than the room temperature. A matchstick is lighted by rubbing it on the rough surface provided on the side of the matchbox (see Figure 4). The heat produced by friction raises the temperature of the chemicals present on the matchstick head to their ignition temperature. Due to this, the chemicals present on the head of the matchstick catch fire and the matchstick starts burning (see Figure 4). Thus, a matchstick starts burning on rubbing it on the side of the matchbox because the heat produced by friction heats the chemicals at the head of the matchstick to their ignition temperature and make it catch fire.

Kerosene oil and wood do not catch fire on their own at room temperature. This is because the ignition temperatures of kerosene oil and wood are higher than the room temperature. Now, if kerosene is heated a little (say, by a burning matchstick), it will catch fire easily. This is because kerosene oil has a comparatively
low ignition temperature which is reached even on little heating. But if wood is heated a little, it does not catch fire. This is because wood has a much higher ignition temperature which is not reached by the little heat being supplied to it by a matchstick. From this we conclude that the ignition temperature of kerosene oil is much lower than that of wood. Since kerosene oil has a low ignition temperature and it can catch fire easily, we have to take special care in storing kerosene oil. Sometimes we see cooking oil in a frying pan catching fire when the frying pan is kept on the burning gas stove for a long time. This happens because the cooking oil gets heated to its ignition temperature when kept over a burning stove for a long time.

We know that a matchstick can light a tiny splinter of wood but not a big log of wood. This can be explained as follows: A splinter of wood has a low ignition temperature. Now, a burning matchstick can produce sufficient heat to reach the ignition temperature of the splinter of wood (which is low), therefore, a matchstick can light (or burn) a splinter of wood directly. The ignition temperature of a log of wood is high which cannot be reached by the small heat produced by a burning matchstick. So, a matchstick cannot light (or burn) a log of wood directly. In order to burn a log of wood (as in a chulha), a small fire is first started by burning straw (or dry grass) with a matchstick, and then the log of wood is placed over this fire. The considerable heat of this fire then heats the log of wood to its ignition temperature due to which the log of wood starts burning.

Coal has a high ignition temperature, so a coal fire cannot be started by using a lighted matchstick directly. This is because the small heat produced by burning matchstick is not sufficient to heat the coal to its ignition temperature (which is high). A coal fire is started indirectly as follows: A piece of cloth is dipped in kerosene oil and some pieces of wood are arranged over it. When the kerosene soaked piece of cloth is ignited by a lighted matchstick, it starts burning. The heat produced by the burning of kerosene soaked cloth makes the pieces of wood to burn. The coal pieces are then placed over the burning wood pieces. The large heat produced by the burning wood pieces heats the coal to its ignition temperature due to which the coal also starts burning. This starts the coal fire.

Sometimes we hear of ‘forest fires’ which occur on their own. The forest fires occur during the hottest summer days. This happens as follows: During extreme heat of summer, sometimes the ignition temperature of dry grass in the forest is reached, which makes the dry grass catch fire. From the burning grass, the fire spreads to bushes and trees, and very soon the whole forest is on fire (see Figure 5). It is very difficult to control such forest fires. We will now describe an activity which shows that it is essential for a substance to reach its ignition temperature to ‘catch fire’ and ‘start burning’.

### ACTIVITY

Make two paper cups by folding two round sheets of paper. Keep one paper cup empty but put about 50 mL of water in the other paper cup. Heat both the paper cups separately over a candle flame (see Figure 6). We will see that the empty paper cup catches fire easily and starts burning [see Figure 6(a)]. On the other hand, the paper cup containing water does not catch fire. The water in this paper cup becomes hot gradually [see Figure 6(b)]. If we continue heating this paper cup, we can even boil the water in it (without the paper cup catching fire). These observations can be explained as follows:
(i) When we heat the empty paper cup over the candle flame, then the ignition temperature of paper is reached quickly. Due to this, the empty paper cup catches fire quickly and starts burning.

(ii) When we heat the paper cup containing water, then the heat supplied to the paper cup is transferred to water inside it by conduction. Due to the continuous transfer of heat from paper cup to water, the paper cup does not get heated too much and its ignition temperature is not reached. So, in the presence of water, the ignition temperature of paper cup is not reached, and hence the paper cup does not catch fire (or does not burn).

We know that it is difficult to burn a heap of green leaves but dry leaves catch fire easily. This can be explained as follows: The green leaves contain a lot of water. This water does not allow the green leaves to get heated to their ignition temperature easily and makes the burning of green leaves difficult. On the other hand, since dry leaves do not contain water, they get heated to their ignition temperature easily and hence catch fire easily.

The History of Matchstick

A short, thin piece of wood having chemicals coated at one end, which is used to light a fire by rubbing against a rough surface, is called matchstick. The history of matchstick is very old. About 5000 years ago, small, thin pieces of pinewood dipped in sulphur at one end, were used as matchsticks in ancient Egypt. The modern safety match (or matchstick) was developed only about 200 years ago.

Earlier, a mixture of antimony trisulphide, potassium chlorate and white phosphorus with some glue and starch was applied to the head of a matchstick made of suitable wood. When the head of this matchstick was rubbed against a rough surface, white phosphorus got ignited due to the heat of friction. This started the combustion (or burning) of matchstick. White phosphorus is poisonous. So, the use of white phosphorus in making matchsticks proved to be dangerous for the workers engaged in making matchsticks as well as for the users.

These days, the head of matchstick (or safety match) contains only antimony trisulphide and potassium chlorate. The rough rubbing surface on the side of the matchbox has a coating of powdered glass and a little red phosphorus (Red phosphorus is much less dangerous than white phosphorus). When the matchstick is rubbed against the rough surface of matchbox, some red phosphorus is converted into white phosphorus. This white phosphorus immediately reacts with potassium chlorate in the matchstick head to produce sufficient heat to ignite antimony trisulphide and make the matchstick head burn. We will now describe how to control unwanted fires.

HOW DO WE CONTROL FIRE

Burning (or combustion) produces fire. Fire is useful as well as harmful. We make small fire in a gas stove to cook our food. This is a useful fire. Without fire, we cannot cook our food. But when a fire breaks out in a house, an office, a factory, an oil tanker, a petrol pump or an electrical equipment, then the fire is harmful. It can cause loss of life and property. Such fires must be brought under control and extinguished at the earliest. The process of extinguishing a fire is called fire-fighting. Every city and town has a Fire Service in the form of Fire Brigade Station. The fire-fighters of Fire Brigade specialise in putting out fires. All of us should know the telephone number of the Fire Service of our city. The telephone number of Fire Service in Delhi is 101. God forbid, if a fire breaks out in our house or in our neighbourhood, we should at once call the Fire Service. We should also know how fire is caused and what are the different ways of fire-fighting or putting off fires. This is discussed on the next page.
Any fire needs three things to be present: Fuel (Combustible substance), Air (or Oxygen) and Heat. If any one of these three things is removed, then the burning will stop and fire will be extinguished. Thus, a fire can be extinguished in three ways:

1. By removing the fuel (combustible substances)
2. By removing the heat (by cooling with water)
3. By cutting off the air supply to the burning substances (with carbon dioxide, etc.)

We will now discuss these three ways of extinguishing fire in detail, one by one.

1. **Remove the Fuel (or Combustible Substances)**

A fuel (or combustible substance) is a food for fire. So, when fire starts in a room, all the combustible substances like furniture, clothes, and books, etc., (which can burn easily) should be removed at once so that fire may not spread. If possible, cooking gas cylinder should be removed and electricity should be switched off. If the fire is near a pile of wood that could provide fuel to keep the fire going, the pile of wood should be removed from there as soon as possible. It is, however, usually not possible to remove all the combustible materials from the place of fire.

2. **Remove the Heat**

Water is used to remove heat from a burning substance and to make it too cool to burn further. Water is the most common fire extinguisher for ordinary fires. Water extinguishes fire by cooling the burning substances. *When water is thrown on a burning substance, it gets cooled below its ignition temperature and stops burning.* The fire gets extinguished. For example, when fire brigade man throws a strong stream of water on a building on fire, the burning materials get cooled to below their ignition temperatures and fire is extinguished. The water vapour produced by the action of heat of fire on water surround the burning material and help in cutting off the supply of air. This also helps in extinguishing fire. Thus, fire-men extinguish the fire by throwing water under pressure on the burning things such as houses, factories or other buildings. Water works as a fire extinguisher only when things like wood and paper, etc., are on fire. The fires caused by burning oil (or petrol) or those caused by electricity, however, cannot be extinguished by using water. This is explained below.

The fire produced by burning oil and petrol (like fire in frying pan, oil tanks, petrol pumps and airports, etc.) cannot be extinguished by using water. This is because of the following reason: Water is heavier than oil and petrol. So, when water is thrown over burning oil (or petrol), it (water) settles down. The oil (or petrol) floats on water and continues to burn. Thus, fires caused by burning oil (or petrol) cannot be extinguished by pouring water over it.

The fires caused by electrical short-circuit in an electrical appliance or in electric wiring should not be extinguished by throwing water. This is because of the following reason: Ordinary water conducts electricity to some extent. So, when water is thrown over the burning electrical appliance (or burning electric wires), it can give electric shock to the persons involved in fire-fighting. Thus, water cannot be used to extinguish fires caused by electricity.

3. **Cut Off the Air Supply**

Many fires can be extinguished by cutting off air supply to the burning substances. The air supply to a burning substance can be cut off in a number of ways such as covering the burning substances with carbon dioxide, sand (or soil), a blanket or a damp cloth, etc.

The electrical fires are extinguished by using carbon dioxide gas fire extinguisher. Carbon dioxide gas is denser than air and forms a layer around the burning substances. Carbon dioxide layer covers the fire like a blanket due to which fresh air cannot reach the burning substances. The burning substance does not get oxygen of air and hence stops burning. In this way, the fire gets extinguished. Please note that carbon dioxide gas neither burns itself nor supports
burning (or combustion). An added advantage of carbon dioxide is that it does not harm the electrical equipment. The fires caused by the burning of inflammable materials like oil or petrol are also extinguished by using carbon dioxide fire extinguishers.

Carbon dioxide used for extinguishing fire can be stored as a liquid at high pressure in cylinders (called fire extinguishers). When released from the cylinder, carbon dioxide expands enormously in volume and cools down. In this way, carbon dioxide not only forms a blanket around the burning substance, it also cools down the burning substance. This makes carbon dioxide an excellent fire extinguisher. Another way to obtain carbon dioxide for extinguishing a fire is to release a lot of dry powder of chemicals like sodium bicarbonate (baking soda) or potassium bicarbonate over the fire. The heat of fire decomposes these chemicals to produce carbon dioxide gas. And this carbon dioxide then extinguishes the fire.

A small fire can be extinguished by throwing sand (or soil) over it. For example, when sand is thrown over burning kerosene oil, the sand covers it like a blanket. The sand cuts off the air supply to the burning kerosene oil due to which the fire gets extinguished. The cooking oil fire in a frying pan in the kitchen can be extinguished by covering the pan with a fire blanket or a damp cloth. When the frying pan is covered with a fire blanket or a damp cloth, the supply of air to the burning cooking oil is cut off and hence the fire gets extinguished. If the clothes of a person working in the kitchen catch fire, the person is immediately covered with a blanket. When the burning clothes of a person are covered with a blanket, the supply of air to the burning clothes is cut off and hence the burning (or fire) stops.

### TYPES OF COMBUSTION

There are various types of combustion. The three important types of combustion are:

(i) **Rapid Combustion**

(ii) **Spontaneous Combustion**, and

(iii) **Explosive Combustion (or Explosion)**.

We will now describe these three types of combustion reactions in a little more detail, one by one.

1. **Rapid Combustion**

   The combustion reaction in which a large amount of heat and light are produced in a short time is called **rapid combustion**. When we bring a lighted matchstick or a lighter near the burner of a gas stove in the kitchen, the cooking gas starts burning at once producing a lot of heat and some light. So, the immediate burning of cooking gas (LPG) in a gas stove to give heat and light, is an example of **rapid combustion**. The burning of kerosene oil in a kerosene stove and the burning of wax in a candle are also examples of rapid combustion.

2. **Spontaneous Combustion**

   The combustion reaction which occurs on its own (without the help of any external heat), is called **spontaneous combustion**. In spontaneous combustion, the substance suddenly bursts into flames and starts burning (even without being heated). Spontaneous combustion takes place at room temperature. The heat required for spontaneous combustion is produced inside the substance by its slow oxidation. Spontaneous combustion is usually undergone by those substances which have quite low ignition temperatures. White phosphorus is a substance which undergoes spontaneous combustion. In other words, white phosphorus burns in air at room temperature. So, if we keep a piece of white phosphorus in a china dish, we will see that it catches fire by itself and starts burning (without being heated). **The burning of white phosphorus on its own at room temperature is an example of spontaneous combustion.** The heat required to start this spontaneous combustion is produced internally by the slow oxidation of phosphorus in air.

   **The spontaneous combustion reactions which take place in nature are very dangerous.** For example, the spontaneous combustion of coal dust has resulted in many disastrous fires in coal mines (leading to the death of many persons working in deep coal mines). Forest fires can also be started by spontaneous
combustion reactions. Sometimes, due to the heat of the sun (or due to the spark of lightning from the sky), spontaneous combustion of straw and forest wood takes place leading to forest fires. Most of the forest fires are, however, caused due to the carelessness of human beings. When human beings throw away lighted cigarettes in the forest or leave behind a burning campfire after having a picnic in the forest, then forest fires are started. It is, therefore, important that burning cigarette butts, etc., are not thrown in the forest, and campfires are completely extinguished before leaving the forest after a visit.

3. Explosive Combustion (or Explosion)

A very fast combustion reaction in which a large amount of heat, light and sound are produced, is called explosive combustion (or explosion). A large amount of gases is released quickly in an explosive combustion. It is the rapid expansion of these gases which causes a loud sound (or explosion). The fireworks (crackers, etc.) which we explode during festivals work on the explosive combustion of substances. When a cracker is ignited with a burning matchstick, the chemicals present in it undergo a sudden (very rapid) combustion producing heat, light and a large volume of gases. The gases produced are heated by the heat evolved in the reaction. The hot gases expand rapidly and cause an explosion (producing a loud sound). Explosive combustion (or explosion) can also take place if pressure is applied on the cracker by hitting it hard. We will now discuss the types of fuels.

FUELS

A material which is burnt to produce heat is called a fuel. Some of the common fuels are: Wood, Coal, LPG (Cooking gas), Kerosene, Petrol, Diesel, Natural gas and Biogas. A fuel is a very good source of heat energy. The heat energy produced by burning a fuel can be used directly to cook food and for running motor vehicles and factory machines or it can be converted into electrical energy at thermal power stations. And this electrical energy (or electricity) is then used for various purposes. The fuels which we use for various purposes can be in the form of a solid, a liquid or a gas. Thus, there are three types of fuels: Solid fuels, Liquid fuels and Gaseous fuels.

(i) Some of the examples of solid fuels are: Wood, Charcoal, Coal, Coke, Agricultural wastes and Cow-dung cakes (Uple).
(ii) The examples of liquid fuels are: Kerosene, Petrol, Diesel, and Alcohol (Ethanol).
(iii) The examples of gaseous fuels are: Natural gas, Petroleum gas, Biogas and Coal gas.

We use different types of fuels for various purposes at home, in industry and in transport for running automobiles. Some of the fuels used in homes are wood, charcoal, coal, LPG and kerosene. Some of the fuels used in industry are coal and natural gas. The fuels used in running automobiles (or vehicles) are petrol, diesel and CNG.

Fuel Efficiency: Calorific Value of Fuels

All the fuels produce heat on burning. All the fuels, however, do not produce the same amount of heat. Different fuels produce different amounts of heat on burning. Some fuels produce more heat whereas other fuels produce less heat. The efficiency of a fuel is expressed in terms of its calorific value. The amount of heat produced by the complete burning (or complete combustion) of 1 kilogram of a fuel is called its calorific value. The calorific value of a fuel is expressed in the unit of ‘kilojoules per kilogram’ (which is written in short form as kJ/kg). We know that kerosene is a fuel. Now, when 1 kilogram of kerosene is burned completely, then 45000 kilojoules of heat energy is produced. So, the calorific value of kerosene is...
45000 kilojoules per kilogram (or 45000 kJ/kg). The ‘calorific value’ of a fuel is also known as ‘heat value’ of the fuel. The calorific values of some of the common fuels are given below.

**Calorific Values of Some Common Fuels**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Calorific value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cow-dung cakes (Uple)</td>
<td>6000 to 8000 kJ/kg</td>
</tr>
<tr>
<td>2. Wood</td>
<td>17000 to 22000 kJ/kg</td>
</tr>
<tr>
<td>3. Coal</td>
<td>25000 to 33000 kJ/kg</td>
</tr>
<tr>
<td>4. Biogas</td>
<td>35000 to 40000 kJ/kg</td>
</tr>
<tr>
<td>5. Petrol</td>
<td>45000 kJ/kg</td>
</tr>
<tr>
<td>6. Kerosene</td>
<td>45000 kJ/kg</td>
</tr>
<tr>
<td>7. Diesel</td>
<td>45000 kJ/kg</td>
</tr>
<tr>
<td>8. Methane</td>
<td>50000 kJ/kg</td>
</tr>
<tr>
<td>9. CNG (Compressed Natural Gas)</td>
<td>50000 kJ/kg</td>
</tr>
<tr>
<td>10. LPG (Liquefied Petroleum Gas)</td>
<td>55000 kJ/kg</td>
</tr>
<tr>
<td>11. Hydrogen gas</td>
<td>150000 kJ/kg</td>
</tr>
</tbody>
</table>

From the above table we can see that the calorific value of LPG is 55000 kJ/kg. By saying that the calorific value of LPG is 55000 kJ/kg, we mean that if 1 kilogram of LPG is burnt completely, then it will produce 55000 kilojoules of heat energy. The calorific value of LPG is much higher than the calorific value of cow-dung cakes and coal. This means that the burning of a given amount of LPG will produce much more heat than burning the same amount of cow-dung cakes or coal. So, if we are asked to heat some water to boil it, then we should prefer to use LPG as fuel rather than cow-dung cakes or coal (because LPG produces much more heat on burning than an equal amount of cow-dung cakes or coal). We will now solve some problems based on calorific value.

**Sample Problem 1.** In an experiment, 4.5 kg of a fuel was completely burnt. The heat produced was measured to be 180,000 kJ. Calculate the calorific value of the fuel.

*(NCERT Book Question)*

**Answer.** Calorific value of a fuel is the heat produced by burning 1 kg of fuel. Now,

Heat produced by burning 4.5 kg fuel = 180000 kJ

So, Heat produced by burning 1 kg fuel = \( \frac{180000 \times 1}{4.5} \) kJ = 40000 kJ

Thus, the calorific value of the given fuel is 40000 kJ/kg.

**Sample Problem 2.** Arrange the following fuels in the increasing order of their calorific values (keeping the fuel with the lowest calorific value first):

Kerosene, Hydrogen gas, LPG, Coal, Wood

**Answer.** Wood, Coal, Kerosene, LPG, Hydrogen gas

(Lowest) (Highest)

**Characteristics of an Ideal Fuel (or Good Fuel)**

An ideal fuel (or a good fuel) has the following characteristics:

(i) **It has a high calorific value.** That is, it produces a large amount of heat (per unit mass).

(ii) **It burns easily in air at a moderate rate.** That is, it burns neither too fast nor too slow.

(iii) **It has a proper ignition temperature** (which is neither very low nor very high).

(iv) **It does not produce any harmful gases or leaves any residue after burning** (which may pollute the environment).

(v) **It is cheap, readily available, and easy to transport.**
Please note that there is perhaps no fuel which can be considered to be an ideal fuel. We should choose a fuel which fulfils most of the requirements for a particular use.

**FLAME**

If we heat one end of a magnesium ribbon over a burner, we find that the magnesium ribbon burns by producing a brilliant white flame. We have also seen a candle flame, a kerosene lamp flame and a Bunsen burner flame (see Figure 10). Actually, flame is the ‘blaze’ of a fire. It is called *jiwala* or *lapat* in Hindi.

![Figure 10](image)

**Figure 10.** Flames of candle, kerosene lamp and Bunsen burner (Gas burner).

A flame is a region where combustion (or burning) of gaseous substances takes place. All the gases which undergo combustion (or burn) produce flame. But only those solid and liquid fuels which vaporise on being heated, burn with a flame. In other words, only those solid and liquid fuels which form gases on being heated, burn with a flame. LPG and biogas are gases which undergo combustion, so LPG and biogas burn by producing a flame. Wax and camphor are solid substances which vaporise (or form gases) on heating, so wax and camphor burn with a flame. Similarly, kerosene oil and mustard oil are liquids which form vapours (or gases) on being heated, so kerosene oil and mustard oil also burn by producing flames. Thus, some of the substances which burn by producing flames are: LPG, biogas, wax (in the form of candle), camphor, magnesium, kerosene oil and mustard oil. Wax candle and kerosene oil lamp have wicks. Molten wax and kerosene oil rise through the wick, get vaporised during burning and form flames. On the other hand, charcoal is a solid fuel which does not vaporise on heating. So, charcoal does not burn by producing a flame. Charcoal only glows on combustion. Similarly, coal is a solid fuel which does not vaporise on heating. So, coal also does not burn by producing a flame. Coal just glows red on combustion (see Figure 11).

![Figure 11](image)

**Figure 11.** Coal does not burn by producing a flame. It just glows.

When fuels burn, the type of flame produced depends on the proportion of oxygen (of air) which is available for burning the fuel (or for combustion of fuel).

*(i)* When the oxygen supply (or air supply) is insufficient, then the fuels burn incompletely producing mainly a yellow flame. The yellow flame is caused by the glow of hot unburnt carbon particles produced due to incomplete combustion of fuel. This yellow flame produces light, so it is said to be a luminous flame (or light-giving flame). When wax burns in the form of a candle, it burns with a yellow, luminous flame (see Figure 12). Thus, the colour of candle flame is mainly yellow. When kerosene is burned in a lamp, it also burns with a yellow, luminous flame.
(ii) When the oxygen supply (or air supply) is sufficient, then the fuels burn completely producing mainly a blue flame. This blue flame does not produce much light, so it is said to be a non-luminous flame (or non light-giving flame). In LPG stove (or kitchen stove), the LPG burns with a blue flame (which is a non-luminous flame) (see Figure 13). The blue flame is produced when the complete combustion of a fuel takes place. Thus, complete combustion of LPG takes place in the kitchen gas stove. The design of the burner of kitchen gas stove is such that it provides sufficient air for the complete combustion of LPG.

Structure of a Flame

A flame consists of three zones (or three parts). These are: innermost zone, middle zone and outer zone. The three zones of a flame have different colours and different temperatures. We will now describe the three zones of a flame in detail by taking the example of candle flame.

(i) The innermost zone of a flame is dark (or black) (see Figure 14). The innermost zone of a flame consists of hot, unburnt vapours of the combustible material (say, wax vapours). The innermost zone is the least hot part of the flame. In other words, we can also say that the innermost zone (or dark zone) is the coldest part of the flame.

(ii) The middle zone of a flame is yellow. It is bright and luminous (light giving) (see Figure 14). The fuel vapours burn partially in the middle zone because there is not enough air for burning in this zone. The partial (or incomplete) burning of fuel in the middle zone produces carbon particles. These carbon particles become white hot and emit light. So, it is the glow of hot carbon particles which makes the middle zone of a flame luminous (or light-giving). These carbon particles then leave the flame as smoke and soot. The middle zone (or luminous zone) of a flame produces a moderate temperature. This zone is the major part of a candle flame.

(iii) The outer zone of a flame is blue. It is non-luminous zone (which does not produce much light) (see Figure 14). In the outer zone of a flame, complete combustion of the fuel takes place because there is plenty of air around it. The outermost zone (or non-luminous zone) has the highest temperature in the flame. In other words, the outermost zone (or non-luminous zone) is the hottest part of the flame. The outermost zone of a flame is quite thin as compared to the middle zone.
ACTIVITY TO SHOW THAT THE INNERMOST ZONE OF A CANDLE FLAME CONSISTS OF UNBURNED WAX VAPOURS

Take a wax candle, fix it on a table and light it with a matchstick. Hold a thin glass tube with a pair of tongs and introduce one end of this glass tube in the innermost zone (dark zone or black zone) of the candle flame (see Figure 15). Now bring a lighted matchstick near the other end of the glass tube. We will see a flame at this end of the glass tube (see Figure 15). This can be explained as follows: The innermost zone (or dark zone) of candle flame near the heated wick consists of unburnt wax vapours. Some of these wax vapours enter the glass tube and come out from its other end. When we bring a lighted matchstick near this end of glass tube, the wax vapours coming out of it start burning, producing a flame. This activity shows that the innermost zone (dark zone or black zone) of a candle flame consists of unburnt wax vapours.

ACTIVITY TO SHOW THAT THE MIDDLE ZONE OF CANDLE FLAME CONSISTS OF UNBURNED CARBON PARTICLES

Light a candle. Hold a clean glass plate with the help of a pair of tongs and introduce it in the middle zone (or luminous zone) of the candle flame (see Figure 16). Hold the glass plate in this position for about 10 seconds. Then remove the glass plate from candle flame and observe it carefully. We will find that a blackish ring is formed on the glass plate (see Figure 16). This blackish ring is produced due to the deposition of unburnt carbon particles present in the luminous zone of the candle flame. This activity shows that the partial combustion of wax vapours in the middle zone produces unburnt carbon particles.

ACTIVITY TO SHOW THAT THE OUTERMOST ZONE (NON-LUMINOUS ZONE) OF A FLAME IS THE HOTTEST

Take a long copper wire and hold its one end with a pair of tongs. Introduce the other end of copper wire just inside a burning candle flame so that it is in the outermost zone (non-luminous zone) of flame (as shown in Figure 17). Keep the copper wire in this position for about 30 seconds. We will see that the part of copper wire which is in the outermost zone of the flame becomes red hot. This tells us that the outermost, non-luminous zone of a flame has a high temperature. In other words, the non-luminous zone (or outermost zone) of a flame is the hottest part of a flame.
A kerosene oil lamp produces a flame exactly similar to the candle flame, consisting of the same three zones. Goldsmiths blow air with a blow-pipe to intensify a kerosene lamp flame for melting and moulding the pieces of gold and silver into desired shapes to make jewellery (see Figure 18). When air is blown through blow-pipe into the flame, it helps in the combustion of unburnt fuel and hence makes the flame hotter. We will now discuss the harmful products produced by the burning of fuels.

**BURNING OF FUELS LEADS TO HARMFUL PRODUCTS**

The burning of fuels produces harmful products which pollute the air around us. So, the increasing use of fuels has harmful effects on the environment. The important harmful effects produced by the burning of fuels are as follows:

1. **The burning of fuels like wood, coal and petroleum products (kerosene, petrol, diesel, etc.) releases unburnt carbon particles in the air.** These fine carbon particles are dangerous pollutants which can cause respiratory diseases such as asthma.

2. **Incomplete combustion of fuels (due to insufficient air) produces a very poisonous gas called carbon monoxide.** Excessive inhaling of carbon monoxide gas can kill a person. We should never sleep in a room with closed door and windows, and having a coal fire burning inside. This is because when coal burns in an insufficient supply of air in the room (due to closed door and windows), then a lot of carbon monoxide gas is produced. When the persons sleeping in this room breathe in poisonous carbon monoxide gas, they may all die.

3. **Burning of fuels releases carbon dioxide into air in the environment.** Increased percentage of carbon dioxide in air is causing **global warming.** This happens as follows: Carbon dioxide gas in the air traps sun’s heat rays by producing greenhouse effect. **Global warming is the rise in temperature of earth’s atmosphere caused by the excessive amounts of carbon dioxide in the air.** Due to rise in the temperature of atmosphere, the ice in polar regions will melt very fast, producing a lot of water. This water may cause a rise in the sea-level leading to floods in coastal areas. The low-lying coastal areas may be completely submerged under water leading to the loss of life and property.

4. **Burning of coal, petrol and diesel produces sulphur dioxide gas which goes into the air.** Sulphur dioxide is an extremely suffocating and corrosive gas. It may damage our lungs. **The burning of petrol and diesel in the engines of vehicles also releases nitrogen oxides into the air.** Sulphur dioxide and nitrogen oxides produced by the burning of fuels dissolve in rain water and form acids. The rain water containing acids is called acid rain. Acid rain is very harmful for forests, aquatic animals and buildings.

**The Case of CNG**

The use of petrol and diesel as fuels in automobiles (vehicles) is being replaced by CNG (Compressed Natural Gas). This is because when CNG burns, it produces very small amount of harmful products. CNG is a clean fuel because it burns without producing smoke. Since the burning of CNG produces much less harmful products and smoke, therefore, the use of CNG as fuel in automobiles has reduced air pollution in our cities.

**The Case of Wood**

Wood has been used as a domestic and industrial fuel for centuries. In many rural parts of our country,
people still use wood as a fuel due to its low cost and easy availability. The burning of wood as a fuel has, however, many disadvantages. Some of the disadvantages of burning wood as fuel are as follows:

(i) The burning of wood produces a lot of smoke which is very harmful for human beings. Smoke causes respiratory diseases.

(ii) Trees provide us with many useful substances. When trees are cut down to obtain wood for use as fuel, then all the useful substances which can be obtained from trees are lost.

(iii) The cutting down of trees to obtain fuel wood leads to deforestation which is very harmful for the environment.

Wood has now been replaced by coal and other fuels such as LPG. LPG is a better domestic fuel than wood due to the following reasons:

(i) LPG has a much higher calorific value than wood, so it produces much more heat on burning than an equal mass of wood.

(ii) LPG burns without producing any smoke but burning of wood produces a lot of smoke.

(iii) LPG burns completely without leaving behind any solid residue but wood leaves behind a lot of ash on burning.

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

**Very Short Answer Type Questions**

1. Define ignition temperature of a substance.
2. Which of the two has a lower ignition temperature: petrol or kerosene?
3. Name the most common fire extinguisher.
4. Which is the best fire extinguisher for fires involving electrical equipment and inflammable materials like petrol?
5. Name one substance which undergoes spontaneous combustion (or burns in air at room temperature).
6. Name the unit in which the calorific value of a fuel is expressed.
7. Which of the following fuels has the lowest calorific value?
   - Diesel, Methane, CNG, Coal, Petrol
8. Which of the following fuels has the highest calorific value?
   - Kerosene, Wood, Hydrogen, Cow-dung cakes, LPG
9. Name the term which is used to express the efficiency of a fuel.
10. Name one solid, one liquid and one gas which burn by producing a flame.
11. Which of the following does not produce a flame on burning?
    - Camphor, Charcoal, Kerosene
12. Name one fuel which burns without producing a flame.
13. How many zones are there in a flame?
14. Which zone of a candle flame is the hottest?
15. In a candle flame, what is the colour of: (a) innermost zone, (b) middle zone, and (c) outer zone?
16. Name any harmful product released by the burning of fuels.
17. Name the very poisonous gas produced by the incomplete combustion of fuels.
18. Name the fuel which is gradually replacing petrol and diesel in automobiles.
19. Name two substances having low ignition temperatures and two having high ignition temperatures.
20. Fill in the following blanks with suitable words:
   (a) A fuel must be heated to its..............before it starts burning.
   (b) The most common supporter of combustion around us is..............
   (c) Fire produced by burning oil cannot be controlled by..............
   (d) A liquid fuel used in homes is ..............
   (e) The amount of heat evolved when 1 kg of a fuel is burnt completely is called its..............
   (f) The substances which vaporise during burning, give ..............
   (g) Burning of wood and coal causes..............of air.
Short Answer Type Questions

21. (a) What are fuels? Name any two common fuels.
    (b) State any four characteristics of an ideal fuel (or good fuel).
22. (a) Define the calorific value of a fuel.
    (b) “The calorific value of LPG is 55000 kJ/kg”. What does it mean?
23. Can you burn a piece of wood by bringing a lighted matchstick near it? Explain.
24. Why do you have to use paper or kerosene oil to start fire in wood or coal?
25. What is meant by rapid combustion? Give one example of rapid combustion.
26. What is meant by spontaneous combustion? Give one example of spontaneous combustion.
27. What is meant by explosive combustion (or explosion)? Give one example of explosive combustion (or explosion).
28. How will you show that air is necessary for combustion?
29. Can the process of rusting be called combustion? Give reason for your answer.
30. Why are fires produced by burning oil not extinguished by pouring water?
31. Explain why, fire caused by electricity should not be extinguished by pouring water.
32. How is the fire produced by burning oil (or petrol) extinguished?
33. How is the fire caused by electricity extinguished?
34. A drum full of kerosene catches fire. What is the simplest way to put off this fire?
35. What is the first thing you should do if a fire breaks out in your home or neighbourhood?
36. (a) What does a Fire Brigade do when it arrives at a place where a building is on fire?
    (b) Describe one method of putting out a fire caused by burning wood or paper.
37. Explain why, we are advised not to sleep in a room having closed doors and windows, with a coal fire burning inside.
38. (a) What is a flame? What type of substances, on burning, give a flame?
    (b) What is the difference between the burning of a candle and the burning of a fuel like coal?
39. How does pouring water extinguish a fire?
40. Explain how, carbon dioxide is able to control fires.
41. If you see a person whose clothes are on fire, how will you extinguish the fire? Give reason for your answer.
42. Give two examples each of: (a) solid fuels (b) liquid fuels, and (c) gaseous fuels.
43. Name the various zones of a candle flame. Which zone (or part) of a candle flame is the least hot (or coldest)?
44. Why does a goldsmith blow air into the kerosene lamp flame with a blow-pipe?
45. In which zone of a candle flame: (a) partial combustion of fuel takes place, and (b) complete combustion of fuel takes place?
46. Explain how, the use of CNG in automobiles has reduced pollution in cities.
47. What are the disadvantages of burning wood as fuel?
48. Give reasons for the following: LPG is a better domestic fuel than wood.
49. Explain why, when a burning candle is covered with an inverted gas jar, the candle gets extinguished after some time.
50. It is difficult to burn a heap of green leaves but dry leaves catch fire easily. Explain.

Long Answer Type Questions

51. (a) What are combustible substances? Name three combustible substances.
    (b) What are non-combustible substances? Name three non-combustible substances.
52. (a) What is meant by ‘combustion’? Explain with an example.
    (b) What are the conditions necessary for combustion to take place?
53. (a) Make a labelled diagram of a candle flame.
    (b) What makes the middle zone of a candle flame luminous (or light-giving)?
54. What is global warming? Name the gas whose increasing percentage in air is leading to global warming. State a harmful effect which can be caused by global warming.
55. Explain how, burning of fuels such as coal, petrol and diesel leads to acid rain. How is acid rain harmful?
Multiple Choice Questions (MCQs)

56. Which of the following substances has the lowest ignition temperature?
   (a) kerosene (b) spirit (c) diesel (d) mustard oil

57. One of the following is not a combustible substance. This one is:
   (a) alcohol (b) hydrogen (c) asbestos (d) chaff

58. Which of the following is not used in making matchsticks these days?
   (a) potassium chlorate (b) white phosphorus (c) antimony trisulphide (d) red phosphorus

59. Which of the following undergoes spontaneous combustion?
   (a) yellow sulphur (b) red phosphorus (c) white phosphorus (d) brown sulphur

60. Which of the following statement is not correct about carbon dioxide acting as a fire extinguisher for electrical fires?
   (a) it is heavier than air (b) it is lighter than air (c) it is not combustible (d) it does not support combustion

61. Fires in underground coal mines usually occur due to the:
   (a) explosive combustion (b) deliberate combustion (c) spontaneous combustion (d) rapid combustion

62. The calorific value of a fuel is 40000 kJ/kg. This fuel is most likely to be:
   (a) biogas (b) methane (c) hydrogen gas (d) liquefied petroleum gas

63. Which of the following fuels has the highest calorific value?
   (a) natural gas (b) liquefied petroleum gas (c) coal gas (d) hydrogen gas

64. On a cold winter night, the persons sleeping in a room with closed door and windows with a coal fire burning inside may die due to the excessive accumulation of:
   (a) nitrogen monoxide (b) nitrogen dioxide (c) carbon dioxide (d) carbon monoxide

65. Which of the following burns without producing a flame?
   (a) camphor (b) coke (c) cooking gas (d) kerosene

66. Which of the following fuels has the lowest calorific value?
   (a) kerosene (b) CNG (c) biogas (d) LPG

67. Which of the following is the main cause of global warming?
   (a) nitrogen dioxide (b) sulphur dioxide (c) carbon dioxide (d) ozone

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

69. Which of the following is the most environment friendly fuel to be used in automobiles?
   (a) petrol (b) diesel (c) natural gas (d) petroleum gas

70. Which of the following does not involve a combustion reaction?
   (a) production of heat and light from kerosene in a lantern
   (b) production of heat and light from hydrogen in a rocket
   (c) production of heat and light from hydrogen in the sun
   (d) production of heat and light from wood in a bonfire

71. A heap of green leaves is lying in one corner of a park. The green leaves in the heap burn with difficulty because:
   (a) they contain a tough material called cellulose
   (b) they contain a lot of water
   (c) they contain a green pigment chlorophyll
   (d) they do not get sufficient oxygen for burning

72. If the clothes of a person working in the kitchen catch fire, then to extinguish the fire:
   (a) sand should be thrown over the burning clothes
   (b) water should be thrown over the burning clothes
   (c) polyester blanket should be used to cover the burning clothes
   (d) woollen blanket should be used to cover the burning clothes

73. The outermost zone of a candle flame is the:
   (a) least hot part (b) coldest part (c) hottest part (d) moderately hot part
74. The flame of a kerosene oil lamp (or lantern) has:
   (a) single zone   (b) two zones   (c) three zones   (d) four zones

75. A lot of dry powder of one of the following chemicals can be released over a fire to extinguish it. This chemical is:
   (a) plaster of Paris   (b) baking soda   (c) washing soda   (d) bitumen

Questions Based on High Order Thinking Skills (HOTS)

76. An electric spark is struck between two electrodes placed near each other in a closed tank full of petrol. Will the petrol catch fire? Explain your answer.

77. Give reason for the following:
   Paper by itself catches fire easily whereas a piece of paper wrapped around an aluminium pipe does not.

78. Abida and Ramesh want to heat water taken in separate beakers. Abida kept the beaker near the wick in the yellow part of the candle flame. Ramesh kept the beaker in the outermost part of the flame. Whose water will get heated in a shorter time? Why?

79. When a lot of dry powder of a substance X is released over a fire, the fire gets extinguished.
   (a) Name the substance X.
   (b) How does this substance extinguish the fire?
   (c) Name another substance which behaves like X.

80. What type of combustion is represented by:
   (a) burning of white phosphorus in air at room temperature?
   (b) burning of LPG in a gas stove?
   (c) ignition of a cracker?
   (d) burning of coal dust in a coal mine?

ANSWERS

20. (a) ignition temperature  (b) air  (c) water  (d) kerosene  (e) calorific value  (f) flames  (g) pollution
38. (b) Candle burns with a flame whereas coal burns without producing a flame. Coal just glows on burning
56. (b) 57. (c) 58. (b) 59. (c) 60. (b) 61. (c) 62. (a) 63. (d) 64. (d) 65. (b) 66. (c) 67. (c) 68. (b) 69. (c)
70. (c) 71. (b) 72. (d) 73. (c) 74. (c) 75. (b) 76. No, the petrol will not catch fire. This is because in a closed tank full of petrol, there is no supporter of combustion like air which can make the petrol catch fire and burn
77. When paper is heated alone, its ignition temperature is reached quickly due to which it catches fire easily. When the paper wrapped around an aluminium pipe is heated, then the heat supplied to paper is transferred to aluminium pipe by conduction. Due to the continuous transfer of heat from paper to aluminium pipe, the paper does not get heated to its ignition temperature quickly and hence does not catch fire easily
78. Ramesh’s water will get heated in a shorter time because the outermost part of the candle flame is the hottest part of flame
79. (a) Sodium bicarbonate (Sodium hydrogen carbonate) (b) The heat of fire decomposes sodium bicarbonate to produce carbon dioxide gas. This carbon dioxide covers the fire like a blanket and cuts off supply of fresh air to the burning substance. Due to this the fire gets extinguished (c) Potassium bicarbonate (or Potassium hydrogen carbonate)
80. (a) Spontaneous combustion (b) Rapid combustion (c) Explosive combustion (or Explosion) (d) Spontaneous combustion