ગુજરાત રાજ્યના શિક્ષણવિભાગના પત્ર-ક્રમાંક
બમશ/૫૫૫/ક-૧, તા. 25-02-2011 –થી મંજૂર

SCIENCE AND TECHNOLOGY

Standard 9

(Semester II)

PLEDGE

India is my country.
All Indians are my brothers and sisters.
I love my country and I am proud of its rich and varied heritage.
I shall always strive to be worthy of it.
I shall respect my parents, teachers and all my elders and treat everyone with courtesy.
I pledge my devotion to my country and its people.
My happiness lies in their well-being and prosperity.

રાજ્ય સરકારની વિનામૂલ્યે યોજના હેઠળનું પુસ્તક

Gujarat State Board of School Textbooks
'Vidyayan', Sector 10-A, Gandhinagar-382010

Authors

Dr. I. M. Bhatt (Convener)
Dr. P. N. Gajjar
Dr. B. K. Jain
Dr. Y. M. Dalal
Dr. A. P. Patel
Dr. D. H. Gadani
Shri C. I. Patel
Shri P. J. Chavda

Reviewers

Shri Hiren H. Rathod
Shri Sanjay D. Jhala
Shri Vishnu S. Patel
Shri Nitin D. Dave
Shri Jaysukh B. Harmani
Shri Sonal Bhatia
Shri Shailesh S. Parmar
Shri Raji Dennis

Language Correction

Dr. Rucha A. Bharahmbhatt

Artist

Shri G. V. Mevada

Co-ordination

Shri Chirag H. Patel
(Subject Co-ordinator : Physics)

Preparation and Planning

Shri Haresh S. Limbachiya
(Dy. Director : Academic)

Lay-out and Planning

Shri Haresh S. Limbachiya
(Dy. Director : Production)

PREFACE

The Gujarat State Secondary and Higher Secondary Education Board has prepared new syllabi in accordance with the new national syllabi prepared by the NCERT based on NCF 2005 and core-curriculam. These syllabi are sanctioned by the Government of Gujarat.

It is a pleasure for the Gujarat State Board of School Textbooks to place before the students this textbook of **Science and Techonology Standard 9, (Semester II)** prepared according to the new syllabus.

Before publishing the textbook, its manuscript has been fully reviewed by experts and teachers teaching at this level. Following suggestions given by teachers and experts, we have made necessary changes in the manuscript before publishing the textbook.

The board has taken special care to ensure that this textbook is interesting, useful and free from errors. However, we welcome any suggestion, from people interested in education, to improve the quality of the textbook.

Dr. Bharat Pandit
Director

Sujit Gulati IAS
Executive President

Date : 05-08-2015

Gandhinagar

First Edition : 2011, Reprint : 2012, 2013, 2014, 2015

Published by : Bharat Pandit, Director, on behalf of Gujarat State Board of School Textbooks, 'Vidyayan', Sector 10-A, Gandhinagar

Printed by :

FUNDAMENTAL DUTIES

It shall be the duty of every citizen of India

(A) **to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;**

(B) **to cherish and follow the noble ideals which inspired our national struggle for freedom;**

(C) **to uphold and protect the sovereignty, unity and integrity of India;**

(D) **to defend the country and render national service when called upon to do so;**

(E) **to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;**

(F) **to value and preserve the rich heritage of our composite culture;**

(G) **to protect and improve the natural environment including forests, lakes, rivers and wild life, and to have compassion for living creatures;**

(H) **to develop the scientific temper, humanism and the spirit of inquiry and reform;**

(I) **to safeguard public property and to abjure violence;**

(J) **to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;**

(K) **to provide opportunities for education by the parent or the guardian, to his child or a ward between the age of 6-14 years as the case may be.**

* Constitution of India : Section 51-A

INDEX

1 Work, Energy and Power

1.1 Introduction

Today there was a lot of work in office. Now I don't have energy even to stand. Our boss is very powerful, he takes a lot of work from us. We are familiar with such statements. But the meaning of words 'work, energy and power' with reference to the given statements differs a lot from their meaning in physics. Writing an account, sitting in a chair is not work from physics perspective.

Puzzled, right !! But in physics for work to be done, it is necessary to act force on the object and displacement of the object is necessary. Also, the capability of doing work is known as energy. Now you would understand why sitting at one place or write, is not work. Perhaps it can be treated to be 'mental work'. So, now let us try to understand the meanings of 'work', 'energy' and 'power' from the physics perspective.

1.2 Work

Activity 1 : Take three iron spheres with different masses. (For this purpose balls of different sizes of ball-bearings or the spheres used to make pendulum in the laboratory may be used.) Also take some fine, wet soil which is stoneless. Spread it in a tray and make the upper surface plane and smooth. (The soil taken should have water, just enough to make it wet.) Now take one sphere and allow it to fall freely from different heights (50 cm, 100 cm, 150 cm) on wet soil. Make sure that they fall on different places, so that depth of the dents produced can be observed. Now, from about 100 cm height, allow all three balls to fall on the wet soil at different places. Observe depth of dents for all the cases.

Here gravitational force does work on spheres. We can have an idea of amount of work done by measuring depth of dents. You must have noticed the fact, from this activity, that work done depends both on force and displacement.

Product of magnitude of force and the magnitude of displacement of the body during time in which force acts is called work. Work is a scalar quantity.

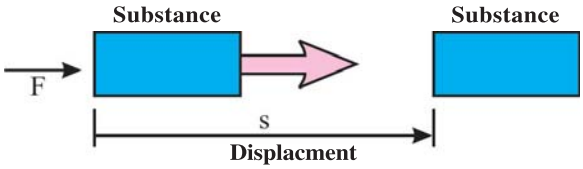


Figure 1.1

If W, F and s indicate work, force and displacement respectively then the work is given by the following formula.

$$W = F\ s \qquad 1.2.1$$

Here units of force and displacement are newton and metre respectively. So, unit of work is newton metre (Nm) which is also known as joule in memory of famous physicist Joule. Thus, for work to be done, action of force is necessary as well as displacement in the direction of force is also necessary. However it is also seen sometimes that force is acting but there is no displacement. For example, a person tries to move a very heavy stone. Here it is clear that work done in this case is zero. Many time, it is observed that force is acting, displacement is also there, but work done is zero. Puzzled again, right ! Let us

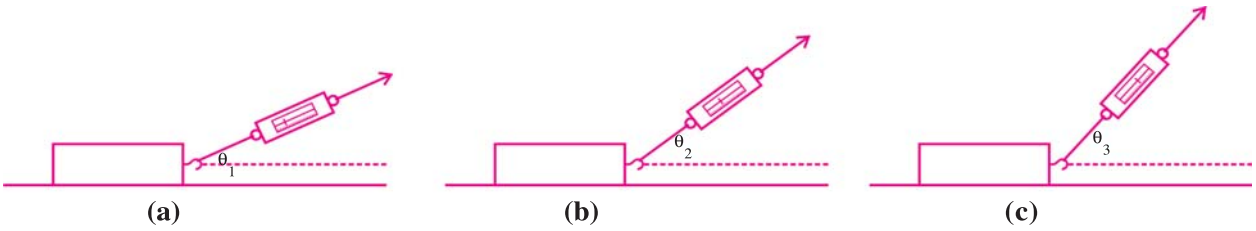


Figure 1.2 : Effectiveness of force

clarify. In order to clarify about this fact, we need to understand 'work done' when force and displacement are not in the same direction.

Activity 2 : As shown in the fig. 1.2, take a block and place it on a smooth horizontal plane surface. Fix a spring balance (of 0-5 kg capacity) to one of its ends. Pull the block, for 5 seconds, in horizontal direction such that indicator on the balance shows 3 kg i.e. 3 unit force. Measure the displacement. Now keep spring balance in such a way that it makes angle θ (θ is a greek alphabet, pronounced as 'theta') and pull the block with same force for 5 seconds and measure the displacement. Increase the angle for different values of angle and repeat the activity and measure the displacement.

Here, you would understand that as angle increases both magnitude of displacement and work reduces. Why does it happen so in spite of same force acting for the same time ? To understand this it is necessary to make definition of 'work' more accurate.

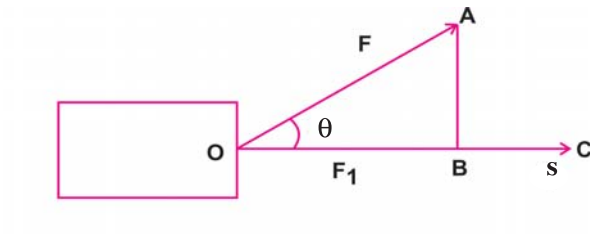


Figure 1.3

As shown in fig. 1.3, suppose that angle between the horizontal line and force acting on block is θ. Draw a line segment OA, having length equal to the magnitude of force, taking proper scale in the direction of force. This is how force can be represented geometrically. Similarly draw line segment OC for displacement. Now draw a perpendicular AB from A on OC. Here OB shows effective force F_1 in the direction of displacement, which is known as component of force in the direction of displacement. Now in this context work can be defined as follows :

Work done, when force acts on a body, is equal to the product of magnitude of displacement during the time period in which force is acting and magnitude of component of force in the direction of displacement.

∴ Work W = magnitude of component of force in the direction of displacement × magnitude of displacement.

What will be the work done if angle between the force and displacement is 90^0 ? In this case magnitude of component of force in the direction of displacement is zero and hence as per definition, given above, work done becomes zero. For example, a stone tied at one end of a string is whirled to make stone to move on a circular path. As displacement is perpendicular to centripetal force, work done is zero. The same fact applies to geo-stationary satellite revolving in certain circular orbits. Gravitational force due to earth acting on it is perpendicular to its displacement. So work done is zero.

If angle between the force and the displacement is acute angle, work is said to be done on the body by the force. If the force and displacement are in opposite directions, work is said to be done by the body against force. When brakes are applied on a moving vehicle, frictional force produced by the brakes and displacement of a vehicle are in opposite directions. So work is done by the vehicle against frictional force. If displacement and force are in opposite directions, work is considered to be negative.

Activity 3 : Form a group of four to five friends and discuss some situations in which work is either done or work is not done and classify them as follows :

(1) Force is acting, but displacement is zero.
(2) Force and displacement are in same direction
(3) Force and displacement are in opposite directions.
(4) Force and displacement are perpendicular to each other.

(5) There is some other angle between force and displacement.

Illustration 1 : A body of mass 15 kg undergoes downward displacement of 40 m under the effect of gravitational force. Calculate work done ($g = 10\ m/s^2$)

Acceleration $a = g = 10\ m/s^2$, mass $m = 15$ kg

displacement $s = 40$ m

Solution :

Work $W = F \times s$

$= m \times a \times s \quad (\because F = ma)$

$= 15 \times 10 \times 40$

$= 6000$ J

Note : Here gravitational force and displacement are in same direction. So, work is said to be done on the body.

Illustration 2 : A body of mass 120 g is taken vertically upwards to reach the height of 5m. Calculate work done ($g = 10\ m/s^2$)

Solution :

Here

$m = 120\ g = 0.120$ kg

$a = -g = -10\ m/s^2$

$s = 5$ m

Work $W = F \times s$

$= m \times a \times s$

$= m \times (-g) \times 5$

$= (0.120)(-10) \times 5$

$= -6$ J

Note : Here since force and displacement are in opposite directions, work is negative. So, work is considered to be done by the body against the force.

1.3 Energy

Ability to do work is energy. If work is done on the body, energy of the body increases. If work is done by the body, energy of the body reduces. A cyclist pedals the cycle and does work on cycle, so energy of cycle and cyclist increases. If brakes are applied to a vehicle in motion, work is done by vehicle against the force of friction. So, energy of the vehicle decreases. Thus when work is done, there is exchange of energy. Work is a process. Body cannot possess 'work', it can possess energy. Unit of energy is also joule. There are many types of energy, out of which we will study kinetic energy and potential energy.

1.4 Kinetic Energy

Suppose a person tries to hit you with a bullet, held in his hand. Another person tries to fire a bullet from his gun. In which case you would be hurt more ? It is obvious that you are more hurt by bullet fired from gun, as its speed is more, and so it hurts more. Why is it, so ? It is clear that the bullet having more speed has more energy. Thus, energy associated with motion is called kinetic energy.

Ability of a body to do work due to its motion is called kinetic energy.

There are two ways to measure kinetic energy of a body moving with velocity v.

(1) A body moving with velocity v, becomes stationary after some time, if force is applied opposite to its motion. We can calculate work done during this time and calculate kinetic energy.

(2) Work required to be done to make a stationary body, move with velocity v, gives the value of kinetic energy acquired by it.

In this context, work done by a vehicle moving with some velocity v, when brakes are applied, during the time in which its velocity reduces to zero, can be calculated. It is clear that if magnitude of v is more, work done will be more. So, higher the speed, more will be the kinetic energy.

So, now let us obtain an expression for kinetic energy. Suppose a body of mass m is lying stationary on a frictionless horizontal surface. When a force F acts on it, in time t, it undergoes a displacement s, and acquires velocity v.

If work done during this process is W then,

$W = F \times s$

But $F = m\ a$

$\therefore \quad W = ma \times s$ 1.4.1

Also $v^2 - u^2 = 2as$ and taking initial velocity $u = 0$, we get $v^2 = 2\ a\ s$

$$\therefore \ as = \frac{1}{2} v^2 \qquad 1.4.2$$

from equation 1.4.1 and 1.4.2 work done

$$W = m \times \frac{v^2}{2}$$

$$= \frac{1}{2} mv^2 \qquad 1.4.3$$

This equation shows that energy to be given to a stationary body of mass m, so that it can move with velocity v, is $\frac{1}{2} mv^2$, which results into its kinetic energy.

Thus, kinetic energy (K) of a body of mass m moving with velocity v can be given by

$$K = \frac{1}{2} mv^2 \qquad 1.4.4$$

In this context when force F acts on a body moving with initial velocity u if the body acquires velocity v during displacement s then work done

$W = F \times s$

$= mas$

$$= m\left(\frac{1}{2}v^2 - \frac{1}{2}u^2\right) \quad (\therefore\ v^2 - u^2 = 2as)$$

$$\therefore\ W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 \qquad 1.4.5$$

Thus, when work is done, there is change in kinetic energy of a body.

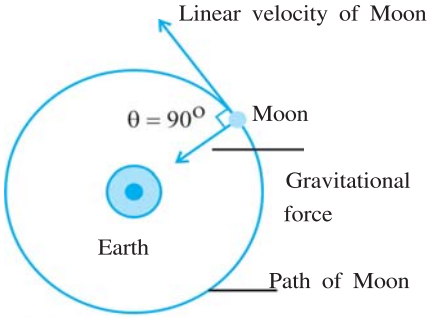


Figure 1.4

Now consider the case of uniform circular motion. Since its speed is constant ($v = u$). Thus, change in its kinetic energy is zero. So, work is also zero. Also centripetal force is perpendicular to displacement. So, work is zero.

Illustration 3 : A ball of mass 200g is moving with speed 27 km/h. Calculate its kinetic energy.

Solution :

m = 200 g = 0.2 kg, v = 27 km/h

$$= \frac{27\times1000}{3600}\ \text{m/s} = 7.5\ \text{m/s}$$

Kinetic Energy K = ?

$$K = \frac{1}{2}mv^2$$

$$= \frac{1}{2}(0.2)\times(7.5)^2$$

$$= 0.1\times56.25$$

$$= 5.625\text{J}$$

Illustration 4 : At what speed a person having 60 kg mass should run to acquire 750 J kinetic energy ?

Solution :

m = 60 kg kinetic energy k = 750 J, v = ?

$$\text{Kinetic energy } K = \frac{1}{2}mv^2$$

$$\therefore\quad v^2 = \frac{2K}{m}$$

$$= \frac{2\times750}{60}$$

$$= 25$$

$$v = 5\ \text{m/s}$$

Illustration 5 : Kinetic energy of a car, having mass 1000 kg, is 1,12,500 J. Driver applies brakes when an obstacle is sighted, and car comes to halt after travelling 100 m distance. (Without meeting with an accident) Calculate frictional force.

Solution :

Here work = F s

Initial kinetic energy K_0 = 1,12,500J, mass m = 1000 kg, Final kinetic energy K = 0

Distance s = 100 m

Work W = F s and W = K – K_0

$\therefore$ F s = K – K_0 = 0 – K_0

$\therefore$ F(100) = 0 – 1,12,500

$\therefore$ F = –1125N

Work W = change in K.E = K – K_0

Here force and displacement are in opposite directions, so force is negative.

1.5 Potential Energy

Ability of a body to do work due to its position or configuration is known as potential energy of the body.

The concept of potential energy is very important for the force fields like gravitational field, electric field and magnetic field. Here we will discuss the potential energy of a substance kept in the gravitational field (gravitational potential energy) only.

Generally potential energy is always mentioned along with reference point. This means that potential energy is relative. It is impossible to find the absolute value of potential energy. Also changes in potential energy are more important rather than its absolute value. Generally at reference point potential energy is taken to be zero. (Potential energy of object can be negative also. In which condition ? Think !)

Activity 4 : Take an object of 5 kg mass and another object of 10 kg mass. First take the object of 5 kg mass to 1m, 2m and 3m height. In which case you have to do more work ?

Now try to take both the objects to 5m height. For which object you have to do more work ? Where does the energy spent in doing this work go ?

You must have understood, from the activity given above, that when a body is taken to a height we have to do work against the gravitational force and to do this work we have to spend energy which is stored in the object in form of potential energy. Value of the potential energy depends on gravitational force acting on a body (gravitational force acting on a body with larger mass is more)

and height. Now let us put this fact in the form of a formula.

Suppose as shown in the figure, potential energy at reference level is zero.

Now on applying a force, having magnitude equal to the gravitational force acting on it, in the opposite direction, it is moved with constant velocity to a height h. Work done in this case is

W = force × displacement

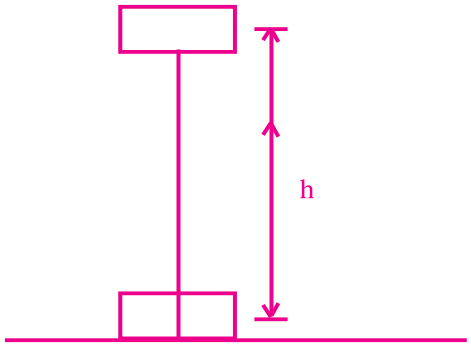


Figure 1.5

As magnitude of applied force is equal to the magnitude of gravitational force,

Force = mg

∴ work = mg × h

Energy spent in doing this work is stored in the body in form of potential energy, so potential energy at height h from the reference level can be given by the following formula.

$$U = mgh \qquad 1.5.1$$

Also this gravitational potential energy depends on the height from the reference level. It is not important along which path it is taken to this height. This is one of the characteristics of gravitational potential energy.

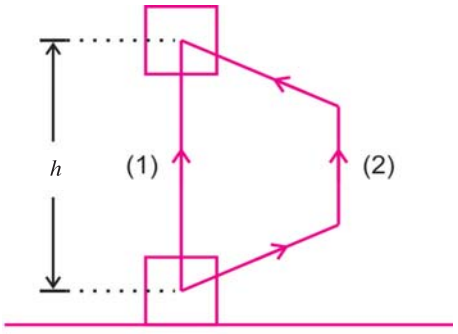


Figure 1.6

Suppose a body is taken to its final position by moving it along path (1) as shown in the fig. 1.6. Change in its potential energy would be same as the change in its potential energy, if it is taken to final position along path (2). This is the peculiarity of gravitational field.

Now as shown in fig. 1.7 consider a freely falling body of mass m. When it is at height h_1 from reference level its velocity is v_1 and at height h_2 its velocity is v_2.

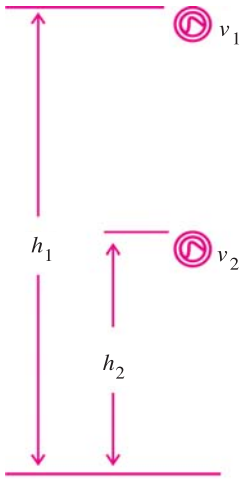


Figure 1.7

Thus, change in its kinetic energy is

$$\frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

which should be equal to work done. Here force acting on the body is gravitational force and displacement is

$$s = (h_1 - h_2)$$

From equation 1.4.5

$$\therefore \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 = W = mg\,(h_1 - h_2)$$

$$\therefore \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 = mgh_1 - mgh_2$$

$$\therefore \frac{1}{2}mv_2^2 + mgh_2 = \frac{1}{2}mv_1^2 + mgh_1$$

$$\therefore K_2 + U_2 = K_1 + U_1 \qquad 1.5.2$$

In the above equation $\frac{1}{2}mv_1^2$ and mgh_1 are kinetic energy (K_1) and gravitational potential energy (U_1) at height h_1 respectively and $\frac{1}{2}mv_2^2$ and mgh_2 are kinetic energy (K_2) and gravitational potential energy (U_2) at height h_2 respectively. The sum of kinetic energy and potential energy is known as mechanical energy.

Equation 1.5.2 indicates that in absence of other forces, in the gravitational field, sum of kinetic energy and potential energy remains constant.

i.e. K + U = constant 1.5.3.

Activity 5 : Take 1m long string and tie a heavy sphere at its one end. Tie the second end of the string with some solid support. Now when the sphere is stationary, give some horizontal velocity. The sphere would oscillate. Is there any relation between potential energy of the sphere at its highest position and kinetic energy at its lowest position ? Think.

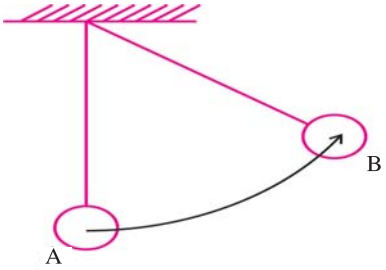


Figure 1.8

Illustration 6 : Calculate potential energy of a person having 60 kg mass on the summit of Mt. Everest. Height of Mt. Everest is 8848 m from sea level. ($g = 9.8\ m/s^2$)

Solution :

mass $m = 60$ kg

height $h = 8848$ m

$g = 9.8\ m/s^2$

Potential energy $U = mgh$

$= (60)\ (9.8)\ (8848)$

$= 52,02,624$ J

Body may possess potential energy due to its configuration also. A spring under compression or extension has ability to do work due to its configuration. This type of potential energy is known as elastic potential energy. Mechanical watch (which requires winding) are operated by energy stored in the spring in form of elastic potential energy.

1.6 Power

Generally everybody wishes to do more work in lesser time. For this purpose man compares work done by other persons or machines in the same interval of time and chooses a person or a machine imparting more work in the same time. In physics as standard interval of time, unit time (1 second, 1 minute or 1 hour) is taken. Work imparted in unit time or time rate of imparting work is known as power. If W work is done in time t

$$\text{Power } P = \frac{\text{work (W)}}{\text{time (t)}}$$

$$\therefore \quad P = W/t \qquad 1.6.1$$

SI units of work and time are joule and second. So, unit of power is joule / second (J/s) or watt (in memory of scientist James Watt).

'watt' is a small unit of power. In practice kilowatt (kW) and mega watt (MW) are used as bigger units of power.

$1\ kW = 10^3\ W$

$1\ MW = 10^6 W$

Horse power (hp) is also one of the well known units of power. (This is a British unit of power). This unit is used to indicate power of water pumps or automobiles.

$1\ hp \approx 746\ W$

Also, power = work/time,

Work can be expressed as

work = power × time

This fact is used in the unit of electrical energy of electricity bill. Here 1 unit means 1 kilowatt - hour energy. When you are consuming 1000 watt power for 1 hour, you have consumed 1 unit of electrical energy.

Thus 1 kWh = 1 kilowatt × 1 hour

$= 10^3$ watt × 3600 s

$= 10^3$ J/s × 3600 s

$= 3.6 \times 10^6$ J

Thus 1 unit = 1kWh = 3.6×10^6 J 1.6.2

1.7 Pulley

A circular device, having a string passed along its circumference, capable of rotating about horizontal axle or axis is called a pulley. Pulley is a simple machine.

Only for information : A simple device, which enables us to have effect of force applied at one point to another convenient point is called simple machine. Slope, screw, wedge, levers, pulley etc are simple machines. Simple machine does not convert one type of energy into the other.

You must have seen pulley being used in many places. If water is to be pulled out of a well (without using pump) pulley must be used. As you pull the rope down, a bucket filled with water, on the other end rises up. Thus pulley is very useful in changing the direction of force applied. A simple pulley, pulley-block (Which is made using two or three pullies) is well known. In physics, forces acting along a string passed over pulley can be considered to be forces acting along the same line.

Illustration 7 : Hetasvi, having her own mass 50 kg, climbs 20 m height along with 30 kg mass in 40 s. Calculate her power and work done. (take $g = 10 m/s^2$)

Solution :

Total mass $m = 50 + 30 = 80$ kg, height $h = 20$ m, time $t = 40$ s

Work done against gravitational force

$W = m\ g\ h = 80 \times 10 \times 20$

$= 16000$ J

Power P = W/t

$$= \frac{16000}{40} = 400 \text{ W}$$

Illustration 8 : 5 tubelights each of 40 W are operated for 10 hours. Calculate electrical energy consumed in 'units'.

Solution :

Power of 1 tubelight = 40 W = 40 J/s

Electrical energy consumed by 1 tube light

W = P × t

= 40 J/s × 10 hour

= 40 J/s × 10 × 3600 s

= 40 × 10 × 3600 J

∴ Electrical energy consumed by 5 tube lights

= 5 × 40 × 10 × 3600

= 7.2×10^6 J

$$= \frac{7.2 \times 10^6}{3.6 \times 10^6} = 2 \text{ units}$$

or

Work = 5 × 40 W × 10 hour

= 2000 Watt hour

= 2 kWh

= 2 units

Work out like this approximately, what is your contribution to the electricity bill at home.

1.8 Different Forms of Energy

In the present chapter we have studied mechanical energy. Apart from this, there are other forms of energy which are as under :

Internal energy : A substance posesses energy due to internal motions of its constituent particles and also due to interactions among these particles. For example, the constituent particles vibrate about their mean positions and hence they possess vibrational kinetic energy. They also possess potential energy due to mutual attraction and repulsion among themselves. The sum of all such energies of constituent particles of a body is known as internal energy of the body.

Heat or thermal energy : The kinetic energy associated with the random motion of the constituent particles of a body, is known as heat or thermal energy of the body. (What then is the difference between internal energy and heat energy ?)

Chemical energy : Energy of a stable chemical compound is always less than the sum of energies of its constituent elements in free state. This difference is known as chemical energy or chemical binding energy. The chemical processes may be endothermic or exothermic, depending on whether the energy of the products is more or less than the energy of reactants.

Electrical energy : Electric current can be utilized in getting some work or in getting different forms of energy. Thus, the energy associated with electric current is known as electrical energy.

Equivalence of mass and energy :

Albert Einstein, from his studies on the theory of relativity, showed that mass and energy are two different forms of same fundamental quantity. Mass and energy are mutually convertible according to the following relation.

$E = mc^2$

where c is velocity of light in vacuum. Its value is 3×10^8 m/s

The above equation shows that conversion of even a small quantity of mass results into production of enormous amount of energy.

Nuclear energy : Microscopic particles like neutrons and protons interact with each other at distances of the order of 10^{-15}m and constitute a nucleus. The mass of a given nucleus is less then the sum of the masses of its constituent particles in free state. The energy equivalent to this mass difference is known as nuclear energy or nuclear binding energy.

When heavy nuclei like uranium are bombarded by neutrons, they absorb the incident neutrons and become unstable. As a result the compound nucleus (uranium + neutron) is broken up into two almost equal parts and in this process some neutrons are also emitted. A huge amount of nuclear energy is released in this process. This process is known as nuclear fission. This is the process which takes place in atom bomb. In nuclear reactor also fission process is allowed to take place under control.

Lighter nuclei like hydrogen, deuteron, combine with each other at high temperatures and form a helium nucleus. In this process, too, nuclear energy is released. This process is known as nuclear fusion. The energy produced in the Sun and stars is due to this process.

Similarity between different forms of energy

After studying different forms of energy, it is found that there is some similarity between them. At the microscopic level all these energies are in the form of kinetic energy and / or potential energy. Examining the problem at the fundamental level it is found that what we call chemical energy is ultimately the potential energy. Then what are internal and heat energies ? Are they not potential and kinetic energies ?

The equivalence of different forms of energy indicate that there might be a limited number of fundamental forces in nature.

Conservation of energy :

While stating the law of conservation of mechanical energy, we had clarified that for the law to hold, the system should be mechanically isolated and the force should be conservative. In this condition we have,

$$\Delta K + \Delta U = 0 \qquad 1.8.1$$

When non-conservative forces like friction are present, a part of the work is used up in doing work against frictional force and rest of the work done is used in changing kinetic and potential energies. The energy spent against friction is converted into heat energy (Q). Hence on the L.H.S. of eqn. (1.8.1) we must add Q.

$$\Delta K + \Delta U + Q = 0 \qquad 1.8.2$$

This equation can still be generalized by inclusion of other forms of energy.

$$\therefore \quad \Delta K + \Delta U + Q + \Delta \text{ (other forms of energy)} = 0 \qquad 1.8.3$$

This generalized equation represents the law of conservation of energy which is stated as under :

One form of energy can be transformed in the other form of energy. Whatever some amount of one form of energy disappears, the equivalent amount of other form of energy is produced. In other words, the total energy of an isolated system remains constant. The universe is an isolated system. So, "the total energy of the universe remains constant." This statement is known as the law of conservation of energy.

What have you learnt ?

- The product of magnitude of displacement during the time period in which force is acting and magnitude of component of force in the direction of displacement is known as work.
- For work to be done, force should act and during the time of action of force body should be displaced in the direction of force.
- If displacement is perpendicular to the force work done is zero.
- If force and displacement are in the same direction, work done is positive, work is said to be done on the body.
- If force and displacement are in opposite directions work done is negative, work is done by the body against force.
- Energy is ability to do work. There are many types of energy.
- Energy possessed by a body due to its motion is known as kinetic energy. If velocity of a body of mass (m) is (v), its kinetic energy is $(\frac{1}{2}mv^2)$
- Energy possessed by a body due to its position or configuration is called potential energy.
- Body of mass m, at height h from reference level possesses gravitational potential energy equal to mgh.

- When work is done on the body or by the body energy of the body changes.
- Sum of kinetic energy and potential energy is called mechanical energy.
- Time rate of imparting work is called power.
- Units of work and energy are joule whereas unit of power is J/s or Watt.
- Pulley is a very useful device which is used to change the direction of force.
- Heat energy, Chemical energy, Electrical energy, Nuclear energy etc are other forms of energy.
- Energy can be transformed in the other form of energy.
- Total sum of energy in the universe is constant. This is law of conservation of energy.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) What is necessary for work to be done ? Choose the correct statement.
(1) Action of force is necessary. (2) Displacement is necessary.
(3) Displacement in the direction of force is necessary.
(A) Statement-1 (B) Statement-2
(C) Statement-3 (D) Statement 1 and 2

(2) As angle between displacement and force increases magnitude of work.....
(A) remains constant (B) increases
(C) reduces (D) remains constant or increases

(3) A body of mass 10 kg performs motion along a circle of radius 5m with speed of 10 m/s. Work done during one revolution is .....
(A) 2000 J (B) 1000 J
(C) 500 J (D) zero

(4) Which one among kinetic energy, potential energy and mechanical energy cannot be negative ?
(A) kinetic energy (B) potential energy
(C) mechanical energy (D) potential energy and mechanical energy

(5) Work done on a body is equal to change in .....
(A) only kinetic energy (B) only potential energy
(C) only mechanical energy (D) energy

(6) A man having his own mass 60 kg, climbs up 20 m height with a bucket having water of mass 15 kg. so, work done is ..... kJ ($g = 9.8\ m/s^2$)
(A) 15 (B) 20
(C) 150 (D) 1.5

(7) A box of 20 kg mass is pulled by force F with constant velocity on a horizontal surface. If force of friction is 49 N, work done during displacement of 10 m is ..... J.
(A) 490 (B) 245
(C) 980 (D) zero

(8) Masses of two bodies are 1 kg and 4 kg respectively. If their kinetic energies are in 2:1 proportion, ratio of their speeds is ..... .
(A) $2\sqrt{2}:1$ (B) $1:\sqrt{2}$ (C) 1:2 (D) 2:1

(9) Engine of a car of mass 1500 kg, keeps car moving with constant velocity 5m/s. If frictional force is 1000 N, power of engine is .....
(A) 5 kW (B) 7.5 kW (C) 15 kW (D) 75 kW

(10) Height of water dam in hydroelectric power station is 20 m. How much water, in 1 second, should fall on turbine, so that 1 MW power is generated ? ($g = 10 m/s^2$)
(A) 5000 kg (B) 10,000 kg (C) 500 kg (D) 7,500 kg

(11) Speed of a body in motion is doubled. Its kinetic energy is now ..... times the original kinetic energy.
(A) two (B) three (C) four (D) one half

(12) An object is thrown vertically upwards with velocity of 20m/s. At what height will its kinetic energy and potential energy be equal ? ($g = 10 m/s^2$)
(A) 10 m (B) 20 m (C) 15 m (D) 5 m

(13) What is true for force F and component of force in the direction of displacement F' ?
(A) $F < F'$ (B) $F > F'$ (C) $F \leq F'$ (D) $F = F'$

(14) 1 kWh = ... J
(A) 36×10^6 (B) 3.6×10^6 (C) 3.6×10^7 (D) 3.6×10^5

(15) When spring is compressed its potential energy.....
(A) remains constant (B) reduces
(C) increases (D) nothing can be said about it.

2. Answer the following questions in short :

(1) What is necessary for work to be done on a body ?
(2) Which type of physical quantity work is ? Scalar or Vector.
(3) Define work
(4) 1 Horse Power = ... J/s
(5) Define 1 kWh.
(6) State law of conservation of energy
(7) If for work done, entire force is responsible what is angle between force and displacement ?
(8) How much energy (in joule) is produced if 1 kg mass is converted into energy ?
(9) What is mechanical energy ?
(10) By which process energy is produced in stars ?
(11) State main use of a pulley.

3. Answer the following questions in detail :

(1) When work is said to be done on a body ? Explain.
(2) Derive the equation of kinetic energy of a body.
(3) Define potential energy. Obtain an equation which gives potential energy of a body of mass m to a height h from reference level.
(4) Define the unit of electrical energy consumed and obtain its value in joule.
(5) Write a short note on nuclear energy.

4. Solve the following examples :

(1) A boy of mass 40 kg climbs a staircase of 30 steps, each of 0.2m height, in 30 s. Calculate power ($g = 9.8\ m/s^2$) (**Ans.** 8 W)

(2) A lady pulls a bucket filled with water having mass 10 kg, from 8m deep well in 20 s. Calculate work done and power. ($g = 10\ m/s^2$) (**Ans.** 800J, 40W)

(3) A car having mass 1000 kg, is moving with speed of 36 km/h. Calculate its momentum and kinetic energy. (**Ans.** 10,000 kgm/s and 50,000 J) (Verify the value of kinetic energy using $K = P^2/2\ m$ 'P' is momentum; how kinetic energy is equal to $K = P^2/2\ m$? Think.)

(4) The pendulum shown in figure 1.10 is kept horizontal. It is released from this position. Calculate its velocity when it reaches the down most position. ($g = 9.8\ m/s^2$) (**Ans.** 7 m/s)

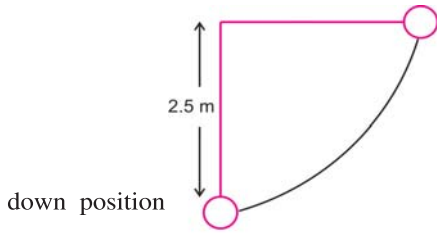


Figure 1.10

(5) In a residence 4 tube lights each of them of 40 W are operated daily for 5 hours and 3 fans each of 120 W are operated daily for 4 hours. Calculate electricity bill at ₹. 5 per unit for September month. (**Ans.** ₹. 336)

2 Wave Motion and Sound

2.1 Introduction

In the study of physics, 'waves' are very important. We like to listen nice music. Music produced by musical instruments reach our ears in the form of sound waves only. Sunlight also reaches the earth in the form of electromagnetic waves. We can enjoy radio and television and even now, from any place, we can talk using mobile phone. All these are possible, because of waves.

Here, in the beginning we shall study 'oscillations' which are responsible for waves. Then we learn about waves, types of waves, characteristics of waves, sound waves and their applications.

2.2 Periodic Motion

If anybody repeats its motion within fixed time interval along a certain path, about a fixed point, it is said to have periodic motion.

Dear students, you must have enjoyed swing and sea-saw in the garden. You must have seen motion of a pendulum of a clock. You are also knowing that the earth is moving around the sun. The moon is moving around the earth. Have you seen any similarities in the motion of these objects ?

All these objects repeat their motion, within fixed time interval, along a certain path, about a fixed point. Such motion of the object is said to be periodic motion.

From further observation of the above examples, we will know that the motion of the earth around the sun and the motion of the moon

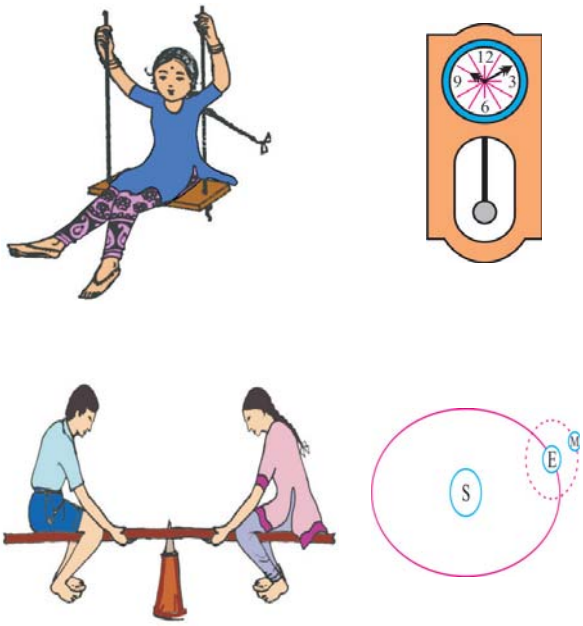


Figure 2.1 Examples of the objects in periodic motion

around the earth are the examples of the body performing uniform circular motion. While motion of a swing is a back and forth motion along a certain path and about a central point. Motion of a pendulum is a to and fro motion along a certain path and about a central point. Motion of a sea-saw is an up and down motion along a certain path and about a central point. This means, during the motion swing, sea-saw or pendulum is not swinging whole circle. Thus, these objects are said to be **oscillating** and such objects are called **oscillators**. Thus oscillation can be defined as follows :

If a body repeats its back and forth, to and fro or up and down motion along a certain path, about a fixed point at a certain time interval then the motion of such object is said to be oscillatory.

Dear students, remember here that a body in oscillatory motion is said to be in periodic motion but a body in a periodic motion may not be in an oscillatiory motion.

Activity 1 : Make a list of examples of objects performing periodic motion. Separate out the examples of the objects performing oscillations.

Activity 2 : You must have seen toy shown in Figure 2.2. Observe the motion of this toy and state which motion it is ?

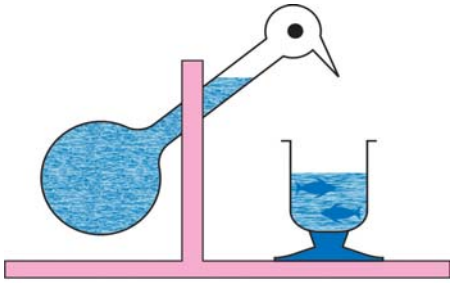
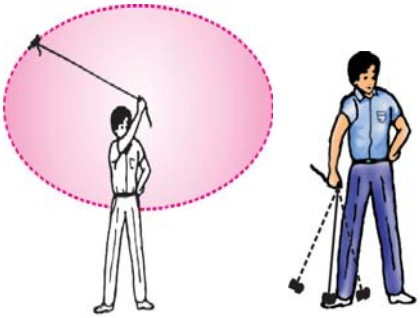


Figure 2.2 Toy of a duck

Activity 3 :



(a) **(b)**

Figure 2.3 Motion of a Pebble tied with a thread

Take a piece of thread. Tie a pebble at one end. Hold the other end of the thread and whirl it round above your head as in fig. 2.3 (a). Now give to and fro motion to the pebble near your legs as in Fig. 2.3 (b). Observe the motion of the pebble in both the cases and understand the difference between periodic and oscillatory motion.

2.3 Simple Harmonic Motion

Oscillatory motion along a linear path executed by a body about a fixed point, under the action of a force proportional to its displacement from that point and direction towards that point is called a simple harmonic motion.

(For simple harmonic motion certain conditions are to be fulfilled, which will not discuss in this chapter and we will assume that all these conditions are fulfilled in the rest of the discussion).

A body performing simple harmonic motion is known as a **simple harmonic oscillator.** For example, tie a massive object to a lower end of vertical spring fixed to a rigid support. Pull this object downward and release gently. Then this object performs (more or less) simple harmonic oscillation. Fig. 2.4 shows various positions of a simple harmonic motion of massive body.

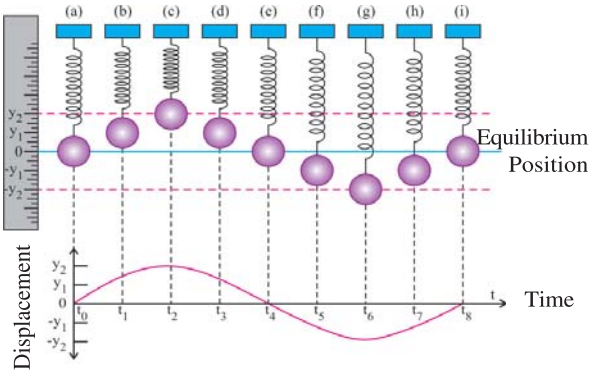


Figure 2.4 Simple Harmonic motion of a massive body tied to a spring and graph of its displacement → time

Now we try to understand some important terms associated with simple harmonic oscillator.

Equilibrium position (Mean position) :

The point about which the simple harmonic oscillator performs simple harmonic motion is known as equilibrium position (mean position).

Displacement :

Distance between the equilibrium position and the instantaneous position of the oscillator is known as displacement.

Amplitude :

Maximum displacement of the simple harmonic oscillator, from the equilibrium position in any direction is known as the amplitude of the oscillator.

The amplitude of the oscillator is represented by symbol 'A' . Its SI unit is metre (m).

Oscillation :

When oscillator starts its motion from the equilibrium position and reach to the maximum displacement on any one side of the equilibrium position, returns back and reach to the maximum displacement on other side of the equilibrium position via equilibrium point and again return to the equilibrium position then it is said that the oscillator has completed one oscillation.

Periodic Time :

Time taken by the oscillator to complete one oscillation is known as periodic time of that oscillator. Periodic time is represented by a symbol 'T'.

Its SI unit is second (s).

Frequency :

Number of oscillations completed by the oscillator in one second is known as frequency.

It is represented by a symbol *f*. Its SI unit is Hertz (Hz).

Henrich Rondolf Hertz (1857-1894)

You also note that the periodic time and frequency are reciprocal to each other. Thus,

$$T = \frac{1}{f} \quad \text{or} \quad f = \frac{1}{T} \qquad 2.2.1$$

Activity 4 : From the Fig. 2.4, answer the following questions :

(i) Which position of the simple harmonic oscillator is shown by (a), (e) and (i) in the figure ?
(ii) What is the displacement at time t_1 and t_3 ?
(iii) What is the displacement of the oscillator at time t_0, t_4 and t_8 ?
(iv) What is the displacement of the oscillator at time t_2 and t_6 ?
(v) What is the amplitude of the oscillator ?
(vi) State the positions of the oscillator through which it moves for completing one oscillaton.
(vii) Write the periodic time for the oscillator.
(viii) Find the frequency for the oscillator.

Example 1 : Calculate frequency of an oscillator having periodic time 0.01 s.

Solution : $f = \frac{1}{T} = \frac{1}{0.01} = 100$ Hz

Thus the oscillator oscillates 100 times in one second.

Example 2 : If one oscillator oscillates 50 times in a second then find out the periodic time for the oscillator.

Solution : Here $f = 50$Hz

$\therefore$ Periodic time $T = \frac{1}{f} = \frac{1}{50} = 0.02$

The periodic time of the oscillator is 0.02 s.

Example 3 : If a boy swings 60 times in a minute then find out the frequency of the swing.

Solution : Frequency means number of oscillations in one second.

Here boy swings 60 times in one second.
In 1 minute (60s) 60 oscillations occur
$\therefore$ How many in 1 s ?

$$f = \frac{60 \times 1}{60} = 1 \text{ Hz}$$

Thus frequency of the swing is 1Hz.

2.4 What is wave ?

Motion of a disturbance in a medium (or space) is known as wave.

Remember that the wave is not a physical object moving ahead in the medium but is an effect. Because of the disturbance in the medium, particles of the medium oscillates. These oscillations produce wave. After the wave effect is over, the particles of the medium acquire their equilibrium position. (Here we are discussing the propagation of waves in elastic medium only. We are not talking about the electromagnetic waves at present.)

Activity 5 : Fill water in a big vessel and wait till water is still. Now drop a stone in water. Observe the water surface. You must have enjoyed the formation of rings on the surface of water while throwing a stone in the pond. These circular rings are said to be waves on the surface of water.

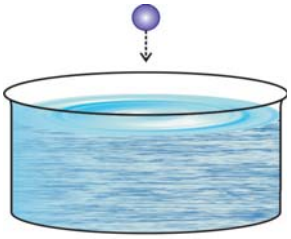


Figure 2.5 A vessel filled with water

Activity 6 : Sound waves are produced by blowing a flute. This result is the motion of disturbance of which medium ? Like this, make a list of various musical instruments and identify which parts of the instrument vibrate to produce sound waves.

2.5 Types of Waves

(1) Mechanical waves :

Waves which require a medium for propagation are known as mechanical waves.

For the propagation of mechanical waves an elastic medium is necessary.

Wave on the surface of water, sound waves etc are mechanical waves.

(2) Non-Mechanical waves :

Waves which do not require a medium for propagation are known as non-mechanical waves.

Non mechanical waves can propagate in vacuum also.

Light waves and electromagnetic waves are non-mechanical waves.

Activity 7 : Plug a rubber band in two fingers. Vibrate this stretched rubber band like 'vina' with finger of other hand. What will be the type of the waves produced in this way ?

During the wave propagation, oscillatory motion of the particles of the medium may be parallel to the direction of the wave propagation or perpendicular to the direction of wave propagation. Depending on this, waves are also classified in two categories :

(i) Transverse waves :

If the particles of the medium oscillate in the direction perpendicular to the direction of propagation of the wave then the wave is said to be a transverse wave.

For example, the waves on a string. In higher standards you will study that light waves are transverse waves. Transverse waves propagate in form of **troughs** and **crests**. If the particles of the medium perform simple harmonic motion along the direction perpendicular to the direction of propagation of a wave the wave is known as a transverse simple harmonic wave. Transverse simple harmonic wave is represented graphically by drawing displacement → time graph as in Figure 2.6. Maximum displacement in positive direction is known as **crest** and maximum displacement in negative direction is known as **trough**.

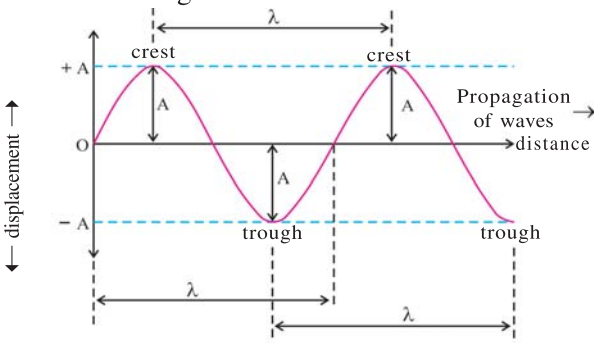


Figure 2.6 Graph for displacement → time for a simple transverse harmonic wave

Let us perform an activity to understand transverse waves.

Activity 8 : Take a string. Tie it firmly with something like a nail on the ground (You can hold it using your foot also). Keep the second end in your hand such that string remains tensed. (See Figure 2.7(a)). Give a jerk to the string as shown in Figure 2.7 (b) and (c). A disturbance is produced in the string in this way. Observe how this disturbance reaches the second end of the string.

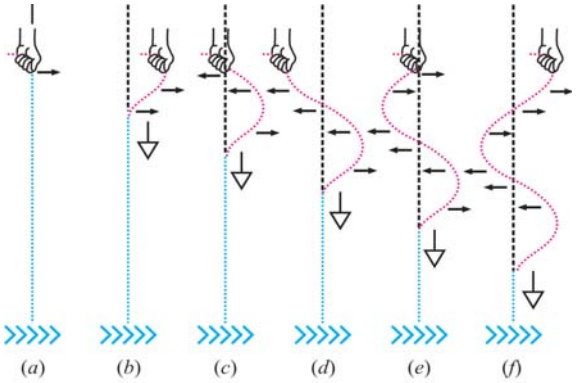


Figure 2.7 Transverse wave on a string

You will notice that the particles of the string remain stationary until the disturbance reaches there. During the passage of the wave they oscillate perpendicular to the direction of propagation of the disturbance and when the disturbance has passed particles of the string become stationary. If we keep giving jerks we can produce many waves, one followed by the other, such a series of waves is known as a wave train. Here observe the direction of oscillations of particles. You must have noted that particles of the string are doing transverse oscillations to the direction of propagation of wave. Hence, such waves are known as transverse waves.

(2) Longitudinal waves :

If the particles of the medium oscillate in the direction parallel to the direction of propagation of wave, the wave is said to be a longitudinal wave.

For example, sound waves are longitudinal waves. Such waves propagate in the form of **condensation (compression)** and **rarefaction.** If during propagation of such a wave particle of the medium perform simple harmonic motion, the wave is known as a **longitudinal harmonic wave.**

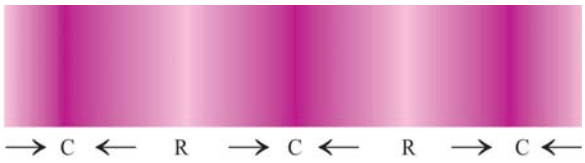


Figure 2.8 Condensations and rarefactions in sound waves propagating in air

In air, during the propagation of longitudinal waves, air particles come closer in the position of condensation and go away in the position of rarefaction, so in the condensation region density of the medium becomes high while density of the medium becomes low at rarefaction region. (See Fig. 2.8)

In Fig. 2.9, graphical presentation of propagation of longitudinal simple harmonic sound waves is shown in terms of density distance.

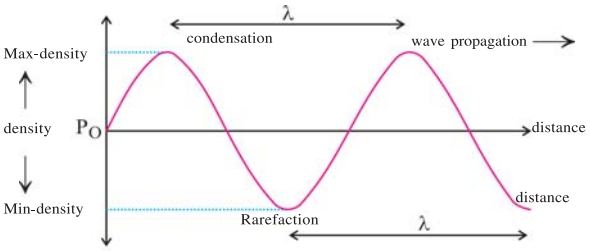


Figure 2.9 Density → distance for longitudinal sound waves propagating in air.

2.6 Characteristics of Wave

Wavelength : In the phenomenon of propagation of a wave, distance travelled by a wave during one complete oscillation of a particle of the medium is known as wavelength.

In the case of a transverse wave, distance between two consecutive crests or troughs is known as wavelength. (See Fig. 2.6). In the case of a longitudinal wave, distance between two consecutive condensations or rarefactions is known as wavelength (See Fig. 2.8). Wavelength is denoted by Greek alphabet λ (read as 'lambda'). Its unit in SI System is metre (m). A smaller unit of wavelength is 'angstrom' ($\mathring{A}$) which is given by

$1\ \mathring{A} = 10^{-10}\ m = 10^{-8}\ cm$

Amplitude of a wave : During propagation of a wave amplitude of oscillations of the particles of the medium is known as amplitude of the wave.

Generally amplitude is denoted by 'a' or 'A'. Its SI unit is metre (m).

Periodic time of a wave : Time taken by a wave to travel distance equal to wavelength in the direction of propagation of the wave is known as periodic time.

It is also the time required for the formation of two successive crests or troughs of a point in the medium. Similarly it is also the time required for the formation of two successive condensations or rarefactions in the medium.

Remember that periodic time of the wave is also equal to the periodic time of the oscillations of the particles of the medium. It is denoted by T and its SI unit is second(s).

Frequency of a wave : Number of waves passing through any point in the medium in one second is known as frequency of the wave.

Remember that frequency of a wave is equal to frequency of the oscillation of the particles of the wave. It is denoted by f or by ν (Greek alphabet ν read as 'nu'). Its SI unit is s^{-1}or Hertz (Hz).

Frequency of a wave and periodic time are reciprocals of each other.

$$f = \frac{1}{T} \text{ or } T = \frac{1}{f} \qquad 2.6.1$$

Wave velocity : Distance travelled by disturbance in unit time in the direction of propagation of the wave is known on wave velocity.

$$\text{Wave velocity} = \frac{\text{Distance travelled by a wave}}{\text{Time taken by the wave to travel the distance}}$$

$$= \frac{\text{Wavelength}}{\text{Periodic time}}$$

$$\therefore v = \frac{\lambda}{T} \qquad 2.6.2$$

From equation 2.6.1 $\frac{1}{T} = f$

$$\therefore v = \lambda f \qquad 2.6.3$$

Thus, product of wavelength of wave and its frequency gives wave velocity.

Dear students, here note that wave velocity is not equal to the velocity of particles of the medium.

Now from equation (2.6.3), the wavelength of a wave having wave velocity λ and frequency f is

$$\lambda = \frac{v}{f} \qquad 2.6.4$$

2.7 Sound Waves and their Range

Medium is necessary for the propagation of sound waves. Waves are mechanical waves. Sound waves can propagate in the mediums like solid, liquid and gas. Sound wave cannot propagate in vacuum. During the propagation of sound waves, particles of the medium oscillate in the direction parallel to the propagation of wave, hence sound waves are longitudinal waves and propagate in form of condensation (compression) and rarefaction. In solid, sound can propagate as longitudinal or transverse waves.

Oscillation of the particles of the medium depend on elasticity and inertia of the medium. So wave velocity also depends upon elasticity and inertia of the medium. Sound velocity in air also depends on temperature and humidity. In Table 2.1, values of sound wave velocity in various media are shown.

(For Information only)

Table 2.1 Velocity of sound in various medium

Medium	Temperature (^{0}C)	Approximate velocity of sound (m/s)
Air	0	332
	20	344
	25	346
Oxygen	25	316
Distilled water	20	1470
	25	1498
Sea water	25	1531
Aluminium	20	5100
	25	6420
Iron	20	5130
	25	5950
Granite	20	6000

As per the audibility of human ear for sound waves, they are classified as follow :

(1) Audible sound :

If frequency of sound ranges between 20Hz to 20,000Hz, it can produce sensation on the ears of a healthy person. So a healthy person can hear such sounds. This frequency range of sound waves is known as **audible range** and such sound is called **audible sound.**

Thus for human ears,

$20\text{Hz} \leq f_{\text{(audible)}} \leq 20{,}000\text{Hz}$

Now if we talk about wavelength of audible sound then

$$\lambda_{\text{(audible)}} = \frac{v}{f_{\text{(audible)}}}$$

$$= \frac{340}{20} \text{ (velocity of sound in air is taken as 340 m/s)}$$

$$= 17\text{m}$$

And $\lambda = \frac{340}{20000}$

$$= 0.017 \text{ m}$$

Thus if the velocity of sound in air is 340 m/s then wavelength of the audible sound in air is

$0.017 \text{ m} < \lambda_{\text{(audible)}} < 17 \text{ m}$.

Velocity of sound in a medium depends on medium density, temperature, etc. hence this range may change.

(2) Infrasonic sound :

Sound having frequency less than 20Hz is known as infrasonic sound. We cannot hear such sound.

Whale and elephant can produce and sense sound waves having frequency less than 20Hz.

Waves produced during an earthquake are infrasonic.

(3) Ultrasonic sound :

Sound having frequency more than 20,000Hz is known as ultrasonic sound.

Animal like bat, dog, cat, some birds and insects can produce as well as hear such sound.

Human ear cannot hear ultrasonic sound.

2.8 Applications of Ultrasonic Sound

Ultrasonic sounds are used in medical field for diagnosis and treatment of internal illness of human body. For example, stone in the gall bladder or kidney

can be detected. Using ultrasound shock, such stone can be broken into small grains which later on get flushed out with urine.

Use of ultrasonography is well known in examination of the foetus during pregnancy, to detect defect in it and to get the information of its growth.

Ultrasonic waves are made to reflect from various parts of heart and from image of the heart. Thus checkup of the heart is possible. This technique is known as 'echocardiography (ECG).

Industrially ultrasonic sounds are useful in examining metal for defects like cracks, make holes in heavy metals, cleaning of parts of machines and manufacturing alloys.

Ultrasonic sounds are also used for inspection of breakage in railway lines.

They are also used for measuring depth of a sea or a lake.

2.9 SONAR

Phenomenon of reflection of sound is used in oceanographic studies. SONAR is abbreviated form of 'Sound Navigation And Ranging . Using SONAR we can get information about submarines, sunken ships, rocks inside oceans etc.

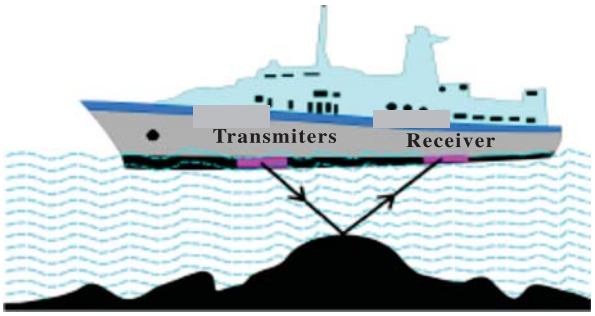


Figure 2.10 Working of SONAR

In this method, ultrasonic sound is sent in the ocean using transmitters and such waves are reflected by submarine, or ship or rocks. Reflected waves are received by the receiver. Also time interval between the signal sent and signal received is noted. If the time interval is t and speed of sound in sea water is v depth h can be calculated as

$$2h = v \times t$$

$$\therefore h = v \times \frac{t}{2} \qquad 2.9.1$$

Bats flying in the dark night without colliding with any object and catch their prey also by this means.

Example 4 : Find frequency of a sound wave having periodic time 0.04 s.

Solution : $f = \frac{1}{T}$

$$= \frac{1}{0.04}$$

$$= 25\text{Hz}$$

Example 5 : Calculate periodic time of a sound wave of frequency 500Hz.

Solution : Periodic time $T = \frac{1}{f}$

$$= \frac{1}{500}$$

$$= 0.002 = 2 \times 10^{-3}\text{s}$$

Example 6 : In a medium, periodic time of a sound wave having wavelength 0.24 m is 2×10^{-3}s, then find the soundwave velocity in that medium.

Solution : Wave velocity $v = \frac{\lambda}{T}$

$$= \frac{0.24\text{ m}}{2 \times 10^{-3}\text{ s}}$$

$$= 120\text{ m/s}$$

Example 7 : Wavelength of a sound wave in air, having frequency 10Hz is 34m. Calculate wave velocity in air.

Solution : Wave velocity

$$v = \lambda f = 34 \times 10 = 340\text{ m/s}$$

Example 8 : Frequency of a sound wave, having wave velocity in air 340 m/s, is 10kHz. Find its wavelength in air.

Solution : $\lambda = \frac{v}{f}$

$$= \frac{340\text{ m/s}}{10 \times 10^{3}\text{Hz}}$$

$$= 3.4 \times 10^{-2}\text{m}$$

Example 9 : Can the sound wave of wavelength 0.17cm with velocity in air 340 m/s be heard by human ear ?

Solution : $f = \frac{v}{\lambda} = \frac{340 \text{ m/s}}{0.17\text{cm}}$

$$= \frac{340 \text{ m/s}}{17\times10^{-4} \text{ m}}$$

$$= 20 \times 10^4 \text{Hz}$$

$$= 2{,}00{,}000 \text{ Hz}$$

This frequency f = 2,00,000 Hz is higher than the maximum frequency of audible range 20,000 Hz. Hence this is ultrasonic sound which cannot be heard by human ear.

Example 10 : A ship sends out ultrasound that returns from the seabed and is detected after 4 s. If the speed of ultrasound through sea water is 1531m/s, what is the distance of the seabed from the ship ?

Solution : In case of SONAR

$$h = \frac{v \times t}{2}$$

$$= 1531\text{m/s} \times \frac{4\,s}{2}$$

$$= 3062 \text{ m}$$

Thus, the distance of the seabed from the ship is 3062 m.

Example 11 : A sound wave has a frequency of 2 kHz and wavelength 100 cm. How long will it take to travel 2 km ?

Solution : Velocity of sound $v = \lambda \times f$

$$= 100 \text{ cm} \times 2 \text{ kHz}$$

$$= 1 \text{ m} \times 2000 \text{ Hz}$$

$$= 2000 \text{ m/s}$$

For time,

$$t = \frac{S}{v}$$

$$= \frac{2 \text{ km}}{2000 \text{ m/s}}$$

$$= \frac{2000 \text{ m}}{2000 \text{ m/s}} = 1\text{s}$$

Thus, the sound wave will take one second to travel a distance of 2km.

2.10 Reflection, Echo and Reverberation of Sound

Reflection :

Like light, sound gets reflected at the surface of a solid or liquid. Following laws of reflection are also applicable to the reflection of sound.

(1) The angle of incidence is equal to the angle of reflection.

(2) The incident sound, the normal drawn to the surface at point of incidence and the reflected sound, all lie in the same plane.

Activity 9 : Take two identical pipes. Put one table near a wall and draw a normal on the surface of the table respect to the wall. Make one angle and put one pipe on one side of the normal as in figure 2.11. Now put a clock near the pipe as shown in figure 2.11. Using this arrangement study laws of reflection of sound.

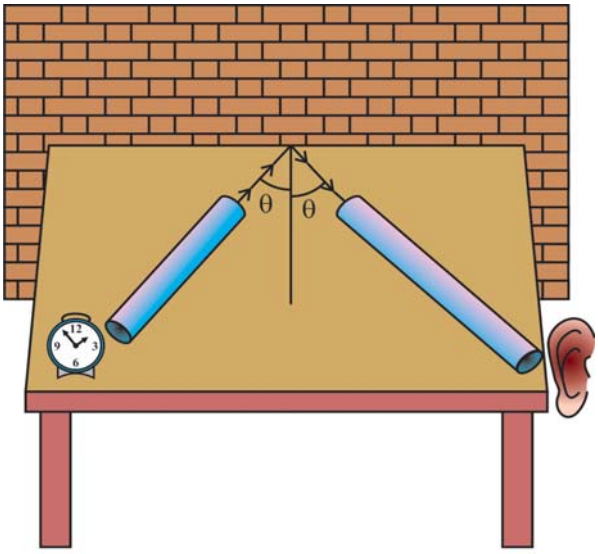


Figure 2.11 Study of reflection of sound

Echo :

You must have enjoyed to hear echo while shout loudly in deep well, big hall, old fort, or hilly area. The effect of reflection of sound is playing very important role in the echos.

If the time interval between original sound and reflected sound is more than $\frac{1}{10}$ second then original sound and reflected sound can be heard clearly. This reflected sound is known as echo.

Experimentaly it is observed that, echo is heard when person sounds from a distance of 17 m (56 ft.) from a wall. As per the temperature of the air there exists small change in this distance.

Reverberation :

When a speaker speaks in an auditorium, his voice is heard for sometime even after he stops speaking. In the auditorium sound reaches the listener after multiple reflection caused by walls and ceiling. Due to this multiple reflection sound is heard for sometime in the auditorium, even after production of sound stops. This phenomenon is called

reverberation time. If reverberation time exceeds 0.8 s, listners cannot hear the speaker clearly, and it is difficult for them to identify successive words. So, to reduce reverberation time walls and ceiling of the auditorium should contain the material which can absorb sound.

Example 12 : A boy clapped near a cliff and heard the echo after 5 s. What is the distance of the cliff from the boy if the speed of the sound is taken as 340 m/s ?

Solution : In case of echo,

$$2\ s = v \times t$$

$$\text{distance } s = v \frac{t}{2}$$

$$= 340\ m/s \times \frac{5}{2} s = 850\ m$$

Thus, the distance between boy and cliff is 850 m.

2.11 Intensity and Loudness of Sound

Intensity of sound is defined as the sound-energy passing through a cross section of unit area in unit time.

Its unit is W/ m^2

Now think of three sources of sound which can produce sound of equal intensity. Frequencies of sound produced by these sources are different. One of these three sounds is audible sound, the second one is ultrasonic sound and the third one is infrasonic sound. Even if these three sources produce sound of same intensity, we cannot hear ultrasonic sound and infrasonic sound. Thus audibility of sound is not related to intensity of sound, since intensity of sound produced by three sources is the same.

You might have also experienced that as one goes away from the source, loudness of sound decreases and one approaches the source loudness of the sound increases.

Thus here, the concept of loudness of sound is arrived at. Loudness of sound is such a characteristic of sound, that it gives us the extent of effect of sound. Loudness of sound depends on the sensitivity of ear of the listener. Sound of same intensity might be very loud for one person and it might not be that loud for somebody else.

Loudness of sound is measured in 'bell' (B) One tenth part of bell is called decibel (dB), which is the unit in common use. Noise level is also measured in dB. This unit is named in memory of Alexander Graham Bell, inventor of telephone. Our ear cannot hear the sound having intensity less than 10^{-12} Wm^{-2}, which is equl to 0 dB. This intensity of sound is known as **threshold of hearing.** Intensity of sound of common conversation is 10^{-6} Wm^{-2} which is equivalent to 60 dB.

2.12 Structure and Function of Human Ear

Have you ever asked yourself, how you can listen to sound? We are able to listen to sound through ear, an extremely sensitive organ of our body. Difference in pressure caused due to audible sound is converted into electric signals by ear. These electric signals revert the brain through auditory nerves and the brain interprets it in the form of sound.

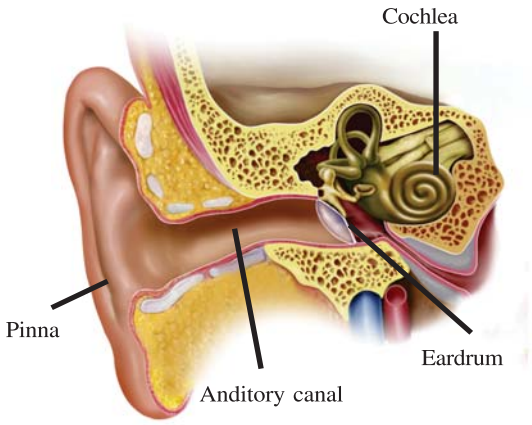


Figure 2.12 Structure of human ear

Human ear is divided into three parts. viz outer ear, middle ear, and inner ear. As shown in the Figure 2.12 outer ear is called pinna of the ear. Pinna of the ear collects sound from outside. This sound passes through auditory canal, and then reaches the thin membrane at the end of the canal. This thin membrane is known as ear drum. When condensation of the medium is incident on the ear drum, pressure on outer side increases, and pushes the ear drum inwards. Similarly when rarefaction is incident on the ear drum, it is pulled outwards. Thus ear drum vibrates. These vibrations which are very minute, are amplified many times by three bones situated in the middle ear are transmitted to the inner ear. Inner ear converts these vibrations into electric signals with the help of cochlea. These electric signals reach the brain through auditory nerves. Brain interprets these signals as sound.

You would be astonished to know that all these happens, within a blink of eye.

What have you learnt ?

- If a body repeats its motion, within fix interval of time, along a certain path, about a fixed point, it is said to have periodic motion.
- If a body repeats its back and forth, to and fro or up and down motion along a certain path, about a fixed point, in a certain time interval then the motion of such objects is said to be oscillatory.
- The oscillating object is known as oscillator.
- Oscillatory motion along a linear path executed by a body about a fixed point under the action of a force proportional to its distance from that point and direction towards that point is called a simple harmonic motion.
- A body performing simple harmonic motion is known as a simple harmonic oscillator.
- Maximum displacement of the simple harmonic oscillator, from the equilibrium position in any direction is known as the ampltitude of the oscillator.
- Time taken by the oscillator to complete one oscillation is known as periodic time.
- Number of oscillations completed by the oscillator in one second is known as frequency.
- Periodic time and frequency are reciprocal to each other.

  $T = \frac{1}{f}$ or $f = \frac{1}{T}$
- Motion of a disturbance in a medium (or space) is known as wave.
- Waves which require a medium for propagation are known as mechanical waves.
- Waves which do not require a medium for propagation are known as non-mechanical waves.
- If the particles of medium oscillate in the direction perpendicular to the direction of propagation or the waves then the wave is said to be a transverse wave.
- If the particle or the medium oscillates in the direction parallel to the direction of propagation of wave, the wave is said to be longitudinal wave.
- In the case of transverse wave, distance between two consecutive crests or troughs is known as wavelength.
- In the case of a longitudinal wave, distance between two consecutive condensations or rarefactions is known as wavelength.
- The product of wavelength of wave and its frequency gives wave velocity.
- Sound waves are longitudinal waves.
- Medium is necessary for the propagation of sound waves.
- Sound waves are mechanical waves.
- Human ear can hear sound of 20 Hz to 20,000 Hz. This sound is known as audible sound.
- Sound having frequency less than 20 Hz is known as infrasonic sound.

- Sound having frequency more than 20,000Hz is known as ultrasonic sound.
- Ultrasonic sound is very much useful in medical and industrial fields.
- Full form of SONAR is Sound Navigation and Ranging.
- Like light sound gets reflected at the surface of a solid or liquid.
- If the time interval between original sound and reflected sound is more than $\frac{1}{10}$ second then original sound and reflected sound can be heard clearly. This reflected sound is known as echo.
- Existence of sound waves in an auditorium due to multiple reflections suffered by the walls and ceiling is called reverberation.
- Intensity of sound is defined as the sound energy passing through a cross section of unit area in unit time.
- Loudness of sound is measured in 'bell' or 'decibel'.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) If A be the maximum displacement of the particle from its equilibrium position, then what is the distance travelled by a simple harmonic oscillator when it completes one oscillation ?
(A) A (B) 2A (C) 3A (D) 4A

(2) What is the type of sound waves propagating in air ?
(A) Longitudinal only (B) Transverse only
(C) It can be either longitudinal or transverse (D) Non-mechanical

(3) What is the type of sound waves propagating in a solid ?
(A) Longitudinal only (B) Transverse only
(C) It can be either longitudinal or transverse (D) Non-mechanical

(4) Which waves don't need a medium for propagation ?
(A) Sound waves (B) Light waves
(C) Earthquake waves (D) Wave on water surface

(5) Earthquake waves are of which type ?
(A) Infrasonic (B) Ultrasonic (C) Supersonic (D) Intrasonic

(6) What is full form of SONAR ?
(A) System of Navigation and Research
(B) Sound Navigation and Ranging
(C) Sound of Natural Agriculture Research
(D) Sound of Navigation and Research

(7) What is the range of wavelength of audible sound in air ? (When sound velocity in air is 340 m/s).
(A) 0.17 m to 170 m (B) 0.17 m to 17 m
(C) 0.017 m to 17 m (D) 0.017 m to 1.7 m

(8) Sound corresponding to which frequency is ultrasonic sound ?
(A) 30 Hz (B) 300 Hz
(C) 3000 Hz (D) 30,000 Hz

(9) When echo is heard ?
(A) If the time interval between original sound and reflected sound is more than $\frac{1}{10}$ s .
(B) If the time interval between original sound and reflected sound is less than $\frac{1}{10}$ s .
(C) If the tme interval between original sound and reflected sound is less than $\frac{1}{150}$ s .
(D) If the time interval between original sound and reflected sound is $\frac{1}{150}$ s .

(10) Which of the following is true for sound wave ?
(A) $\lambda \alpha f^2$ (B) $\lambda \alpha f$ (C) $\lambda \alpha \frac{1}{f}$ (D) $\lambda \alpha \frac{1}{f^2}$

2. Answer the following questions in short :

(1) Are all objects doing oscillatory motion have periodic motion ?
(2) Are all objects doing periodic motion have oscillatory motion ?
(3) Give the relation between periodic time and frequency of simple harmonic oscillator.
(4) Which type of waves propagate through crests and troughs ?
(5) Which types of waves propagate through condensations and rarefactions.
(6) In which type of wave particles of the medium oscillate parallel to the direction of propagation of the wave ?
(7) Which type of wave is a light wave ?
(8) During time equal to periodic time, the distance travelled by a wave in the direction of wave propagation is known as, what ?
(9) What is the range of frequency of audible sound for human ear ?
(10) For echo, what is the minimum distance required between the source of sound and reflecting surface ?
(11) Write unit of intensity of sound.

3. Answer the following questions in detail :

(1) When object is said to be oscillating ?
(2) Give examples of the objects performing periodic motion.
(3) Define amplitude.
(4) What is wave ?
(5) What is the name of sound vave having frequency more than 20 kHz ? Which animals are sensitive to such sound ?
(6) What is an echo ?
(7) Explain uses of ultrasonic sound.

(8) Explain SONAR system.
(9) What is meant by mechanical wave ?
(10) What is meant by non-mechanical wave ?
(11) What are longitudinal waves ?
(12) What are transverse waves ?
(13) Explain concept of the intensity and loudness of sound.
(14) What is reverberation of sound ?
(15) Explain following terms

(1) Periodic time
(2) Simple harmonic motion
(3) Wave
(4) Wavelength
(5) Amplitude of a wave
(6) Frequency of a wave
(7) Wave velocity
(8) Audible sound
(9) Infrasonic sound
(10) Ultrasonic sound
(11) Echo
(12) Reverberation

4. Solve the following examples :

(1) Sound wave propagating in a medium have wavelength 0.34 m and frequency 10^{-3}s. Calculate velocity of sound in the medium. (**Ans.** 340 m/s)

(2) A sound is having wavelength 6.8×10^{-2}m and frequency 500 Hz. Calculate velocity of soundwave in the medium. (**Ans.** 340 m/s)

(3) Frequency of a sound wave with velocity 340 m/s is 5 kHz. Calculate its wavelength.

(**Ans.** 0.068 m)

(4) Is a sound wave with wave length 1.32 cm and wave velocity 330 m/s audible to a human ear ? Why ?

(**Ans.** No. $f = 25{,}000$ Hz which is more than maximum audible frequency)

(5) Human ear is sensitive to 20 Hz to 20,000 Hz for sound waves. If these waves are propagating in water calculate the maximum and minimum wavelength. Consider the wave velocity of sound in water is 1500 m/s.

(**Ans.** 0.075 m < λ<75 m)

3 Periodic Classification of Elements

3.1 Introduction

In the universe 114 elements have been discovered till today. Each of these elements possesses different properties. Innumerable compounds are formed by these elements through different types of chemical reactions. It is difficult to understand the properties and the uses of each element at a time together. Basic laws are necessary to understand the method of reactions of elements on the basis of their properties. It becomes very easy to understand the properties of these elements if they are classified. Thus, so many elements can be arranged in a systematic way and then their study can be made easy.

3.2 Concept of Dobereiner and Newland

In 1803, Dalton gave information about atomic masses of the element. At that time the known elements were classified on the basis of their atomic masses. In 1817, German scientist Dobereiner started classifying elements on the basis of their chemical properties. He mentioned the triads of the elements having chemically similar properties. If the three elements are arranged in their increasing order of atomic masses, the atomic mass of the intermediate (second) element was similar to the average of atomic masses of first and the third elements.

Table 3.1
Dobereiner's Triad of Elements

Element	Atomic mass	Average atomic mass
Lithium (Li)	07	
Sodium (Na)	23	$\frac{7+39}{2} = 23$
Potassium(K)	39	
Chlorine (Cl)	35.5	
Bromine (Br)	79.9	$\frac{35.5+127}{2} = 81.25$
Iodine (I)	127.0	
Calcium (Ca)	40.1	
Strontium (Sr)	87.7	$\frac{40.1+137.3}{2} = 88.7$
Barium (Ba)	137.3	

More than three elements having similar properties can be classified through Dobereiner's triads of elements. Because of the limited number of elements classified by this method, it did not succeed. Fluorine can be added to the triad of chlorine, bromine and iodine. Similarly magnesium can be added to the triad of calcium, strontium and barium. Hence the possibility of group arose instead of triads. In 1864, Newlands when arranged the elements in the increasing order of their atomic weights, it was observed that the properties of the eighth element was found to be similar like the notes of the music Sa, Re, Ga, Ma, Pa, Dha, Nee, Sa. Hence, it is called law of octaves.

Table 3.2
Arrangement of elements according to Newland's law of octaves

Sr. No.	1	2	3	4	5	6	7
Element	Li	Be	B	C	N	O	F
Sr. No.	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Element	Na	Mg	Al	Si	P	S	Cl
Note of music	Sa	Re	Ga	Ma	Pa	Dha	Nee

Looking at the table of arrangement of elements, it was observed that when elements are arranged in the increasing order of their atomic weights, then eighth element sodium is placed below element lithium having similar properties. Ninth element magnesium is placed below element beryllium having similar properties. It is worthwhile to note that Newland was the first scientist to

arrange elements in their increasing order of atomic weights. When the elements were arranged according to this method, it was observed that there is some systematic relation among their properties. The vertical column of table is called group. They are seven in number. The horizontal row is called a period. Many scientists have contributed in the development of periodic table but the credit of development goes to Russian scientist Mendeleef.

3.3 Periodic Table of Mendeleef : Classification of Elements

In 1869, Russian scientist Mendeleef studied the relation between atomic masses of elements and the basic chemical properties of element and found out that there is some definite systematic relationship among elements. Hence, he arranged elements in different groups on the basis of their basic properties-chemical properties. Mendeleef prepared a periodic table by classifying elements having similar properties from the study of 63 elements known at that time. He arranged elements in seven groups on the basis of arranging elements in their increasing order of atomic weights. Here, the properties of most of the elements in each group were similar. Hence, it was concluded that "The properties of elements are periodic in nature based on their atomic mass which is called Mendeleef's periodic law.

The vertical columns of the periodic table are called groups and the horizontal rows of the table are called periods. Mendeleef placed element titanium (Ti) below Silicon (Si) instead of aluminium (Al) on the basis of similar properties of them. Hence, the place below aluminium remained vacant. If this periodic law is true, then some element must be discovered for this vacant place. Above this, the atomic mass of element must be more than 48 and its properties must be similar to those of boron (B) and aluminium (Al). After five years, the element gallium (Ga) was discovered and the forecast made by Mendeleef on the basis of periodic law came true. Thus element gallium (Ga) was placed below element aluminium (Al).

Table 3.3 Periodic Table of Mendeleef (1871)

	I	II	III	IV	V	VI	VII	VIII
	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_3 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4
Period ↓	A B	A B	A B	A B	A B	A B	A B	Transition series
1	H 1.008							
2	Li .939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998	
3	Na 22.99	Mg 24.31	Al 26.98	Si 28.09	P 30.974	S 32.06	Cl 35.455	
4 First series	K 39.102	Ca 40.08	Sc 44.08	Ti 47.90	V 50.94	Cr 50.20	Mn 54.94	Fe Co Ni 55.85 58.93 58.71
Second series	Cu 63.54	Zn 65.37	—	—	As 74.92	Se 76.96	Br 79.909	
5 First series	Rb 85.47	Sr 87.82	—	Zr 91.22	Nb 92.91	Mo 95.94	Tc 99	Ru Rh Pd 101.07 102.91 106.06
Second series	Ag 107.87	Cd 112.40	In 114.82	Sn 118.69	Sb 121.75	Te 127.60	I 126.90	
6 First series	Cs 132.90	Ba 137.34	La 138.91	Hf 178.49	Ta 180.95	W 183.85		Os Ir Pt 190.2 192.2 195.2
Second series	Au 196.97	Hg 200.59	Tl 204.37	Pb 207.19	Bi 208.98			

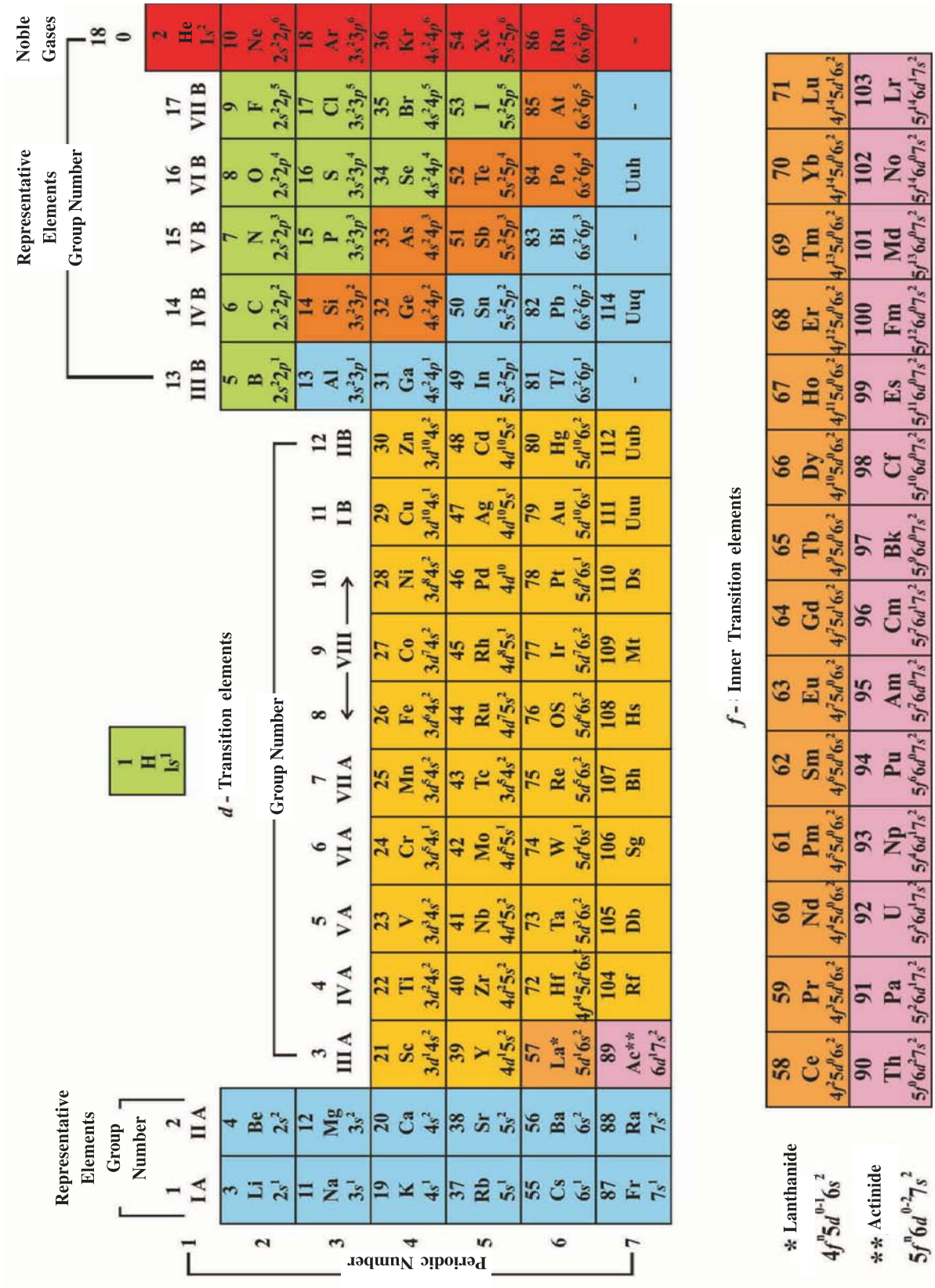


Fig. 3.4 : Modern Periodic Table

3.4 Important Aspects of Mendeleef's Periodic Table

(1) Elements can be arranged more properly in the different groups as compared to earlier arrangement of elements (Triads or octaves)

(2) A forecast could also be made for the elements which were not discovered for the vacant places in the periodic table and their properties.

(3) On the basis of the places of elements in the periodic table, the errors in atomic masses can also be forecasted.

(4) The arrangement of even not a single element in the periodic table is found to be wrong afterwards. A separate group of elements like newly discovered inert gases were also invented. This separated group of inert gases was placed at the end of the periodic table without making any change in the periodic table, over and above, proper and reserved places for each of the newly discovered element was provided without disturbing periodic table.

3.5 Modern Periodic Table

Most of the elements were arranged in the increasing order of their atomic masses in the periodic table of Mendeleef. Even then, Iodine (I) and Tellurium (Te) could not be placed in the increasing order of atomic masses. In addition, Lord Rayleigh and Sir Ramsay in 1894 discovered inert gases helium, neon and argon. Thus a new group of inert gases was formed because of the discovery of inert gases.

Henry Moseley in 1913, found atomic numbers from the study of X-ray spectra. After this discovery of atomic number, the elements were arranged in the increasing order of atomic numbers. In this connection, modern periodic table came into existence. The modern periodic based law mentions "The properties of the elements are periodic of their atomic numbers." In the scientific language, it can be said that the number of protons and electrons is periodic.

All the elements discovered so far are included in the modern periodic table. The atomic number of one element from the other increases successively by one unit. The irregularities in arranging elements in the Mendeleef periodic table, in the increasing order of the atomic weight was resolved by arranging the elements in the periodic table in the order of increasing atomic numbers of elements. (Tellurium (Te) and Iodine (I) as well as Potassium (K) and Argon (Ar)).

The periodic table prepared by Mendeleef on the basis of atomic masses became very useful in the preparation of modern periodic table. At the time of Mendeleef the idea about atomic number was not known and the atom was considered to be indivisible.

3.6 Group and Period

3.6.1 Group : In the modern periodic table the vertical columns are called groups. There are total 18 such groups. Elements having similar properties are placed in one group. The characteristic of the modern periodic table is that the elements are classified into 18 groups on the basis of the electronic configuration of outermost orbits of the elements. In the old periodic table, I to VIII groups were there and each was divided in two sub blocks as A and B. The electronic configuration of the valence orbit of all the elements in any group is same viz. In the elements of the first group, the electron in the outermost orbit of an atom is one (ns^1). This number of electrons is called the valence electrons. First group elements lose one electron. Hence, the valency of these elements is +1. Elements of first group Li, Na, K, etc lose one electron from their outermost orbit and forms 1+ positively charged ions Li^+, Na^+, K^+ respectively. Similarly elements of second group Mg, Ca, etc. lose two electrons from their outermost orbit and form 2+ positively charged ions Mg^{2+}, Ca^{2+} etc. respectively.

This way, elements F, Cl, Br, I etc. of 17th group possess 7 electrons in their outermost orbit. These elements prefer to receive one electron instead of losing seven electrons and form negatively charged ions F^-,Cl^-, Br^-, I^- etc respectively. Considering on the whole, all the elements in one group have similar number of electrons in their outermost orbit and so they show similar chemical reactions.

The 18^{th} group of periodic table is of inert gases. In the elements of this group except helium (He) all have eight electrons in their outermost orbit. This configuration is called closed shell configuration or octet configuration. These elements are chemically inert because the orbit cannot give or take electrons. With the increase in atomic number of elements in any one group, the number of electron orbit also increases but the number of electrons in the outermost orbit remains same.

3.6.2 Period : The horizontal row in the moden periodic table is called period. There are seven such periods.

In the first period there are two elements : hydrogen (H) and helium (He). In this second period, there are eight elements from lithium (Li) to neon (Ne). In the third period, there are 8 elements from sodium (Na) to argon (Ar). In the fourth and the fifth period there are 18 elements and in the sixth period there are 32 elements. While seventh period is incomplete.

In the elements of first period there is one orbit (K). In the second period there are two orbits (K, L). In the elements of the third period there are

three orbits (K, L, M) while in the elements of the fourth period there are four electron orbits (K, L, M, N).

In every period, moving from left side to right side, the atomic number of elements successively increases. The outermost orbit of an element is called valence orbit. In the period moving from left side to the right side the tendency of elements to lose the electron and later on to gain the electron is increasing. Viz. Sodium of first group loses one electron and form (Na^+) ion and chlorine of group 17 receives one electon and forms Cl^- ion. Generally if there are 1, 2 and 3 electrons in the outermost orbit there is a tendency to lose the electrons, but if there are 5, 6 and 7 electrons in the outermost orbit there is more tendency to gain 3, 2, and 1 electrons respectively.

Moving from left to right in the periodic table, the electrons are successively arranged in the outermost orbit of the atoms of the elements. In the last element of the period eight electrons are arranged in the outermost orbit of the elements. This is called closed configuration or octet configuration. The elements on 18^{th} group formed of final elements of the period, have closed configuration of octet configuration and so do not lose or gain electrons. Hence the group of these elements is called zero group or inert group.

3.7 Blocks of Modern Periodic Table

On the basis of electron configuration the modern periodic table is divided into four blocks.

According to old table, groups 1 and 2 are known as s-block, groups IA, IIA,

Groups 13 to 18 are known as p-block, groups IIIA, IVA, VA, VIA, VIIA, VIIIA,

Groups 3 to 12 are known as d-block, groups IIIB to VIIIB and IB, IIB.

The block shown below periodic table is called f block (They are also called innertransition elements).

3.8 Periodicity in Properties

The properties of the elements in the modern periodic table depend on the basis of regular changes in electron configuration of elements arranged in groups and periods; elements in the groups on the left side of the periodic table are metallic elements and the elements in the groups on the right side of the periodic table are non-metallic elements. The elements in between are known as semimetals. The elements having 1 to 3 electrons in the outermost orbit are called metal elements. The elements in the group having 4 electrons in the outermost orbit are semimetal elements and the elements having more than 4 electrons in the outermost orbit are called non-metallic elements. Generally moving from left to right in the period, the metallic property decreases and non-metallic property increases. Similarly with the increase in atomic number in the group, the concerned property increases.

Table : The zigzag line shown in the modern periodic table as mentioned on page no.27. separates metal and non-metal elemens. The elements on the zigzag line, namely boron (B), silicon (Si), arsenic (As), antimony (Sb), tellurium (Te) and polonium (Po) possessing properties of both the types are called semimetals or metalloids. In the outermost orbits of the elements of 14^{th} group, there are four electrons which they cannot lose and also cannot accept four electrons. Hence they are called semimetal elements with the increase in atomic numbers of the elements in the period that is going down from the top, the metallic property increases. Hence the elements tin (Sn) and lead (Pb) of 14^{th} group are the metallic elements.

3.9 Atomic size – Volume

The exact value of volume of any independent atom cannot be obtained. The atomic volume can be understood with the help of atomic radius. Generally, the distance from the nucleus to outermost orbit of an independent atom is called atomic volume. In the diatomic molecule having single covalent bond of a non-metal element half of the average of the distance between the two atoms of hydrogen in a hydrogen molecule is 37 pm (pm = picometer = 10^{-12} meter). It is called radius of hydrogen atom. For metallic atoms, half of the average distance between nuclei of two atoms arranged in orbital structure of metal is called its atomic radius.

In a group, with the increase in atomic number that is going down from the top in the group new orbits are added and so radius is found increasing in atomic radius table. The value of atomic radius of elements of the first group are given. In the group with increase in atomic number of the element or going to down from top to bottom, new orbits are added and so increase in atomic radius is found in the table 3.5. The values of atomic radii of elements of first group are given. In the period with the increase in atomic number of the element that is if we move from left to right no new orbit is added and also the positive electric charge of nucleus attracts electrons more and so decrease in atomic radii is observed. In the table 3.6 are given the values of atomic radii of the elements of second period.

Table 3.5 Atomic radii of elements of first group

Elements of first group	Atomic radius (pm)
Li	133
Na	154
K	201
Rb	216
Cs	235

Table 3.6

Atomic radii (pm) of elements of second period

Elements of second period	Li	Be	B	C	N	O	F
Atomic radii (pm)	133	89	80	77	70	66	64

3.10 Ionisation Enthalpy

One of the chemical properties of the elements depends upon its tendency to lose or gain the electron. Its measurement is carried out through ionization enthalpy or electron affinity.

Ionization enthalpy means the energy required to remove electron from the outermost orbit of any gaseous atom. The values of ionization enthalpy or energy are expressed in kcal mol^{-1} or $kJmol^{-1}$ (in S.I. unit)

$A_{(g)} + I.E. \rightarrow A^{+}_{(g)} + e^{-}$ I.E. = Ionization enthalpy

Generally, the value of ionization enthalpy of elements in the same group decreases with the increase in atomic number or going down from the top. While, in the period, with the increase in atomic number that is moving from left to right, value of ionization enthalpy increases.

3.11 Electron Affinity

When an electron enters in the neutral gaseous atom and forms negative ion, the energy released is called electron affinity (E.A.)

$A_{(g)} + e^{-} \rightarrow A^{-}_{(g)} + E.A.$ E.A. = Electron affinity

The tendency of the element to receive the electron, i.e. electron affinity depends on its size and configuration. In the groups, the atomic radii of elements increases and so its electron affinity decreases while in the period, the atomic radius decreases and so its electron affinity increases.

In the modern periodic table, the position of the elements describes its electronic configuration. Electronic configuration means in how many orbits the electrons are arranged in an atom. In addition, the group of the elements is determined on the basis of how many electrons are arranged in outermost orbits or valence orbits. The number of electrons in the outermost orbit of the element describes the properties, valency, metallic character, atomic size, ionization enthalpy, electron affinity etc. Hence, knowing the position of any element in the periodic table, the forecast about its properties can be made viz. The atomic number of magnesium is 12. Its position is in third period and second group in the periodic table. The orbits of magnesium are three and there are two electrons in its outermost orbit. Hence its valency is +2. It possesses metallic property and forms Mg^{2+} ion by losing two electrons of the outermost orbit.

Electronegativity : The effect of positive charge is prevailing more or less outside the orbital area of the atom that is beyond the area after the valence orbital. Hence, the attraction forces of the nucleus of the atom affects the bond between the atoms joined by covalent bond. This attraction force is called electronegativity. The absolute value of electronegativity cannot be measured. The value of electronegativity of lithium is accepted as unity, the relative values of electronegativities of other elements are determined. The electronegativity of F is four times that of lithium and so electronegativity of F is 4.0, which has the highest value of electronegativity amongst all the elements. As we move from left to right in the periodic table, electronegativity increases and as we go down in the group the value of electronegativity decreases.

What have you learnt ?

- Classification of 114 elements discovered in the universe till today.
- Dalton, Dobereiner, Newlands and Mendeleef classified the elements and framed the periodic table.
- Dalton classified on the basis of atomic masses. Dobereiner classified on the basis of chemical properties and Newland classified on the basis of octaves.
- Mendeleef classified the elements on the basis of relation between atomic masses and basic chemical properties and prepared a systematic classification. He classified elements in horizontal row as periods and vertical columns as groups.
- You have already studied by important aspects of Mendeleef's periodic table and the modern periodic table.
- Obtained explanation about blocks of the periodic table, periodicity in properties, atomic mass, ionisation enthalpy, electron affinity and electronegativity.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) How many elements are discovered in the universe till present time ?

(A) 141 (B) 124 (C) 114 (D) 94

(2) Modern periodic table is classified in how many blocks ?

(A) 18 (B) 8 (C) 8 (D) 4

(3) Which scientist gave the law of triads of elements ?

(A) Dalton (B) Newlands (C) Dobereiner (D) Mendeleef

(4) The atomic numbers of elements A,B,C and D are 9, 18, 53 and 35 respectively. Which element differs from the remaining elements from the point of view of their position in periodic table ?

(A) A (B) B (C) C (D) D

(5) Which scientist gave the rule of octet ?

(A) Mendeleef (B) Newlands (C) Dalton (D) Dobereiner

(6) In which block of modern periodic table, the inner-transition elements are included ?

(A) p (B) s (C) d (D) f

(7) Which of the following elements is a semimetal ?

(A) Aluminium (B) Chlorine (C) Sodium (D) Silicon

(8) Which of the following elements, having atomic number as below possesses non-metallic property ?

(A) 24 (B) 35 (C) 40 (D) 26

(9) Which of the following will not have 18 electrons ?

(A) K^+ (B) Cl^- (C) K (D) Ca^{2+}

(10) Which of the following statements is not correct for the element having electronic structure 2,8,8,2 ?

(A) Its valency is 2. (B) It is in fourth period.

(C) It is in group II. (D) Its atom forms negative ion.

(11) The construction of modern periodic table owes to research of which scientist ?

(A) Sir Ramsay (B) Moseley (C) Lord Rayleigh (D) Mendeleef

2. Answer the following questions in short :

(1) Which scientists discovered inert gases ?

(2) Who was the first scientist to prepare periodic table ?

(3) On which basis the Mendeleef's periodic table was constructed ?

(4) By discovery of which element, the position of the element below Al was filled in the Mendeleef's periodic table.

(5) Which element is above titanium (Ti) in the Mendeleef's periodic table ?

(6) What is meant by group and period ?

(7) Mention the number of groups and periods in the modern periodic table.

(8) How many electrons are possessed by outermost orbits in the elements of 17^{th} group ?

(9) In which element except the inert gas elements have 7 electrons in the outermost orbit ?

(10) Mention the position of element $_{53}I$ in the periodic table.

(11) In which unit the value of ionisation enthalpy is mentioned ?

3. Answer the following questions in detail :

(1) Explain the laws of Dobereiner and Mendeleef for classification of elements ?

(2) Write Newland's law of octave and modern periodic law for classification of elements.

(3) Who discovered atomic number and by which study ?

(4) Why does atomic radii increases as we go down in the group ? While decreases as we move from left to right in the period.

(5) The ionisation enthalpy decreases as we go from top to bottom in the group, while it increases as we move from left to right in the period ?

(6) The elements placed on which position of modern periodic table are called semimetal elements.

(7) Explain : (i) Ionisation enthalpy (ii) Valence electrons (iii) Electron Affinity.

(8) Mention the modern periodic law and describe it in detail.

(9) Write names of three metals, three non-metals, and three semimetals of the periodic table.

(10) Elements of which groups of the periodic table can easily lose electrons and elements of which groups of the periodic table can easily gain electrons.

(11) How many elements can be included in the s-, p-, d- and f-blocks ?

(12) Write a short note on groups and periods of the periodic table.

(13) What is meant by periodicity ? Why the properties of elements in the same group are similar ?

4 Chemical Bonding

4.1 Introduction

Substance is made up of elements, compounds or mixtures. Two or more than two atoms of the same element or different elements combine chemically and form molecule or a compound. For example, two atoms of oxygen combine to form a molecule of oxygen (O + O = O_2). When two molecules of hydrogen and one molecule of oxygen combine two molecules of water are formed. $2H_2 + O_2 = 2H_2O$.

The properties of the elements depend upon the electronic configuration of its atom. Thus, the properties of the molecules depend on the electronic configuration of the atoms present in it and how they are combined with each other. Each molecule possesses definite type of electronic configuration.

The cause by which the atoms in the molecule of a compound are combined by strong combination is called chemical bond. Thus, it can be said that the chemical bond is a strong attraction force or bonding between two or more atoms.

Stronger the attraction force between atoms, stronger will be the bond. Atoms combine with each other by chemical bond and form molecule. In such a state the atoms possesses different characteristics than they possess when they were in free state. For example, two molecules of hydrogen in gaseous form combine with one molecule of oxygen in gaseous form by attraction forces and form two molecules of liquid water and it possesses different properties as compared to their original states.

4.2 Formation of Chemical Bond

In the 18^{th} group of periodic table, inert elements, Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe) and Radon (Rn) are arranged. This group is called Inert gas elements group. Its this nature is responsible for the atomic configuration of these elements. There are two electrons in the outermost orbit of helium, while in all other inert gas elements there are eight electrons in their outermost orbit. Because of this closed shell configuration they do not possess any chemical reactivity, but possess stability in comparison to other elements. Hence, in the 18^{th} group of these elements, there is electron octet configuration in the outermost orbit and stable configuration. Helium has only two electrons; even then it is inert which is an exception.

On the basis of this configuration Lewis proposed the rule of octet. When one or more atoms exchange their valence orbit electrons or share the electrons, they attain octet configuration like inert gases.

On the basis of this rule, one or more atoms of any element exchange electrons with one or more atoms they form molecules by combining through chemical bond. During this phenomenon of formation of molecule, the energy of combining elements decreases and the stability of the molecules increase because decrease in energy results in increase in the stability.

4.3 Types of Chemical Bond

There are two types of chemical bonds – ionic bond and covalent bond formed between most of the molecules or the atoms in compounds. They are generally bound by the octet rule.

4.4 Ionic Bond

In solid sodium chloride (NaCl) the chemical bond formed between sodium ion (Na^+) and chloride ion (Cl^-) is called ionic bond, Sodium element is placed in the first group and third period of the periodic table. As the electronic configurations

of the elements of first group is (2, 8, 1) there is one electron in the valence orbit of sodium. This one electron in the valence orbit of sodium is lost easily and plays the important role in the formation of ionic bond. As one electron of valence orbit is lost sodium ion is formed and its closed electronic configuration becomes (2, 8).

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

Chlorine element is placed in the seventh group and third period of the periodic table. The electronic configuration of chlorine is (2, 8, 7) and seven electrons are arranged in outermost orbit. Here, chlorine instead of losing seven electrons, gains one electron to gain nearest inert gas like configuration and forms chloride ion (Cl^-) and its closed electronic configuration becomes (2, 8, 8)

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

Ionic bond is formed because of the strong attraction forces between oppositely charged ions and closed electronic configuration possessing Sodium ion (Na^+) and chloride ion (Cl^-). Both the Na^+ and Cl^- ions are attracted by their nuclei and forms ion pair Na^+Cl^-. This we call common salt – sodium chloride (NaCl) compound. It is in ionic form even in solid state.

Generally the atoms of the elements which have one, two or three electrons in their valence orbit, also loses the electrons and form octet configuration like the nearby inert gas and give positive ions like the ionic bond in sodium chloride.

Similarly the elements which have five, six or seven electrons in their valence orbit configuration gains three, two or one electron respectively and form octet configuration like the nearby inert gas and form negative ions. Here, the strong attraction force that is created between oppositely charged and closed electronic structures possessing ions is called ionic bond. Thus there is transfer of electrons between atoms of the elements during bond formation.

Ionic bond in magnesium chloride : Magnesium is placed in the second group in the periodic table and its electronic configuration is (2,8,2). Hence, there are two electrons in its valence orbit and it can lose two electrons to achieve inert gas configuration. Like that in the nearby inert gas neon (2,8) and forms magnesium ion (Mg^{2+}). These liberated two electrons are accepted by two atoms of chlorine (each one accepts one electron) and forms inert gas configuration (2, 8, 8) like the nearby inert gas argon and forms two (Cl^-) ions. Here the attraction force between one Mg^{2+} ion and two Cl^- ions results into the formation of ionic bond in magnesium chloride.

$$\underset{\text{Magnesium element}}{\underset{(2,8,2)}{Mg}} \longrightarrow \underset{\text{Magnesium ion}}{\underset{(2,8)}{Mg^{2+}}} + \underset{\text{Electron}}{2e^-}$$

$$\underset{\text{Chlorine element}}{\underset{(2,8,7)}{2Cl}} + \underset{\text{Electrons}}{2e^-} \longrightarrow \underset{\text{Chloride ion}}{\underset{(2,8,8)}{2Cl^-}}$$

$$Mg^{2+} + 2Cl^- \longrightarrow \underset{\text{Magnesium chloride}}{MgCl_2}$$

In the same way in MgO – Magnesium oxide, magnesium element loses two electrons and forms magnesium ion Mg^{2+} and one oxygen element gains two electrons and forms oxide ion (O^{2-}). Both these ions achieve the octet configuration like their nearby inert gases. Because of the opposite electric charge, attraction force is created and ionic bond is formed resulting into the formation of magnesium oxide compound.

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{Oxygen}}{\frac{1}{2}O_2} \longrightarrow \underset{\text{Magnesium oxide}}{MgO}$$

Characteristics of atom, ion and molecule : When ion is formed from the atom it loses its original properties viz. Sodium metal being highly active, reacts easily with oxygen of the air and forms sodium oxide (Na_2O) which reacts readily with water and gives sodium hydroxide. When one electron is lost from atom of sodium metal and Na^+ ion is formed having configuration like inert gas does not react with oxygen of air or react with water. Positive electric charge possessing sodium ion (Na^+) attracts negative electric charge possessing chloride ion (Cl^-) and forms sodium chloride (NaCl). The reason for the activity of sodium atom is due to its tendency of losing one electron from its valence orbit. Sodium ion formed by loss of one electron possesses electronic configuration like that of closed shell configuration and so it becomes inert. Hence

all of its properties depend upon the positive electric charge containing (Na^+). Hence the common salt Na^+Cl^- is harmless for edible purposes because of the changes in the properties of the elements.

4.5 Crystal Structure of Ionic Compunds

If we observe the crystal structure of sodium chloride (NaCl), it will be seen that six negatively charged Cl^- ions are arranged around each positively charged Na^+ ion and each negatively charged (Cl^-) ion is surrounded by six (Na^+) ions. They are arranged in three dimensional directions.

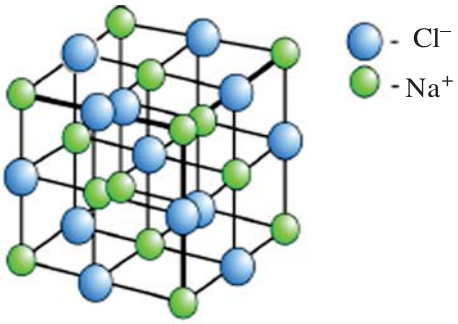


Figure 4.1

By arrangement of this type, possibly high attraction is created between ions having opposite charges. Hence, the energy of the crystal decreases and stability increases. Thus ionic compound sodium chloride is an ionic solid compound.

4.6 Properties of Ionic Compounds

(1) Physical nature : Ionic compounds are obtained in solid form. They are hard and brittle because there is strong electrostatic forces between ions possessing opposite electric charges. Generally, this type of compounds are so brittle that they break into small pieces on application of pressure because of the repulsion between ions.

(2) Solubility : Generally, ionic compounds are soluble in polar solvents like water because the water decreases the attraction between the ions in the compound and so ionic compounds are fairly soluble in water; but they are insoluble in nonpolar organic solvents like ether, carbon tetrachloride, benzene. Hence sodium chloride dissolves easily in water but does not dissolve in carbon tetrachloride.

(3) Melting point and Boiling point : Ionic compounds possess crystalline structure. In the crystal structure of these compounds, the positive and negative ions are combined very strongly by interionic attraction forces. Thus, more energy is required to break the crystal structure of the positive and negative ions regularly arranged in the crystal. Hence, melting points and boiling points of ionic compounds are higher.

(4) Electrical conductivity : Ionic solid compounds are bad conductors of electricity because there are no unpaired electrons in the positive and negative ions in the crystal structure. The positive and negative ions neutralize each other but their aqueous solutions or the melted solid substances are conductor of electricity because their ionisation is possible in molten condition or aqueous solutions.

4.7 Covalent Bond

Ionic bond is not formed when the atoms do not lose electrons of their outermost orbits easily. There are several examples in which two similar atoms combine to form a molecule. e.g. In hydrogen molecule the ionic bond cannot be formed because one hydrogen does not lose electron and the other does not receive electron. Here, two atoms of hydrogen share their electrons of outermost orbit and achieve the double closed shell configuration like nearby inert helium. Here, both the atoms jointly share the electrons for being inert and stable.

Covalent bond in hydrogen molecule : Hydrogen atom possesses one electron. As there is only one electron in each hydrogen, they require one–one electron to achieve double closed shell configuration like helium gas. Hence, the two hydrogen atoms jointly share one-one electron and achieve the closed shell configuration like helium resulting into formation of covalent bond. In such covalent bonds, both the electrons are used by joint sharing in combination of the elements.

hydrogen atom | hydrogen atom | hydrogen molecule | covalent single bond

Similarly dinitrogen (N_2), dioxygen (O_2), dichlorine (Cl_2) etc. jointly share the electrons of their outermost orbits and achieve octet configuration like the nearby inert gas.

Covalent bond in chlorine molecule : In chlorine molecule, there is sharing of electrons of outermost orbit of each chlorine atom and results into the octet configuration like nearby inert gas. The electronic configuration of chlorine is (2, 8, 7) and has seven electrons in outermost orbit. Thus each chlorine atom requires one electron to complete the octet configuration. Here, both the chlorine atoms

share jointly one–one electron and forms covalent bond and achieve octet configuration.

chlorine atom | chlorine atom | chlorine molecule | covalent single bond

Here, only the electrons present in outermost orbit of the atoms take part in the bond formation.

As the two atoms in chlorine molecule are same, there is equal sharing of electrons between them. The electron pair taking part in this sharing is called bonding electron pair or bond electron pair. This bonding electron pair is attracted jointly by the nucleus of the two atoms as a result both the atoms arrange themselves close to each other.

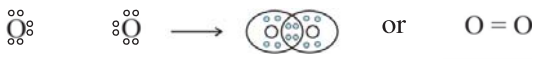
Thus, in hydrogen molecule and in chlorine molcule, two hydrogen atoms and two chlorine atoms form covalent bond by sharing of electrons between them and giving hydrogen and chlorine molecules respectively. One pair of electrons form one covalent bond. Thus, there is one covalent bond between hydrogen and chlorone atoms in the molecules of hydrogen and chlorine atoms in the molecules of hydrogen and chlorine respectively.

e.g. H – H and Cl – Cl

Generally, the number of electrons lost, gained or shared in the bonding of one atom with another atom is called valency of that atom. The valency of an atom can be defined for both ionic and covalent bond and can be shown. e.g. In sodium chloride, the valency of chloride ion is minus one and in chlorine molecule the valency is also one.

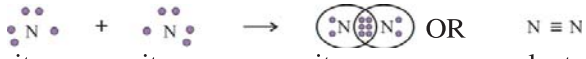
Covalent bond in oxygen molecule : Two atoms of the oxygen in oxygen molecule share two–two electrons each and form two covalent bonds.

The electronic structure of oxygen atom is (2, 6) and so each oxygen atom requires two electrons to complete the octet, and so shares two electrons of each oxygen atom. Hence, two electron pairs of bonding electrons between two atoms of oxygen form two covalent bonds. Hence, the valency of oxygen is considered to be two because of double bond in oxygen. Because of this, it is also called divalent compound.



oxygen atom | oxygen atom | oxygen molecule | covalent double bond

Covalent bond in nitrogen molecule : As seen earlier, a triple bond will be formed between two nitrogen atoms by sharing three–three electrons through three electon pairs, resulting into nitrogen molecule. Hence the valency of nitrogen atom is three or it is trivalent.



nitrogen atom | nitrogen atom | nitrogen molecule | covalent triple bond

Covalent bond in molecule of water : In the molecule of water, two hydrogen atoms and one oxygen atoms are present. One electron is there in the outermost orbit of hydrogen atom. Hence hydrogen atom requires one electron to achieve electronic configuration like nearby inert gas helium. The electronic configuration of oxygen is (2, 6). Since oxygen atom requires two electrons to attain the octet configuration. Hence, two unpaired electrons of outermost orbit of oxygen atom will form two covalent bonds by sharing them with one electron with each hydrogen atom. Oxygen atom is divalent and hydrogen atom is monovalent, the two bonds in water molecule will be with oxygen and two hydrogen atoms.

two hydrogen atoms | oxygen atoms | water molecule | two covalent bonds

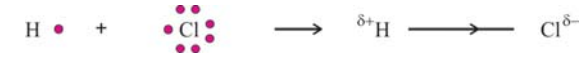
Polar covalent bond : If the two atoms present in a molecule are of the same element, the bonding electron pairs sharing between them will experience similar attraction because their electronegativity is the same and electron pair will remain at equal distance from the nucleus of both the atoms and so their electron pair will not be attracted towards any atom or element.

Now, two atoms present in a molecule are atoms of two different elements, then, the bonding electron pair of covalent bond formed by sharing of electrons between them will be attracted towards the element or atom which has more electronegativity. Hence, the bonding electron pair will not remain at equal distance from the nucleus of both the atoms but will be attracted towards the atoms having more electronegativity, because of the polar tendency of the covalent bond formed in this way is called polar covalent bond.

For example, in hydrogen chloride, the bonding electron pair will be attracted more towards electronegative chlorine atom, because electronegativity of chlorine is more than that of hydrogen.

The chlorine atom will achieve partial negative electric charge in the proportion to its attraction towards chlorine atom and in the same proportion hydrogen atom will achieve positive electric charge.

Here, the partial electric charge produced on atom being less in magnitude, it is expressed with symbol "δ". To express polar covalent bond the arrow (⟶) at half distance from the atom possessing partial positive electric charge (δ^+) is shown towards the atom possessing negative electric charge (δ^-)



Hydrogen atom | Chlorine atom | Polar covalent bond

In the same way polar covalent bonds are there in water and hydrogen fluoride.

Water | Hydrogen fluoride

In addition, if the difference between electronegativities of the two atoms is more than certain definite limit, ionic bond is formed, viz. the elements of the first group of the periodic table and elements of the seventeenth group of elements form ionic compounds e.g. NaCl, KCl, NaBr, KBr, Nal, KI etc are ionic compounds.

Sometimes, both the types of bonds, ionic bond and covalent bond are seen in certain compounds viz in sodium hydroxide (NaOH) there is ionic bond between Na^+ ion and hydroxide OH^- ion. While, there is covalent bond in bond between oxygen and hydrogen in OH^- ion.

4.8 Properties of Covalent Compounds

(1) Physical nature : Covalent compounds are in all the three states solid, liquid and gas.

(2) Solubility : Generally covalent compounds are soluble in non-polar or less polar solvents like ether, benzene etc. while insoluble in polar solvents like water.

(3) Melting point and boiling point : The molecules in the compounds having covalent bond are bound by weaker bonds as compared to the molecules in the compounds having ionic bond. Hence, in general, the melting point and boiling point of covalent compounds are lower.

(4) Electrical conductivity : Compounds having covalent bonds are weak electrolytes, because there are no ions or free electrons responsible for electrical conductance in these compounds.

4.9 Hydrogen Bond

Generally the covalent bond formed between atoms of elements having unequal electronegativity are partially polar. In hydrogen fluoride HF molecule, the electronegativity of fluorine is more than that of hydrogen, the electrons of covalent bond remains more attracted towards the fluorine atom. As a result partial positive electric charge (δ^+) is possessed by hydrogen and partially negative electric charge (δ^-) is possessed by fluorine.

Over and above, two or more molecules of HF in any state, are combined by some definite attraction near each other. This type of attraction force is called hydrogen bond. Hydrogen bond is represented by dotted (.....) line.

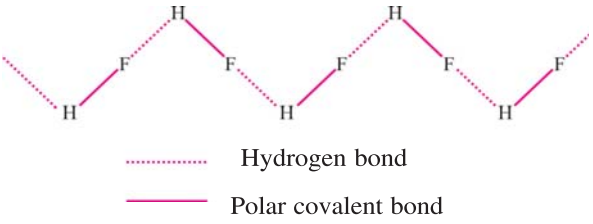


Figure 4.2 Hydrogen bond in Hydrogen Fluoride

Hydrogen bond is also there in molecules of water. Water in its liquid state is not obtained as free molecule. The evaporation of water is slow at normal temperature because of the formation of weak hydrogen bond in water. Hence, water is retained on the earth.

The elements like N, O, F having more electronegativity in their compounds with hydrogen shows the property of hydrogen bond.

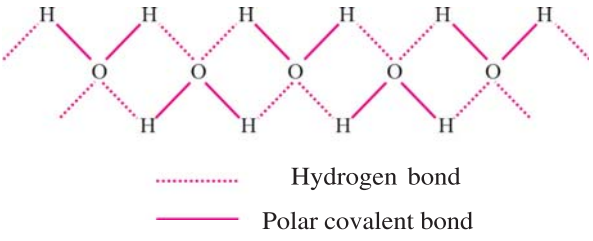


Figure 4.3 Hydrogen bond in water

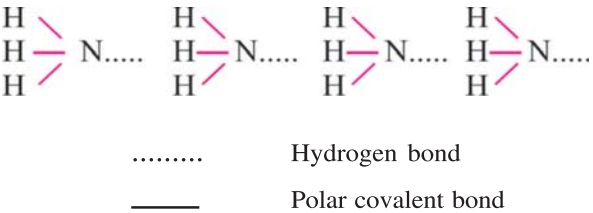


Figure 4.4 Hydrogen bond in Liquid Ammonia (NH_3)

Importance of Hydrogen bond :

- The evaporation of water is slow at normal temperature because of the formation of hydrogen bond in water. Hence large amount of water is retained on the surface of the earth.
- The storage of water in plant cell and animal cell is due to hydrogen bond.
- The molecules of water forms hydrogen bond with the components of the soil of the land. Hence moisture is maintained in the soil.
- Because of hydrogen bond, the clothes of artificial fibres like terrylene etc. dry faster than the clothes of cotton.

What have you learnt ?

- Substance is made up of element, compound or mixture.
- Two or more atoms combine through chemical bond and form molecule or compound in which formation of chemical bond and type of chemical bonds such as ionic bond. In ionic compounds sodium chloride (NaCl), magnesium chloride ($MgCl_2$) formation of ionic bonds. Characteristics of atom, ion and molecule.
- You have studied in this unit crystal structure of ionic compounds such as NaCl, properties of ionic compounds viz, physical nature, solubility, melting point, boiling point, electrical conductivity. etc.
- You have obtained information about covalent bond in dihydrogen molecule, covalent bond in dichlorine molecule and covalent bond in dioxygen molecule, covalent bond in dinitrogen molecule and water molecule.
- Became familiar with polar covalent bond as well as properties of covalent compounds viz. physical nature, solubility, melting point, boiling point, electrical conductivity as well as hydrogen bond and importance of hydrogen bond.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) How many electrons are there in outermost orbit of helium ?

(A) 8 (B) 4 (C) 2 (D) 1

(2) Which of the following elements is of inert group ?

(A) Na (B) Cl (C) Mg (D) Kr

(3) How many electrons are there in chloride ion ?

(A) 17 (B) 18 (C) 16 (D) 8

(4) Which bond is present in NaCl crystal ?

(A) Ionic (B) Polar (C) Covalent (D) Hydrogen–bond

(5) There are 13 electrons in an atom of an element. What can be said about this element ?

(A) It will form negative ion (B) It will form positive ion

(C) It will form co–ordinate covalent bond (D) Hydrogen bond

(6) How many electrons are there in the outermost orbit of inert gas elements ?
(A) 8 (B) 2 (C) 8 or 2 (D) 0

(7) How many electrons are shared by two atoms for the formation of triple bond ?
(A) 3 (B) 2 (C) 4 (D) 6

(8) Which of the following possesses polar bond ?
(A) H_2O (B) O_2 (C) N_2 (D) Cl_2

(9) How many electrons will be required by oxygen atom to achieve electronic configuration like that of neon ?
(A) 1 (B) 2 (C) 8 (D) 0

(10) Which of the following bond shows formation of oxygen molecule is correct ?
(A) Ionic bond (B) Covalent bond
(C) Double bond (D) Triple bond

(11) Which compound is formed when sodium reacts very fast with water ?
(A) Na_2O (B) NaOH (C) NaCl (D) Na_2O_2

(12) In which solvent NaCl is soluble ?
(A) Ether (B) Carbon tetrachloride
(C) Benzene (D) Water

(13) The atom of which of the following elements forms dual closed shell configuration by receiving one electron ?
(A) He (B) H (C) Li (D) B

2. Answer the following questions in short :

(1) How are molecules and elements formed ?

(2) Properties of molecules depend on what ?

(3) Why inert gases do not possess reactivity ?

(4) What is meant by octet configuration ?

(5) Write rule of octet.

(6) Which type of elements possess tendency to form positive ions ?

(7) Which type of elements possess tendency to form negative ions ?

(8) Give formula of aluminium chloride. Which element in it loses electrons ?

(9) Mention only in the form of equation the formation of chemical bond formed in magnesium chloride.

(10) Common salt is harmless for edible purpose. Why ?

(11) How many chloride ions around each sodium ion and how many sodium ions around each chloride ion are arranged in a crystal of sodium chloride ?

(12) Why solid ionic compounds are non-conductors ?

(13) The melted or aqueous ionic compounds are conductors of electricity. Why ?

(14) Which type of atoms do not form ionic bonds ?

(15) What is doublet closed configuration ? Which atom occupies this structure.

(16) Draw diagram showing structure of hydrogen molecule.

(17) Explain only the electronic configuration of covalent bond formation in the structure of chlorine molecule.

(18) What is called electron pair in chlorine molecule ? What is its function ?

(19) What is the valency of a molecule ?

(20) Mention valency of chloride ion in barium chloride and also valency of chloride in chlorine molecule.

(21) How many covalent bonds are formed by how many electrons in oxygen molecule ?

(22) Oxygen is divalent while nitrogen is trivalent. Why ?

(23) What is called polar covalent bond ?

(24) Mention bonds present in water and hydrogen fluoride and draw the figure.

(25) In which compounds both types of bonds – ionic and covalent bond are present ?

(26) Cotton clothes do not dry faster ? Why ?

(27) Molecules of water are not in free form ? Why ?

3. Answer the following questions in detail :

(1) What is chemical bond ? Explain its types giving one example of each.

(2) What is called ionic bond ? Explain with the example of sodium chloride.

(3) Write properties of ionic compounds.

(4) Giving two examples of compounds having covalent bonds, explain their properties.

(5) Molecules of hydrogen and chlorine are formed but argon atom does not form molecule. Why ?

(6) Explain the covalent bonds by examples of oxygen and nitrogen and wirte the number of bonds present in them.

(7) What is called polar covalent bond ? Explain this bond with example.

(8) What is called hydrogen bond ? Mention by figure the formation of hydrogen bond in hydrogen fluoride and ammonia and also mention their properties.

(9) Mention the chemical bond in following molecules or compounds :

Hydrogen	Oxygen
Nitrogen	Chlorine
Iodine	Sodium chloride
Magnesium chloride	Sodium fluoride
Water	Hydrogen fluoride
Hydrogen chloride	Potassium bromide

5 Chemical Reactions

5.1 Introduction

We experience information about number of types of chemical changes in our every day life, viz. Change of milk to curd, rusting of iron, digestion of food in body, ripening of fruits, preparation of alcohol by fermentation from grapes or molasses, reaction of molecules present in cells of the body with oxygen and nitrogen during respiration etc. These are some important examples.

We are associated with the use of chemical substances right from the morning we get up till we go to bed at night.

During this type of change the nature and identity of the compounds change which we describe as chemical reactions. In the scientific language, we express chemical reaction as an option to write it descriptively, in the form of symbols. The chemical equation of any chemical reaction is expressed in such a way that maximum information about the reaction can be obtained. In fact, chemical equation is the symbolic representation instead of describing the chemical reaction in words. In chemical reaction, reactants and products are mentioned. If required, the conditions (pressure, temperature, catalyst) are also mentioned.

5.2 Formulae of Simple Compounds

You know how atoms or molecules of different elements combine by chemical bond to form ionic or covalent compounds. You have studied this earlier.

The chemical formula of a compound shows each of the elements present and their number. In fact, chemical formula expresses the chemical composition of atoms and molecules of the component elements. The definite number of atoms or molecules of compounds is formed in definite chemical arrangements. You have earlier studied the laws regarding this. The type of atom and its numbers present in compound can be expressed in chemical formula. e.g. The molecule of water is expressed as H_2O. In this formula, symbol H indicates hydrogen atom and O indicates oxygen atom. The subscript 2 of H (the number written on lower side) indicates that H_2O compound is formed by combination of two H atoms and one O atom. Similarly CH_4 indicates that it is a combination of one atom of carbon with four atoms of hydrogen.

The formula NaOH for sodium hydroxide indicates that with one atom of sodium one hydroxyl (OH) group is combined. In the same way in $Ca(OH)_2$, one atom of calcium is combined with two OH groups. Hence OH group is expressed with subscript 2 and the formula of the compound can be written as $Ca(OH)_2$.

The simplest molecule or ionic compounds are binary compounds which are formed from two different elements. When formula of such binary compounds are written, the more electropositive element is written on left hand side and more electronegative element is written on right hand side. e.g. In NaCl, Na is more electropositive and Cl is more electronegative. If the compound is ionic cation it is written on left hand side and anion is written on right hand side. e.g. Na^+Cl^-

When metal element (electropositive) combines with non-metal (electronegative) then, metal element is written on left hand side and non-metal element on right hand side. e.g. MgO. In expressing the names of binary compounds, initially the name of metal element and then name of non-metal element is placed. Here the suffix ide is added to the name of the more electronegative element. Some examples are given in Table 5.1.

Table 5.1

Name of molecule	Formula	The suffix ide combined with element
Magnesium oxide	MgO	Oxide from oxygen
Copper sulphide	CuS	Sulphide from sulphur
Potassium chloride	KCl	Chloride from chlorine
Sodium bromide	NaBr	Bromide from bromine
Potassium iodide	KI	Iodide from iodine

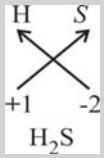
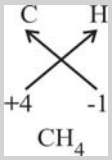
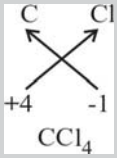
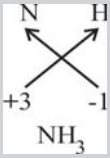
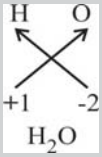
5.3 Formulae of Molecular Compounds

The compounds having covalent bond are called molecular compounds.

The number by which the combination of one atom with other atoms through sharing of electrons is called the combining capacity of the atom and it is called the valency of the atom.

There is one electron in the valence orbit of hydrogen. The hydrogen ion obtained by loss of one electron has valency +1. In the outermost orbit of oxygen there are six electrons and the octet is completed by accepting two electrons in that orbit. Hence, its valency is –2. In the formula of water, there are two convalent O-H bonds. In the formula of this type of molecular compounds, the symbols of component elements are indicated and below them, the number of valency is indicated. Then, they are written in diagonal form as a cross. In Table 5.2, the formula and names of certain molecular compounds are shown.

Table 5.2

Element Valency Molecular formula of compound Name	 Hydrogen chloride	 Hydrogen sulphide	 Methane
Element Valency Molecular formula of compound Name	 Carbon tetrachloride	 Ammonia	 Water

5.4 Nomenclature of Binary Molecular Compounds

In binary compounds the formula of the element is written on the left hand side and then 'ide' is added as suffix to the other element and is written on right hand side. e.g.

In HCl, Hydrogen is on left hand side and element chlorine is on right hand side. So ide is added to element chlorine. Hence the name of this compound will be hydrogen chloride. The names of some of the binary molecular compounds can be written as follows :

KCl	Potassium chloride	NaI	Sodium iodide
CaO	Calcium oxide	ZnO	Zinc oxide
CuS	Copper sulphide	LiF	Lithium fluoride

In a compound, when more than one number of same element is present a number is indicated as a prefix of it. Some examples are given in table 5.3

Table 5.3

No.	Prefix	Name of compound	Formula of compound
1	Mono	Carbon monoxide	CO
2	Di	Carbon dioxide	CO_2
3	Tri	Phosphorus trichloride	PCl_3
4	Tetra	Carbon tetrachloride	CCl_4
5	Penta	Phosphorus penta chloride	PCl_5
6	Hexa	Sulphur hexa fluoride	SF_6
7	Hepta	Chlorine heptoxide	Cl_2O_7

In the nomenclature of bimolecular compoud, the prefix showing number of elements is very important, because two nonmetallic elements (like nitrogen and oxygen) forms a number of compounds. The molecular compounds formed by combination of nitrogen with oxygen are N_2O, NO, N_2O_3, NO_2, N_2O_4, and N_2O_5. Here the naming is carried out with respect to number of nitrogen or oxygen. e.g.

N_2O Nitrous oxide	N_2O_3 Nitrogen trioxide
NO Nitric oxide	N_2O_4 Nitrogen tetroxide
NO_2 Nitrogen dioxide	N_2O_5 Nitrogen pentoxide

5.5 Formulae of Ionic Compounds

In the formulae of ionic compounds the symbol of the positive ion is written on left hand side and the symbol of the negative ion is written on right hand side. Positive and negative ions are expressed as small whole integer number because valency of the positive ion and negative ion can be different. The total electric charge of the positive ion should be equal to that of the negative ion. Hence the compound can be expressed without any charge. e.g. In the formula of sodium chloride - NaCl, the electric charge of the positive ion (Na^+) is balanced (neutralised) by the electric charge of the negative ion (Cl^-). Hence it is not necessary to express electric charge on the formula of sodium chloride. Its formula is written as NaCl. Some examples are given in Table 5.4.

Table 5.4

Symbol of element	K	Br	Zn	Cl
Symbol of ion	K^+	Br^-	Zn^{2+}	Cl^-
Electric charge of ion	1+	1–	2+	1–
Number of electrons lost	1	–	2	–
Number of electrons received	–	1	–	1
Required number of elements for balancing of electric charge	1	1	1	2
Formula of compound	KBr			$ZnCl_2$
Name of compound	Potassium bromide			Zinc chloride

Some positive and negative ions are monoatomic (Cl, Br, I, etc.), while some of the negative ions are formed by combination of one or more negative ions (OH^-, HCO_3^-, CO_3^{2-}, SO_4^{2-}). In table 5.5 common monoatomic ions and in table 5.6 common polyatomic ions are shown :

Table 5.5 Some common Monoatomic ions

Name of ion	Formula of ion	Name of ion	Formula of ion 2+ electric charge	Name of ion	Formula of ion 3+ electric charge
Sodium	Na^+	Magnesium	Mg^{2+}	Aluminium	Al^{3+}
Potassium	K^+	Calcium	Ca^{2+}	* Iron (III)	Fe^{3+}
* Lead (I)	Pb^+	* Lead (II)	Pb^{2+}		
Silver	Ag^+	* Iron (II)	Fe^{2+}	* Chromium (III)	Cr^{3+}
* Copper (I)	Cu^+	* Copper (II)	Cu^{2+}		
		Zinc	Zn^{2+}		

* As the ions of these elements possess more than one valency, their valency is shown in Roman figures in brackets. e.g. (Cu(I), Fe(II). Ions having lower valency are expressed as ous. e.g. Pb^+ or Pb(I) plumbus, Cu^+ or Cu (I) cuprous. The ions with higher valencies are expressed accordingly in Roman figures (II, III, IV) etc. and they are expressed as e.g. Cu^{2+} or Cu (II) Cupric.

Pb^{2+} or Pb (II) Plumbic

Fe^{3+} or Fe (III) Ferric

Name of ion	Formula of ion 1 – electric charge	Name of ion	Formula of ion 2 – electric charge
Fluoride	F^-	Oxide	O^{2-}
Chloride	Cl^-	Sulphide	S^{2-}
Bromide	Br^-		
Iodide	I^-		

Table 5.6 Some polyatomic ions

Name of ion	Formula of ion 1– Electric charge	Name of ion	Formula of ion 2–Electric charge	Name of ion	Formula of ion 3–Electric charge
Hydroxide	OH^-	Carbonate	CO_3^{2-}	Phosphate	PO_4^{3-}
Nitrate	NO_3^-	Sulphate	SO_4^{2-}		..
Nitrite	NO_2^-	Sulphite	SO_3^{2-}		**1+ Electric charge**
Bromate	BrO_3^-	Chromate	CrO_4^{2-}	Ammonium	NH_4^+

For showing formula of Polyatomic compounds

(i) Write the formulae of positive and negative ions.

(ii) Write the numbers showing their electric charge below them.

(iii) Mention the required multiplication number of the ion to balance the electric charge and write the total electric charge.

(iv) Write the formula of the compound and its name so that the compound can be shown without electric charge.

The following illustration will explain all these points :

Formula of ion Number showing electric charge	**Positive** Al^{3+} 3+	**Negative** SO_4^{2-} 2-
Balancing of electric charge	$2 \times Al^{3+}$	$3 \times SO_4^{2-}$
Total electric charge	6+	6 –
Formula of compound	$Al_2(SO_4)_3$	
Name of compound	Aluminium sulphate	

5.6 Chemical Equation and its Balancing

The substances taking part in the reaction are called reactants and the substances that are produced in the reaction are called products. In the chemical reaction, reactants are written on the left hand side of the arrow (→) and the products on the right hand side of the arrow. The physical states of reactants and products are expressed in the equation. e.g. (s) for solid, (*l*) for liquid, (g) for gas and (aq) for aqueous. The state of a substance is expressed on the right hand side of the symbol representing atom, ion or molecule in the lower part in the bracket. e.g.

$$2Na_{(S)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$$

Earlier, arrow was shown in upward (↑) for gaseous compound and in downward direction (↓) for precipitates but now, they are expressed as (g) and (s) respectively in the reaction. For example, when an aqueous solution of silver nitrate is added to an aqueous solution of sodium chloride, white precipitates of silver chloride are obtained and sodium nitrate remains in solution. This can be shown as below in the form of chemical equation :

$$AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow AgCl\ (\downarrow) + NaNO_{3(aq)}$$

is written as

$$AgNO_3(aq) + NaCl_{(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$$

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_2(\uparrow)$$

is written as

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

Certain reactions occur in presence of suitable catalyst, temperature and pressure. These conditions are shown on the upper or the lower side of the arrow. e.g. when nitrogen gas and hydrogen gas are heated in a closed vessel at 200 Bar (unit of pressure) 703 K temperature in presence of Fe_2O_3 catalyst, ammonia gas is formed, which is an equilibrium process.

$$N_{2(g)} + 3H_{2(g)} \underset{200\ Bar,\ 703\ K}{\overset{[Fe_2O_3]}{\rightleftharpoons}} 2NH_{3(g)}$$

⇌ indicates equilibrium

On the basis of molecular formulae the equation of any chemical reaction can be shown in detail. It is most important to balance this equation because the law of conservation of mass must be obeyed.

In a chemical equation when the number of reactants shown on left hand side of the arrow (→) and the number of products shown on the right hand side of the arrow (→) are made equal, the chemical equation is called balanced equation. This is because the total mass of the reactants will be equal to the total mass of the products. (Law of conservation of mass). Let us study the balancing of chemical reaction equation by taking some of the following illustrations

(1) $Al(OH)_3 + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2O$

Aluminium hydroxide — Sulphuric acid — Aluminium sulphate — Water

First of all we will do balancing of number of elements in the reaction. As there are two atoms of aluminium on the right hand side we will put prefix 2 before aluminium hydroxide. Similarly, there are three atoms of sulphur in aluminium sulphate on right hand side, so we will put prefix 3 before sulphuric acid on the left hand side. Now the number of atoms of hydrogen has become 12 on the left hand side. We will put prefix 6 before the molecule of water on the right hand side. By doing so, the equation will be balanced as follows :

$2Al(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O$

Aluminium hydroxide — Sulphuric acid — Aluminium sulphate — Water

In the above equation, Al (two), O (eighteen), H (twelve) and S (three) atoms are equal. In addition there is no possitive or negative electric charge because the total electric charge is also balanced.

$2Al^{3+} + 6OH^- + 6H^+ + 3SO_4^{2-} \rightarrow$

$2Al^{3+} + 3SO_4^{2-} + 6H^+ + 6OH^-$

$(6+) + (6-) + (6+) + 3(-2) \rightarrow$

$2(+3) + 3(-2) + 6(+1) + 6(-1)$

$6-6+6-6=0$ $\quad +6-6+6-6+6-6=0$

(2) $KNO_3 \xrightarrow{\Delta} KNO_2 + O_2$

Potassium nitrate — Potassium nitrite — Oxygen

(Δ indicates heat is supplied)

In the above reaction, there are 3 atoms of oxygen on the left hand side and 4 atoms on the right hand side, so the prefix 2 will be placed before both KNO_3 and KNO_2. By doing so the balancing of equation will take place.

$2KNO_3 \xrightarrow{\Delta} 2KNO_2 + O_2$

Potassium nitrate — Potassium nitrite — Oxygen

Electric charge on left hand side 2 + $(2K^+)$ and 2– $(2NO_3^-)$ will give zero on adding and on the right hand side 2^+ $(2K^+)$ and 2– $(2NO_2^-)$ will give zero on addition. O_2 has no electric charge.

Thus the electric charge in the equation will be balanced.

(3) In balancing of ionic equations, the balancing of ions is necessary in addition to balancing of atoms. e.g.

$Al + H^+ \rightarrow Al^{3+} + H_2$

Here, by putting prefix 2 before H^+, hydrogen atoms are balanced. So

$Al + 2H^+ \rightarrow Al^{3+} + H_2$

Thus the equation is balanced from point of view of number of atoms, but balancing of electric charges on both the sides is necessary. To balance electric charge on both the sides prefix 3 will have to be multiplied with $2H^+$ and the prefix 2 will have to be placed before Al^{3+}. Thus,

$2Al + 3 \times 2H^+ \rightarrow 2 \times Al^{3+} + 3H_2$ or

$2Al + 6H^+ \rightarrow 2Al^{3+} + 3H_2$

Thus balancing of electric charge (+6) on both the sides is done. Such ionic reactions generally take place in aqueous solutions.

5.7 Types of Chemical Reactions

When reactants are reacted under suitable conditions, the products are obtained, but the process or method of obtaining product may not be same. The different types of chemical reactions are as follows :

(1) Combination reactions : The reaction in which two or more than two elements or compounds combine with one another and form new compound is called combination reaction. For example, when certain elements are combusted in presence of air, they combine with oxygen of air and give oxides corresponding to their elements.

(i) $2H_{2(g)} + O_{2(g)} \xrightarrow{\Delta} 2H_2O_{(l)}$

Dihydrogen — Dioxygen — Water

(ii) $C_{(s)} + O_{2(g} \xrightarrow{\Delta} CO_{2(g)}$

Carbon — Dioxygen — Carbon-dioxide

(iii) $2Zn_{(s)} + O_{2(g)} \xrightarrow{\Delta} 2ZnO_{(s)}$

Zinc — Dioxygen — Zinc oxide

where Δ indicates heat i.e. combusted. Many oxidation reactions are also combination reaction. All the above three reactions can be said to be oxidation reactions.

Activity : After the complete study of this unit, prove the above statement.

By combination reaction between dihydrogen gas and dichlorine gas, hydrogen chloride gas is produced. When hydrogen chloride gas is dissolved in water, hydrochloric acid is formed.

$$\underset{\text{Dihydrogen}}{H_{2(g)}} + \underset{\text{Dichlorine}}{Cl_{2(g)}} \rightarrow \underset{\text{Hydrogen chloride}}{2HCl_{(g)}}$$

$$\underset{\text{Hydrogen chloride}}{HCl_{(g)}} + \underset{\text{water}}{H_2O_{(l)}} \rightarrow \underset{\text{Hydrochloric acid}}{HCl_{(aq)}}$$

The practical example of combination reaction is the white wash of wall with slaked lime. Calcium oxide (quick lime) is dissolved in water and solution of calcium hydroxide (slaked lime) is prepared. It is filtered and the filtered solution is applied on the walls. Calcium hydroxide of this solution reacts with carbon dioxide of air and forms insoluble white thin layer of calcium carbonate. The reactions are as follows :

$$\underset{\text{Calcium oxide}}{CaO_{(s)}} + \underset{\text{Water}}{H_2O_{(l)}} \rightarrow \underset{\text{Calcium hydroxide (slaked lime)}}{Ca(OH)_{2(aq)}}$$

$$\underset{\text{Calcium hydroxide (filtered solution)}}{Ca(OH)_{2(aq)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}} \rightarrow \underset{\text{Calcium carbonate}}{CaCO_{3(s)}} + \underset{\text{Water}}{H_2O_{(l)}}$$

Activity 1 : Take magnesium ribbon. Remove the oxide on it by rubbing the surface with sand paper. Now hold one end of this ribbon with pair of tongs and heat the other end in the oxidising (blue) flame of Bunsen burner. Observe.

You will notice that magnesium ribbon burns with bright and deflagrating light and white substance is formed which is magnesium oxide. This is a combination reaction because oxygen combines with magnesium and compound magnesium oxide is formed.

$$\underset{\text{Magnesium}}{2Mg_{(s)}} + \underset{\text{Dioxygen}}{O_{2(g)}} \xrightarrow{\Delta} \underset{\text{Magnesium oxide}}{2MgO_{(s)}}$$

(2) Decomposition reaction : In decomposition reaction two or more than two substances are obtained by decomposition of one substance. In reality, decomposition reaction is the opposite reaction of combination reaction. In decomposition reaction, heat, electric current or light of proper wavelength is used to decompose the compound. The decomposition reaction by electric current is called electrical decomposition or electrolysis reaction. The photochemical reaction in plants is carried out due to light. When water to which one or two drops of sulphuric acid are added is electrolysed by passing D.C. electric current the reaction occurs as follows and dihydrogen and dioxygen are obtained. This is the example of electrolysis reaction.

$$\underset{\text{Water}}{2H_2O_{(l)}} \xrightarrow{\text{Electric current}} \underset{\text{Dihydrogen}}{2H_{2(g)}} + \underset{\text{Dioxygen}}{O_{2(g)}}$$

This electrolysis reaction can be carried out by using voltameter

If heat is used for decomposition of the compound, it is called thermal decomposition.

E.g. when lime stone (calcium carbonate) is heated calcium oxide (solid) and carbon dioxide (gas) are obtained due to decomposition reaction. Hence it is an example of thermal decomposition.

$$\underset{\substack{\text{(Lime stone)}\\ \text{Calcium carbonates}}}{CaCO_{3(s)}} \xrightarrow{\Delta} \underset{\substack{\text{(Quicklime)}\\ \text{Calcium oxide}}}{CaO_{(s)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}}$$

Activity 2 : Take lead nitrate powder in a hard glass tube and heat in the flame of Bunsen burner, observe. Lead nitrate will be decomposed and lead oxide is obtained as powder in the glass tube. Brown coloured NO_2 gas evolves as fumes.

$$\underset{\text{Lead nitrate}}{2Pb(NO_3)_{2(s)}} \xrightarrow{\Delta} \underset{\text{Lead oxide}}{2PbO_{2(s)}} + \underset{\text{Nitrogen dioxide}}{4NO_{2(g)}}$$

Activity 3 : Fill half of beaker with water. Drop one small piece of lime stone in it. Observe.

You will not find any reaction to occur. Now hold other small piece of lime stone with pair of tongs and heat it for 5 to 10 minutes in the flame of Bunsen burner. Then drop this piece in water. Observe. Water will be warm and will appear as if it is boiling. White substance will be obtained in water.

When lime stone (calcium carbonate) is heated, it decomposes and quick lime (calcium oxide) is formed. Quick lime reacts quickly with water and produces solution of slaked lime (solution of calcium hydroxide). As this reaction is exothermic heat is evolved which heats the water and makes it to boil.

$$\underset{\substack{\text{(Lime stone)}\\ \text{Calcium carbonate}}}{CaCO_{3(s)}} \xrightarrow{\Delta} \underset{\substack{\text{(Quick lime)}\\ \text{Calcium oxide}}}{CaO_{(s)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}}$$

Utility : The utility of decomposition reaction is that it can be used to obtain metals from their oxides, sulphides or salts by their decomposition. Pure metal can be obtained at the cathode by electrolytic decomposition of metal salts.

The digestion in body is also the example of decomposition reaction. Simple sugar is formed by decomposition of starch taken in food. Protein is also decomposed and amino acid is formed.

(3) Displacement reaction : You know that more active metal displaces less active metal from solution of its salt. Such a reaction is called monodisplacement reaction. e.g. When a piece of iron is placed in a solution of copper sulphate, the blue colour of solution changes to green coloured solution and red coloured solid particles of copper are collected. Thus less active Cu metal in $CuSO_4$ is displaced by Fe metal. The reaction can be shown as below :

$$\underset{\text{Copper sulphate (Blue coloured solution)}}{CuSO_{4(aq)}} + \underset{\text{Iron}}{Fe_{(s)}} \rightarrow \underset{\text{Iron sulphate (Ferrous sulphate) (Green coloured solution)}}{FeSO_{4(aq)}} + \underset{\text{Copper (Red Coloured particles)}}{Cu_{(s)}}$$

In certain displacement reactions, two different atoms or group of atoms of one substance are displaced by atoms or group of atoms of another substance. e.g. When solution of sodium sulphate is added to a solution of barium chloride, white precipitates of barium sulphate are obtained and sodium chloride remains in solution.

$$\underset{\text{Barium chloride}}{BaCl_{2(aq)}} + \underset{\text{Sodium sulphate}}{Na_2SO_{4(aq)}} \rightarrow \underset{\text{Barium sulphate}}{BaSO_{4(s)}} + \underset{\text{Sodium chloride}}{2NaCl_{(aq)}}$$

Here, the cations Ba^{2+} of $BaCl_2$ are displaced by cations Na^+ of Na_2SO_4 and anions Cl^- are displaced by anions SO_4^{2-}. In this reaction both atoms and groups are displaced simultaneously. Hence, it is called double displacement reaction. If such a reaction occurs in decomposition reaction, it is called double decomposition reaction. Displacement reactions are found generally occurring in aqueous solutions of ionic compounds.

(4) Oxidation and reduction reaction : In a chemical reaction, if oxygen is added to or hydrogen is removed from an element, molecule or a compound, it is called oxidation reaction. The reaction opposite to this in which hydrogen is added to or oxygen removed from an element, molecule or a compound, it is called reduction reaction.

e.g. $2Zn_{(s)} + O_{2(g)} \rightarrow 2ZnO_{(s)}$ oxidation reaction

$CuO_{(s)} + H_{2(g)} \rightarrow Cu_{(s)} + H_2O_{(l)}$ Reduction reaction

Reduction reaction occurs simultaneously with oxidation reaction and so it is called redox reaction.

Redox reactions are balanced by two methods : (i) Electron exchange method and (ii) oxidation number method.

$Mg_{(s)} + Cl_{2(g)} \rightarrow MgCl_{2(s)}$ is a redox reaction but in it neither obtaining or losing of hydrogen or oxygen takes place. Hence, it is difficult to know that this reaction is redox or not ? But it can be determined by the following method.

(i) Electron exchange method : In the reaction $Mg_{(s)} + Cl_{2(g)} \rightarrow MgCl_{2(s)}$ $(Mg^{2+}\ 2Cl^-)$

(1) $Mg_{(s)} \rightarrow Mg^{2+}{}_{(s)} + 2e^-$ Oxidation reaction

and (2) $Cl_{2(g)} + 2e^- \rightarrow 2Cl^-$ Reduction reaction

In reaction (1) magnesium loses two electons and forms Mg^{2+} ions. Here magnesium loses the electrons and so it is oxidation reaction. Thus the loss of electron is called oxidation.

In reaction (2) Cl_2 receives two electrons and gives $2Cl^-$. Hence it is a reduction reaction. Thus gaining of electrons is a reduction reaction.

Oxidation and reduction reactions are occurring simultaneously, their total reaction is called redox reaction. When any one element, molecule or compound loses electron which is received by the other element, molecule or compound and when both the oxidation and reduction reactions are combined, redox reaction is obtained. If the number of electrons released or received are not same, then they are made equal by multiplying them with proper multiple. For example,

In the reaction

$Cu_{(s)} + 2Ag^+{}_{(aq)} \rightarrow Cu^{2+}{}_{(aq)} + 2Ag_{(s)}$

(i) $Cu_{(s)} \rightarrow Cu^{2+}{}_{(aq)} + 2e^-$ Oxidation reaction

(ii) $Ag^+{}_{(aq)} + e^- \rightarrow Ag_{(s)}$ Reduction reaction

In redox reaction, electrons are balanced (not obtained free) and so the second reaction is multiplied by two, so as to make same number of electrons.

$2Ag^{+}_{(aq)} + 2e^{-} \rightarrow 2Ag_{(s)}$ Reduction reaction

Hence total redox reaction will be

$Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^{-}$ Oxidation reaction

$2Ag^{+}_{(q)} + 2e^{-} \rightarrow 2Ag_{(s)}$ Reduction reaction

$Cu_{(s)} + 2Ag^{+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$ Balanced redox reaction

(ii) Oxidation number method : Increase in oxidation number means oxidation and decrease in oxidation number means reduction.

In the above reaction.

$$Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^{-}$$

oxidation number 0 +2

Oxidation reaction

$$Ag^{+}_{(aq)} + e^{-} \rightarrow Ag_{(s)}$$

oxidation number +1 0

Reduction reaction

The change in oxidation number is equalised by multiplying with suitable multiple. Hence, the second reaction will be

$$2Ag^{+}_{(aq)} + 2e^{-} \rightarrow Ag_{(s)}$$

The total redox reaction can be written as follows :

$$Cu_{(s)} + 2Ag^{+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$$

oxidation number 0 $2 \times (+1)$ $+ 1 \times (+2)$ 0

$0 + 2 = 2 + 0$ i.e $2 = 2$

Hence, the above reaction is balanced from atom and electric charge point of view.

Oxidising agent and Reducing agent : In chemical reaction the element, molecule or compound that loses the electron is oxidised. The element, molecule or compound which receives the lost electron is reduced. Oxidising agent loses the electron and reducing agent receives the electron. Hence oxidising agent is reduced and reducing agent is oxidised. In the reaction.

$$Cu_{(s)} + I_{2(s)} \rightarrow CuI_{2(s)}$$

Copper (Cu) is oxidised to copper ion (Cu^{2+}). Hence it is a reducing agent and iodine (I_2) is reduced to iodine ions (I^{-}). Hence it is an oxidising agent.

Activity : Find the oxidising and reducing agents in the following reactions :

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

(ii) $MnO^{-}_{4\,(aq)} + Fe^{2+}_{(aq)} \rightarrow Fe^{3+}_{(aq)} + Mn^{2+}_{(aq)}$

(iii) $Cl_{2(aq)} + 2I^{-}_{(aq)} \rightarrow 2CI_{(aq)} + I^{+}_{2(s)}$

(iv) $Cr_2O_7^{2-}{}_{(aq)} + Fe^{2+}_{(aq)} \rightarrow Fe^{3+}_{(aq)} + Cr^{3+}_{(aq)}$

(v) $2Ag^{+}_{(aq)} + Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2Ag_{(s)}$

Differences between oxidising agent and reducing agent

Oxidising agent	Reducing agent
(1) It oxidises other element, molecule or compound.	(1) It reduces other element, molecule or compound.
(2) Oxidising agent is reduced.	(2) Reducing agent is oxidised
(3) Oxidising agent-element, molecule or compound receives electron.	(3) Reducing agent-element, molecule or compound loses electron.
(4) Oxidising agent containing oxygen and hydrogen element. Molecular or compound loses oxygen or receives hydrogen.	(4) Reducing agent containing oxygen and hydrogen-element, molecule or compound gains oxygen or loses hydrogen.
(5) In the example $Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Cu_{(s)} + Zn^{2+}$ $Cu^{2+}_{(aq)}$ is an oxidising agent.	(5) In the example $Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$ $Zn_{(s)}$ is a reducing agent.

What have you learnt ?

- Information about chemical change. Studied the formulae of simple compounds, formulae of molecular compounds such as HCl, H_2S, CH_4, CCl_4, NH_3 and H_2O.
- You have learnt about nomenclature of diatomic molecular compounds, formulae of ionic compounds, symbols of ion, electric charge, number of electrons as well as neutralisation of electric charges.
- Rules for expression of formulae of polyatomic ions, polyatomic compounds.
- Chemical equations and balancing.
- Types of chemical reactions such as combination reaction, displacement reaction, decomposition reaction, oxidation and reduction reaction.
- You have learnt in this unit about balancing of redox reactions and its methods. Oxidising agents and reducing agents, difference between them also.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Which of the following statements is correct for the oxidation reaction ?

(A) Oxygen is added or hydrogen is removed

(B) Hydrogen is added or oxygen is removed

(C) Oxygen and hydrogen are added

(D) Oxygen and hydrogen are removed

(2) If hydrogen is added to a compound (or an element) in a chemical reaction, the reaction is known by which reaction ?

(A) Oxidation (B) Reduction

(C) Decomposition (D) Redox

(3) The phenomenon of formation of simple sugar from starch in our body is the example of which reaction ?

(A) Combination (B) Reduction

(C) Decomposition (D) Redox

(4) Amino acid is formed by decomposition of which component of our diet ?

(A) Carbohydrate (B) Starch

(C) Protein (D) Fat

(5) The colour change when Fe piece is placed in copper sulphate solution is due to which reaction ?

(A) Oxidation (B) Decomposition

(C) Displacement (D) Redox

(6) What is the chemical name of quick lime ?

(A) Calcium oxide (B) Calcium carbonate

(C) Calcium hydroxide (D) Carbon dioxide

(7) What is the chemical formula of slaked lime ?

(A) CaO (B) $CaCO_3$ (C) $Ca(OH)_2$ (D) $Ca(OH)_3$

(8) Reducing agent..... electron during chemical reaction ?

(A) regain (B) loses

(C) gains or loses (D) nothing can be said

(9) Which simple substance is formed by decomposition of starch in food ?

(A) Fat (B) Amino acid (C) Sugar (D) Cellulose

(10) What is the valency of nitrogen element in NH_3 ?

(A) 3 (B) 2 (C) 1 (D) –1

2. Answer the following questions in short :

(1) What is mentioned by chemical formula ?

(2) What is called a chemical reaction ?

(3) Explain combining capacity of an atom.

(4) Write formulae of following compounds :

Ferric oxide, Plumbus chloride, Cuprous iodide, Carbon tetrafluoride, Ammonium chloride

(5) What are molecular compounds ? Write one example.

(6) Write two examples each of monoatomic positive ion and monoatomic negative ion.

(7) Write names of two compounds known by common names.

(8) Write three examples of polyatomic negative ions.

(9) What are called reactants and products ?

(10) What is called combination reaction ?

(11) What is called decomposition reaction ?

(12) What is called displacement reaction ?

(13) What is meant by oxidation ?

(14) What is meant by reduction ?

(15) Why balancing of chemical reaction equation is necessary ?

3. Answer the following questions in detail :

(1) Write in brief about reaction of electrolysis of water. By which apparatus the study of electrolysis of water can be studied ?

(2) What is thermal decomposition ? Explain giving suitable example and write its utility.

(3) Explain giving suitable examples, monodisplacement and double displacement reactions.

(4) Explain the following reaction by electron exchange reaction.

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$

(5) Explain the following reaction by oxidation number method.

$Cu^{2+}_{(aq)} + Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$

(6) Mention differences between oxidising agent and reducing agent.

(7) Balance the following reactions and mention the states of reactants and products.

$KMnO_4 + HCl \rightarrow KCl + MnCl_2 + H_2O + Cl_2$

(8) Separate oxidising agents and reducing agents from the following substances :

$KMnO_4$, O_2, Cl_2, $FeSO_4$, Na.

6 Diversity in Living Organisms-I (Classification of Plants)

6.1 Introduction

Why the classification of living organisms ?

You know that diversity is seen in living organisms. They show diversities in their structure, functions and behaviour. In short, there are unlimited varieties in the living world. The varieties we see in the organisms today, is a result of evolution through very long time. During this long period many species of organisms have become extinct, while numerous species have been originated. The study of every organism separately and individually is practically impossible. For convenient study and identification of organisms, they are to be classified into systematic groups as per rules on the basis of their various structural levels.

The scientific methods of dividing organisms into smaller and bigger groups by taking account of similarities and diversities at their various organization level is known as classification. A branch of biology for the study of classification is called Taxonomy.

Why classification of organisms is required ?

Classification of living organisms has the following advantages :

(1) Classification makes the study of various organisms simpler and easier.

(2) Classification is essential to understand the interrelationships among different groups of organisms.

(3) Classification projects before us a picture of all life forms at a glance.

(4) Classification provides fundamental information for the development of other biological sciences. For example, whether it is biogeography, ecology or behavioural sciences, accurate identification and classification are very important.

(5) Several fields of applied biology such as agriculture, social health etc., depend on the information of classification.

Thus, the science of classification contributes greatly in advancing knowledge of many other branches of biology.

6.2 Basis of Classification

For studying the diversity of living organisms in an effective way, we have to arrange various kinds of organisms in an orderly or systematic manner. For example, if we want to study about an organism, our first requirement would be to assort its various varieties under the species and in the next step, on the basis of similarities and dissimilarities of their characteristics. During further steps, on the basis of similarities and differences species are arranged into higher and higher categories such as, genus, order, class and phylum. The method of arranging organisms into groups or sets on the basis of similarities and differences is called classification.

6.3 Classification and Evolution

Living things are identified and categorized on the basis of their body design in relation to their form and function. Some characteristics are likely to make more wide ranging changes in body design than the others. Such changes are sequential and take place in long duration. In other words, characteristics that came into existence earlier are likely to be more fundamental than characteristics that have come into existence later.

The classification of life forms is closely related to their evolution. What is evolution ? Most life forms have arisen by an accumulation of changes in its body design that allow the organism possessing them to survive better.

When the idea of evolution is connected to classification we will find following groups of organisms.

(1) Group one includes all the organisms which have ancient body design and have not changed much. These organisms are referred to as primitive or lower organisms. For example, prokaryotes are regarded as primitive than eukaryotes and bryophytes are regarded as primitive than gymnosperms.

(2) Group second includes those organisms which have evolved their particular design relatively recently. These types of organisms are called advanced or higher organisms.

In other words we can say that first formed (ancient, older) organisms are simpler while younger organisms (later formed or modern) are more complex, i.e. complexity in design of simpler forms has increased over evolutionary time, so that they ultimately become modern complex form.

6.4 Principles and Categories of Classification

6.4.1 Principles of Classification (Rules of Classification)

While developing a system of classification of organisms, certain basic principles are observed. Some of these are as follows :

(i) Morphological criteria : Morphology forms the primary basis for classifying organisms into various taxonomic groups or taxa. In earlier artificial systems, only one or a few morphological characters were taken into consideration (e.g. plants were classified into herbs, shrubs, trees, climbers, etc. on the basis of their habit). The sexual system proposed by Linnaeus was based mainly on the characteristics of stamens and carpels.

Later on, in the natural systems of classification a large number of morphological characters were taken into consideration. As a result, classification of plant groups was more satisfactory and their arrangement was showing natural relationships with each other. The similarities in the morphological characters are used for grouping the plants together, since these similarities indicate their relationships. On the other hand, dissimilarities of characters are used for separating the plant groups from each other. Plant groups with greater differences are considered to be unrelated or distantly related.

Example : All flowering plants with ovules enclosed in an ovary cavity are grouped together as Division - Angiosperms whereas, the angiosperms are further classified into two classes: (i) Dicotyledons and (ii) Monocotyledons.

(ii) Phylogenetic considerations : In the more recent systems of classification of plants, a greater emphasis is given on the phylogenetic arrangement of plant groups, an arrangement which is based on the evolutionary sequence of the plant groups. These systems also reflect on the genetic similarities of the plants.

(iii) Chemical taxonomy or chemotaxonomy : Chemotaxonomy is the application of phyto-chemical data to the problems of systematic botany.

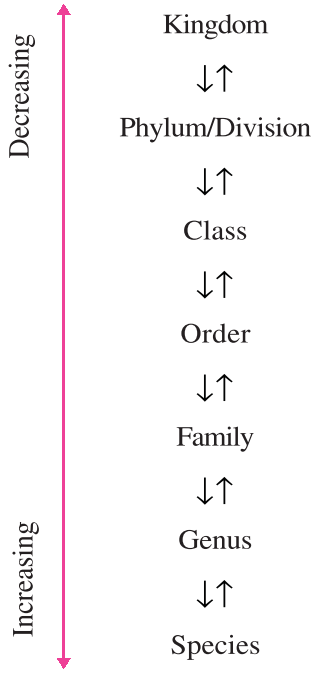
The presence and distribution of various chemical compounds in plants serve as taxonomic evidences. Nearly 33 different groups of chemical compounds have been found to be of taxonomic significance.

(iv) Numerical taxonomy : Application of numerical methods (data) in the classification is called numerical taxonomy.

The numerical data thus collected for various plant groups is tabulated systematically. Computers are used for this purpose.

6.4.2 Categories of classification : The living organisms are grouped together by certain similarities, that show how one group is related to another and how the modern day organisms have evolved. The major groups of organisms are given categories of kingdoms. Then successively taxa like subkingdom, division or phylum, subdivision or subphylum, superclass, subclass, series, order, family, genus and species are organized. As one moves downward from kingdom towards species, the differences decrease and the similarities increase.

Categories of Classification



Kingdom is the highest category of classification and species the lowest.

Kingdom : It includes all organisms that share a set of distinguished common characters.

Phylum : Each kingdom is divided into different phyla. Each phylum has organisms related to each other by certain common characters.

Class : Each phylum is further divided into a number of classes, which are related by some common features.

Order : Each class may have a number of orders. Members of an order have some common characters. An order includes a number of families.

Family : A group of genera which are closely related constitute a family. Each family possesses certain common characters.

Genus : Each family is divided into a number of genera. Members of each genus are similar to each other.

Species : A genus comprises a number of species. A species is the basic unit of classification and evolution. All members of a species are capable of interbreeding and giving rise to fertile offsprings.

A number of scientists tried to give a framework of classification. The hierarchy of classification is as given below :

Carolus Linnaeus (1758) : He recognized only two groups of organisms, plants and animals. The differences between the plants and animals are very clear. Plants are stationary and trap radiant energy of sun to make their food. Some plants have indefinite growth. Whereas animals generally move, eat plants or animals as food and their bodies stop growing after attaining a certain size. Plant cell is surrounded by a cell wall and possesses chloroplast. Animal cells neither have cell wall nor chlorophyll containing chloroplast. Because of these basic differences Linnaeus put plants and animals into two groups- Plant kingdom and Animal kingdom. In this way he proposed two kingdoms classification.

Ernst Haeckal (1894) : When, taxonomical studies indicated that certain organisms do not fit either under plant kingdom or animal kingdom. Ernst Haeckel raised a third kingdom Protista for unicellular organisms.

Robert Whittaker (1969) : Added fourth kingdom Monera for bacteria which are prokaryotes and fifth kingdom Fungi for fungi which lack chlorophyll and are eukaryotes.

Carl Woese (1977) : Divided kingdom Monera into Archaebacteria (or Archaea) and Eubacteria (or Bacteria).

6.5 Nomenclature

The nomenclature of organisms is required for their separate identification from each other. The local name for an organism is enough for any one region and people of that region; but it is not fruitful for other regions of the world. Therefore, there should be an universal scientific name for each organism. The scientific method of naming an organism is called nomenclature. The scientific name of each organism is composed of two components, in which, the first word is called the generic name and second one the species name. Because a name has two components this type of naming is called binomial nomenclature.

Important Features of Binomial Nomenclature :

(1) Scientific name of every organism has two words. First word is the name of genus called generic name and the second word is the name of species called specific name. For example the scientific name of human being is *Homo sapiens*. Homo is generic name and sapiens is a specific name. Similarly, the scientific name for maize is *Zea mays.*

(2) The scientific names are unique and are followed all over the world.

(3) These names are guided by a set of rules stated in the International Code of Nomenclature.
- Scientific names should be written in italics if printed and underlined if hand written.
- Generic name should begin with a capital letter but specific name should be written in small letter

(4) Binomial nomenclature was given by Carolus Linnaeus, who is considered to be Father of Taxonomy.

6.6 Five Kingdom Classification

Whittaker (1969) has classified the living organisms into following five kingdoms :

(1) Kingdom Monera : includes prokaryotic bacteria and blue green algae

(2) Kingdom Protista : includes unicellular eukaryotic organisms like protozoans, fungi and algae

(3) Kingdom Fungi : includes multinucleate higher fungi

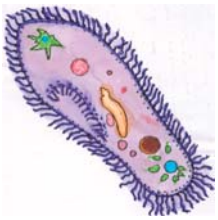
(4) Kingdom Plantae : include multicellular green plants and advanced algae

(5) Kingdom Animalia : include multicellular animals. The important characteristics of five kingdoms are as follows :

6.6.1 Kingdom Monera : Organisms of this kingdom do not possess well developed nucleus. Nuclear membrane, nucleolus and membranous organelles are absent. The mode of nutrition of the organisms could be either autotrophic (synthesizing their own food) or heterotrophic (getting food from the environment). Most of the organisms have a rigid cell wall. This kingdom is divided into two divisions : (a) Schizophyta or Bacteria and (b) Cyanophyta or Blue green algae. Bacteria live mainly as transformers, decomposers and also as parasites.

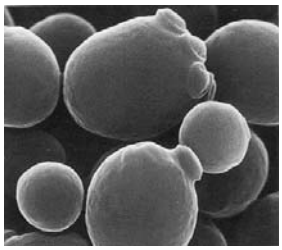
6.6.2 Kingdom Protista : This group includes many kinds of unicellular eukaryotic organisms. They possess a well developed nucleus. They often have hair like cilia or whip like flagella for locomotion. Membraneous organelles like mitochondria, golgi body etc., are also present. They do not exhibit division of labour. Their mode of nutrition can be autotrophic or heterotrophic. Diatoms and protozoans like Amoeba and Paramoecium are the examples.

Amoeba

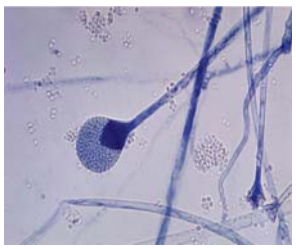


Paramoecium

6.6.3 Kingdom Fungi : They are heterotrophic eukaryotic organisms. Mostly they live on dead and decaying organic matter and hence, have saprophytic mode of nutrition. Some may be parasitic also. The cell wall is made up of chitin and cellulose or chitin . Mitochondria with flat cristae, organelles like lomasomes which are responsible for chemical constitution of cell wall and scattered ribosomes are representative characters of fungi. Their body is called mycelium and the filament like structures are called hypha. Examples are Yeast, Mucor, Mushroom.



Yeast



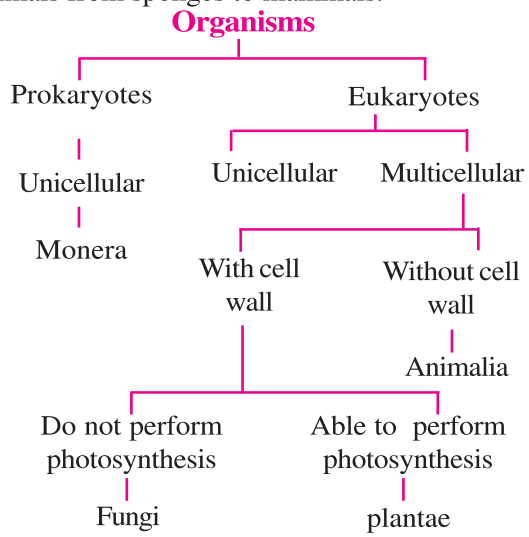
Mucor

Lichen : Some fungal species live in permanent mutually dependent relationship with blue green algae. Such relationships are called symbiosis. These symbiotic life forms are called lichens.

Lichen

6.6.4 Kingdom Plantae : These are multicellular and eukaryotic organisms with cell wall. Cell wall is rigid and made up of cellulose. As they possess chlorophyll and synthesize food by the process of photosynthesis, they show autotrophic mode of nutrition. They include major groups like thallophyta, bryophyta, pteriodophyta, gymnospermae and angiospermae.

6.6.5 Kingdom Animalia : This is animal kingdom in which all multicellular and eukaryotic organisms are included. They do not possess cell wall. They show heterotrophic mode of nutrition. They could be free living , parasitic or symbiotic. (live at the expense of others). The group includes all multicellular invertebrates and vertebrates, all animals from sponges to mammals.

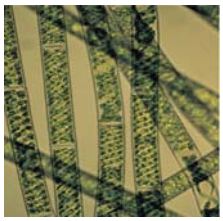


6.7 Plant Classification

Kingdom plantae is further divided into various divisions based on the following features :

- The first level of classification among plants depends on whether plant body is well differentiated or not.
- The next level of classification is based on whether the differentiated body has special tissues for the transport of water and other substances.
- Further classification is based on the ability to bear seeds and whether they are naked or enclosed within fruits.

(1) Thallophyta : The plants of this division are unicellular or multicellular. Plant body is not differentiated into root, stem and leaves and is called thallus. Plants are autotrophic and reserve food is generally starch. Reproductive organs are unicellular. After fertilization the zygote does not develop an embryo. Hence, these plants are called nonembryonic plants. The plants included in this division are predominantly algae. Most algae are water growing or aquatic, both marine and fresh water; some are terrestrial i.e. live on land near moist places. **Examples :** Spirogyra, Ulothrix, Ulva and Chara.



Spirogyra

Ulva

(2) Bryophyta : Bryophytes are small multicellular land plants. These simplest land plants are confined to shady damp places. They are also called amphibians of the plant kingdom. The plant body may be a thallus or it may possess organs like stem and leaves as in mosses. Thallus is flat, green and heart shaped. They are known as liverworts. In some forms roots do not occur but thin, branched root like structures called rhizoids are present which anchor the thallus to the ground. Plants do not possess conducting tissue. Reproductive organs are multicellular and are surrounded by a jacket of sterile cells. Water is absolutely essential for fertilization. In the life cycle the gametophytic stage is principal or dominant stage while sporophytic stage is subsidiary stage. Bryophyta and all the groups higher than it are called embryophyta. **Examples :** Riccia, Marchantia and Funaria (Moss)

Funaria (Moss)

Marchantia

(3) Pteridophyta : They are basically land plants that grow well in moist, shady and cool places. The plant body is differentiated into all three organs like root, stem and leaves and has specialized tissue for the conduction of water and other substances. The green leafy part that we see is the sporophyte. It is dominant phase of life cycle. The gametophytic stage is subsidiary stage. The spore producing structures are called sporangia which arise on the foliage leaf known as sporophyll. **Examples :** Nephrolepis, Marsilea, Adiantum etc.

Nephrolepis

Adiantum

The thallophytes, the bryophytes and the pteridophytes have naked embryo that are called spores. The reproductive organs of plants in all these three groups are very inconspicuous and they are therefore, called cryptogamae, or those with hidden reproductive organs. On the other hand, plants with well differentiated reproductive tissues that ultimately make seeds are called phanerogams. This group is further classified, based on whether the seeds are naked or enclosed in fruits, into two groups : (1) gymnosperms and (2) angiosperms.

Gymnosperms : The plants of this division occupy the position between pteridophytes and angiosperms. They possess root, stem and leaves. They are primitive seed bearing plants and regarded as lower flowering plants. In the life cycle the principal stage is sporophyte while subsidiary stage is gametophyte. The sporophytic stage produces two types of spores. The smaller microspores are produced in microsporangia, which develop on microsporophyll (small leaf like structure). The large megaspore are borne on megasporophylls. Megasporophylls possess naked ovules. The female gametophyte is contained within the ovule. Pollination takes place only by wind. Seeds are not covered by fruits and hence they are called gymnosperms. **Examples :** Pine, Cycas, Pinus, and Deodar.

Cycas

Angiosperms : The advanced seed bearing plants, also regarded as higher flowering plants are included in angiosperms. The plant body is differentiated into organs like root, stem, leaves, flowers, fruits and seeds. Plants possess well differentiated conductive tissues, xylem and phloem for transport of materials. Well developed unisexual or bisexual flowers are present. Accessory whorls such as calyx and corolla also develop in the flowers. After fertilization ovules are converted into seeds and the ovary into fruit. As the seeds are

enveloped by pericarp and enclosed in the fruit, this group is called angiosperms. Pollination may be affected by wind, insects, birds and water.

The angiosperms are further sub divided into two classes : dicotyledons and monocotyledons on the basis of cotyledons present in the seeds.

Class - Dicotyledons :

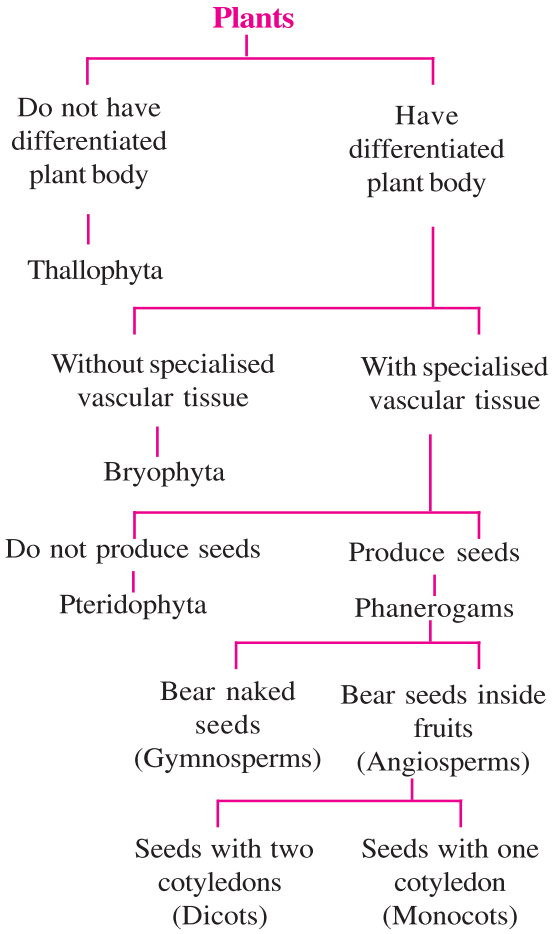
- Plants have seeds with two cotyledons.
- Normally they possess tap root system.
- Stem is normally branched.
- The leaves show reticulate venation
- Flowers are either tetramerous or pentamerous. **Example :** Sunflower.

Sunflower

Class - Monocotyledons :

- These plants have a single cotyledon in their seeds.
- They possess adventitious fibrous root system.
- Normally the stem is unbranched. Rarely it may be feebly branched.
- Leaves possess parallel venation
- Flowers are trimerous. **Example :** Maize

Maize



Classification of plants

What have you learnt ?

- The scientific methods of dividing organisms into smaller and bigger groups by taking account of similarities and diversities at their various organization level is known as classification . A branch of biology for the study of classification is called Taxonomy.
- While developing a system of classification of organisms , certain basic principles like Morphological criteria, Phylogenetic considerations, Chemotaxonomy and Numerical taxonomy are observed.
- Categories of classification include Kingdom, Phylum, Class, Order, Family, Genus and Species.
- As one moves downward from kingdom towards species, the differences decrease and similarities increase.
- The scientific name of each organism is composed of two components, in which, the first word is called the generic name and second one the species name. Because a name has two components this type of naming is called binomial nomenclature.

- Binomial nomenclature was given by Carolus Linnaeus, who is considered to be Father of Taxonomy.
- Whittaker (1959) has classified the living organisms into following five kingdoms : Monera, Protista, Fungi, Plantae and Animalia.
- Kingdom plantae is further divided into various divisions like Thallophyta, Bryophyta, Pteridophyta, Gymnosperms and Angiosperms.
- The Thallophytes, the Bryophytes and the Pteridophytes have naked embryos that are called spores. The reproductive organs of plants in all these three groups are very inconspicuous and they are therefore, called Cryptogamae.
- On the other hand Gymnosperms and Angiosperms possessing well differentiated reproductive tissues that ultimately make seeds, are called Phanerogams.
- The angiosperms are further sub divided into two classes : Dicotyledons and Monocotyledons on the basis of cotyledons present in the seeds.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Nephrolepis (fern) belongs to :

(A) Gymnosperm (B) Angiosperm

(C) Pteridophyta (D) Bryophyta

(2) Which group has seeds enclosed in fruits ?

(A) Bryophyta (B) Pteridophyta

(C) Angiosperms (D) Gymnosperms

(3) Binomial classification was given by

(A) Whittaker (B) Robert Hook

(C) Carolus Linnaeus (D) Schleiden and Schwann

(4) Each kingdom is divided into :

(A) Species (B) Phyla

(C) Classes (D) Genera

(5) Who gave five Kingdom classification ?

(A) Carolus Linnaeus (B) Ernst Haeckal

(C) Robert Whittker (D) Carl Woese

(6) Kingdom Monera includes :

(A) Unicellular eukaryotic organisms

(B) Prokaryotic bacteria

(C) Multinucleate higher fungi

(D) Multicellular animals

(7) Cyanophyta is included in the kingdom :

(A) Protista (B) Monera

(C) Fungi (D) Plantae

(8) Lichens have symbiotic relationship between :

(A) Algae and Fungi (B) Fungi and Bryophytes

(C) Algae and Bryophyte (D) Fungi and bacteria

(9) Adventitious fibrous root system is present in :

(A) Dicot plants (B) Monocot plants

(C) Bryophytes (D) Pteridophytes

2. Answer the following questions in short :

(1) What does the first word in a scientific name of an organism signify ?

(2) Give two important features of bryophytes.

(3) In which group, plant shows wind pollination ?

(4) In which division the plant body is not divided into root, stem and leaf ?

(5) Which divisions are included in cryptogamae ?

(6) Plants of which division are referred to as amphibians ?

(7) In which division the gametophytic stage is principal and sporophytic stage as subsidiary ?

(8) Name the divisions of plants included in Phanerogams

(9) Give chemical composition of cell wall of fungi

(10) Define : Taxonomy

3. Answer the following questions in detail :

(1) Differentiate between algae and fungi

(2) Why bryophytes are known as amphibians ?

(3) Differentiate between bryophytes and pteridophytes

(4) Differentiate between monocots and dicots

(5) Write a note on chemotaxonomy

(6) Describe the advantages of classification of living organisms.

(7) Explain the basis of classification.

(8) Explain morphological criteria as principle of classification

(9) Explain important features of binomial nomenclature.

(10) Explain the categories of classification.

7 Diversity in Living Organisms-II (Classification of Animals)

7.1 Introduction

These organisms are multicellular animals having eukaryotic nucleus and heterotrophic or parasitic. Their cells do not have cell wall, most of the animals are mobile and most of the animals have locomotary organs (except sponges). These animals are free living, parasitic or symbiotic. These multicellular animals include invertebrate and vertebrate.

Animal kingdom includes millions of species and shows a diversity. On the basis of cellular organization, symmetry, notochord and presence or absence of body cavity animals are classified into different phyla. On the basis of presence or absence of notochord there are two main types.

Animal Kingdom

Invertebrate or non-chordate Absence of notochord	Phylum Chordata Presence of notochord
Phylum	Main class
(1) Porifera (Sponges)	(1) Pisces (catilage or bonyfish)
(2) Coelenterata	(2) Amphibia
(3) Platyhelminthes	(3) Reptilia
(4) Nematoda	(4) Aves
(5) Annelida	(5) Mammalia (Mammals)
(6) Arthropoda	
(7) Mollusca	
(8) Echinodermata	

7.2 Phylum Porifera

Meaning of word Porifera is animal having Pores. In simple multicellular animal cell has cellular organization. On body surface pores are found. Cavity in middle is known as Spongeoel, that open outside by a large opening is called osculum. Animals are mostly marine and few live in fresh water. Animals are stationary. The animals are of different shapes and solitary or colonial. Porifera cells do not show division of labour. They reproduce both asexually and sexually.

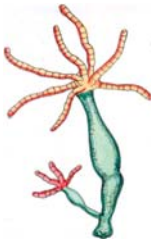
Porifera

Example : Venus' flower basket, sycon, spongilla.

7.3 Phylum Coelenterata

Animals of this phylum are aquatic, and most of them are marine and few live in fresh water. Body wall made up of two layers, of which outer is called ectoderm and inner is endoderm. Between these two layers found jelly like substance mesogloea. Centre of the body cavity named coelenteron is found. The function of digestion and circulation are done by coelenteron. Coelenteron open out through mouth, which helps in ingestion and egestion. Surrounding the mouth tentacles are found, that helps in locomotion and to catch the prey. Ectoderm has special type cells called cindoblast. Generally cindoblast is used to catch the prey and to escape from the predator.

Example : Hydra; Jellyfish and sea anemones.



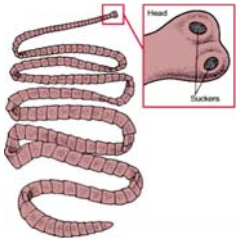
Hydra

Jelly Fish

7.4 Phylum Platyhelminthes

First tribloblastic animals i.e body is formed from three primary germ layers. Body is thin, dorsoventrally flat and unsegmented. Tapeworm has false segments. They show tissue grade of organization, body is without cavity. Alimentary canal is incomplete, there is mouth, and no anus. First time flame cells are found as excretory unit. Nervous system is primary type most of the animal is hermaphrodite and possessing complex reproductive organs. **Example :** Planaria. Liver fluke and Tape worm.

Liver fluke



Tape worm

7.5 Phylum Nematoda

Worms of this phylum look like round tube and unsegmented. Tribloblastic animals. They look like long thread. The body wall is covered by shining, thin cuticle. Alimentary canal is complete. Body cavity is pseudocoelom. Animals of this phylum are unisexual.

Example : Ascaris, Guineaworm, Wuchereria.

Ascaris

Wuchereria

7.6 Phylum Annelida

The animals of this phylum live in land and pond, show bilateral symmetry, animals possess true coelom. Body of the animals of this phylum is divided into many segments. Outside the body wall layer of cuticle is found, body wall remains moist and respiration through body wall. Excretory organs are nephridia. Nervous system is made up of ganglion. Their locomotion is through setae. Animals are unisexual or hermaphrodites show sexual reproduction method.

Example : Earthworm, Leech and Nereis

Earthworm

Nereis

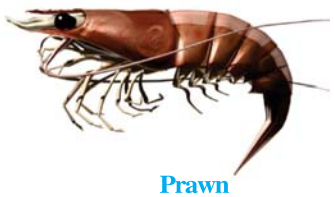
7.7 Phylum Arthropoda

Animals of this phylum have jointed legs. They are triploblastic, and segmented. Body is externally segmented and each segment having jointed appendages. Body is often divided into head, thorax and abdomen. The body cavity is filled with blood and is called haemocoel. Respiration is by gills, trachea, lungs or book lungs. Excretion is by green gland or malpighian tubules.

Animals undergo moulting i.e. shed off the exoskeleton periodically and grow new. Sexes are separate. Nearly 80% to 90 % animals of animal kingdom belong to this phylum. A diverse group of animals, found everywhere on land, in soil and water may be free living or parasitic.

Example : Prawn, Crab, Scorpion, Butterfly, House fly, Millepede.

Crab



Prawn

7.8 Phylum Mollusca

Body is soft and unsegmented. The body is covered by a hard continuous shell made up of calcium. In aquatic animal respiration through ctenidia, while inland animal respiration through lungs, locomotion is by muscular foot. Circulatory system is of open type. Kidney is found as excretory organ.

Example : Chiton, Pila, Octopus.

Pila

Octopus

7.9 Phylum Echinodermata

All animals of phylum Echinodermata are free living aquatic and marine. Body wall is rough made up of calcarious plate. In many animals various types of spines are found on this plates. Water vascular system found inside the body and tubefoot associated with it is unique feature of this phylum. Generally tubefeet help to capture food, respiration and excretion.

Example : Starfish, Brittle star, Sea urchin, Sea cucumber, Sea lily.

Sea urchin

Starfish

7.10 Phylum Chordata

Animals of Phylum Chordata are highly developed. They possess three distinct features.

(1) Presence of a rod like notochord at some stage of life.

(2) Presence of hollow tubular nerve cord present dorsally

(3) Presence of gill-slits at some stage in life. All chordates are triplbolastic and coelomate. Phylum chordata is divided into two major groups. (A) Group Protochordata (B) Group Vertebrata.

Phylum Chordata

Protochordata	Vertebrata
(1) Have notochord	(1) Notochord is replaced by vertebral column.
(2) No definite head and brain	(2) Definite head and brain
	Class :
	(1) Pisces (Fishes)
	(2) Amphibia
	(3) Reptilia
	(4) Aves (birds)
	(5) Mammalia

7.11 Division Protochordata

Presence of notochord throughout life. Notochord is long rod like supporting structure that runs along the back (dorsal side) of the animal.

Notochord provides a place for attachment of muscles for possible movement, exclusively marine animals.

Example : Balanoglossus and Amphioxus.

Balanoglossus

Amphioxus

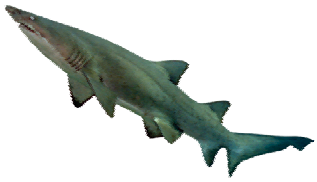
7.12 Division Vertebrata

In vertebrate animals notochord is transformed into vertebral column. Nervous system is well developed in them. Endoskeleton is made up of bone or cartilage. Heart is situated ventral to digestive system and respiration through lungs.

7.12.1 Class Pisces : Only live in water, skin is covered with scales. Body is spindle shaped and respiration takes place through gills. Locomotion occurs through fins. Pectoral and pelvic fins are paired. Tail fins are unpaired and help in changing the direction. Lateral line organs to receive the stimuli from body. Cold blooded animals i.e. their body temperature is not constant, but body temperature depends on surrounding environment.

Most fishes lay eggs. On basis of their internal skeleton there are two types of fishes. In cartilagenous fishes internal skeleton is cartilage while in bony fishes it is made up of bone.

Example : cartilagenous fishes shark, ray fish, bony fishes, Rohu and sea horse etc.



Shark

Ray fish

7.12.2 Class Amphibia : It includes frogs and toads. They live in water and on land. Their skin is without scale, smooth, slimy and moist. Have mucous gland in skin. Body is divided into head and trunk. The trunk part is extended into tail. In tadpole respiration is through gills, in adult respiration is through skin and lungs. Heart is 3-chambered. Cold-blooded, their body temperature depends on environment.

Example : Frog, Toad, Salamander.

Frog

Salamander

7.12.3 Class Reptilia : Skin is dry, scaly. Have two pairs of limbs but snake is limbless. Respiration through lungs, heart 3-chambered. Lay the eggs on land. Unisexual cold-blooded animals.

Example : Lizard, Draco, Turtle, Chameleon, Snake etc.

Chameleon

Lizard

7.12.4 Class Aves : Body is covered by feathers, forelimbs are transformed into wings for flying. Posterior limbs used to walk on land, sit on twig of tree, or modified for swimming in water. Internal skeleton is porous bones hence its weight is less; teeth are absent in jaws, mouth has a horny beak. Heart is complete 4-chambered two auricles and two ventricles, respiration through lungs. Air-sacs are attached to lung's wall. Warm blooded. Urinary bladder is absent. They are unisexual and lay egg.

Example : Heron, Duck, Sparrow, Pigeon, Crow.

Pigeon

7.12.5 Class Mammalia : Skin having hair, oil glands and sweat gland. They are warm blooded animals. Heart four chambered and divided into two auricles and two ventricles. External ear having pinna. Respiration through lungs.

Example : Bat, Rat, Cat, Man, Whale.

Bat

Rat

What have you learnt ?

- Animals are divided in : Poritea, Coelenterata, Platyhelminthes, Nematoda, Annelida, Arthropoda, Mollusca, Echinodermata, Protochordata and Vertebrata.
- Animals are further subdivided on basis of their complex organization.
- Animals evolved from unicellular to multicellular.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Mesoglea is a characteristic of

(A) Coelenterata (B) Platyhelminthes (C) Mollusca (D) Poritere

(2) The common name for Ascaris is

(A) Round worm (B) Shipworm (C) Pinworm (D) Tapeworm

(3) In Arthropoda respiration is done through what ?

(A) Gills (B) Book lungs

(C) Trachea (D) All of the above.

(4) Which excertory organs are in platyhelminthes ?

(A) Flame cell (B) Osculum (C) Nephridium (D) Green gland

(5) From following which animal is cold blooded ?

(A) Frog (B) Salamander (C) Toad (D) All three

(6) In shark heart is of how many chambers ?

(A) One (B) Two (C) Three (D) Four

(7) In birds which organ is lacking ?

(A) Lungs (B) Kidney

(C) Urinary bladder (D) Heart

2. Answer the following questions in short :

(1) State characters by which poriferan animals differ from coelenterate animal.

(2) How annelida animals differ from arthropod animals ?

(3) State the difference between amphibians and reptiles.

(4) State three main characteristics of chordates.

(5) State the difference between bony fish and cartilagineous fish.

(6) How will you identify a protozoan, a sponge, a fish, a round worm, a centipede and snake

(7) Give the names of different classes of Phylum chordata.

8 Our Natural Resources

8.1 Introduction

Natural resources are all the natural commodities and features of the Earth's physical environment that are exploited by the human population. They are used to provide our needs-food, water and other materials. Human beings use natural resources for the maintenance of their life as well as for development.

8.2 Natural Resources on the Earth

The Earth's physical environment is made up of the following four major sections or spheres:

(1) **Atmosphere :** The 100 km thick layer of gases that surrounds the Earth

(2) **Hydrosphere :** The earth's various water bodies namely seas and oceans, lakes, rivers, ice sheets, glaciers etc.

(3) **Lithosphere :** The rocks and soil that makes up earth's crust (outermost layer) is called lithosphere.

(4) **Biosphere :** Those part of the above mentioned three spheres in which all living things exist.

Living things constitute the biotic component of the biosphere. The air, the water and the soil form the non-living or abiotic components of the biosphere.

The natural resources can be classified into two major types namely (1) Inexhaustible natural resources and (2) Exhaustible natural resources.

(1) **Inexhaustible natural resources :** This type of resources are available in unlimited quantities and are not exhausted by human activities. The solar energy, air, water and tidal energy of sea are included in this type of natural resources.

(2) **Exhaustible natural resources :** The natural resources which are available in limited quantities and are considered to be exhausted are called exhaustible natural resources. There is a probability to decrease in the quantities and qualities of this type of natural resources by constant use in various human activities. The exhaustible natural resources are subdivided into two types :

(a) The renewable natural resources : If the exhaustible natural resources like land, water and living organisms are used carefully and judiciously, then these resources can be obtained further. Therefore, they are known as renewable natural resources.

(b) The non-renewable natural resources : The constant use of coal, minerals, petroleum and their products, results in their decline. There is no way of replenishing them. Such resources which cannot be renewed after their consumption are called non-renewable natural resources.

8.3 The Breath of Life - Air

The transparent covering of gases around the earth is termed as atmosphere, which is arranged concentrically around the earth's surface in the form of many layers. The main layers from earth's surface to space include troposphere, stratosphere, mesosphere and thermosphere in sequence.

The air of normal atmosphere comprises of 78 % nitrogen, 21 % oxygen, 0.03 % carbon dioxide, a small amount of carbon monoxide, helium, argon, hydrogen and other gases. The presence of major portion of air in the troposphere layer helps to maintain life as it consists oxygen, CO_2 and nitrogen.The Ozone layer of the stratosphere absorbs the harmful solar radiation, so that it protects the living organisms.

Air is an important medium for flying animals and also for the dispersal of pollen, spores, seeds and fruits.

Eukaryotic cells and many prokaryotic cells need oxygen to break down glucose molecules and get energy for their activities. This results in the production of carbon dioxide. Combustion is another process during which oxygen is utilized and carbon dioxide is released. Despite this very small quantity of carbon dioxide is present in the atmosphere. This is due to :

(i) photosynthesis during which green plants fix carbon dioxide into glucose and

(ii) many marine animals use carbonates dissolved in sea water to make their shells.

8.4 The Role of the Atmosphere in Climate Control

As the air is a bad conductor of heat, the atmosphere keeps the average temperature of the earth fairly steady during day. The atmosphere also prevents the sudden increase in temperature during the daylight hours. During night time, it slows down the escape of heat into outer space. For example moon is about at the same distance from the sun that the Earth is. But as there is no atmosphere on the surface of moon, the temperature ranges from -190° C to –110° C.

The accumulation of CO_2, a green house gas, in the atmosphere causes an increase in the earth's temperature. However, oceans provide one of the principal storehouses for carbon and carbon dioxide, and so act to regulate greenhouse gases in the atmosphere.

8.5 The Movement of Air – Wind

A cool evening breeze after a hot day or rain after a few days of hot weather bring us considerable relief. These phenomena are the result of changes that takes place in our atmosphere due to the heating of air and the formation of water vapours. Water vapours are formed due to heating of water resources. When the solar radiations fall on the Earth, some are absorbed but majority of them are reflected back by the land and heat water resources. These reflected radiations heat the atmosphere from below. As a result convection currents are set up in the air. But since the land gets heated faster than the water, the air over land also gets heated faster than the air over the water resources.

If we look at the situation in coastal regions during the day, the air above the land gets heated faster and start rising. As this air rises, a region of low pressure is created and the air over the sea moves into this area of low pressure. The movement of air from one region to other creates wind. Thus during the day the direction of wind is from the sea to land. During night, both the land and the sea start to cool. Since water cools down slower than the land, the air above water would be warmer than the air above land. Thus during the night the direction of wind is from land to the sea.

Thus, movement of air is caused by temperature or pressure differences and is experienced as wind. Where there are differences of pressure between two places, a pressure gradient exists, across which air moves from the high-pressure region to the low-pressure region.

8.6 Rain

Water continuously circulates between the atmosphere and lithosphere and this process is called hydrologic cycle. Solar heat evaporates water from the ocean which is the great reservoir of water. A lesser amount of water is also evaporated from the surface of land and from plants . Due to solar heat air is also heated . The hot air rises up carrying the water vapour with it. As the air rises it expands and cools. This cooling causes the water vapour in the air to condense in the form of tiny droplets. These droplets grow bigger by the process of condensation. When these drops become heavy they fall down in the form of rain.

8.7 Water – A Wonderful Liquid

Water is the main component of aquatic environment. The three-fourth of the earth's surface is covered by water. 97 % of the aquatic environment is comprised of marine water which is unusable for us; remaining 3 % of the total water is fresh water which is found frozen in the ice caps at the two poles, in rivers, lakes and ponds. Some amount of water exists in the form of water vapour.

Life is impossible without water. Water plays a key role in a control of climatic conditions. The water in seas absorbs or releases heat and helps to maintain the atmospheric temperature by keeping it cool or warm. All living organisms depend on the water . It provides a medium for chemical reactions in the cell. It is a good solvent. Most of the substances are easily soluble in water and hence,

they are transported from one part of the body to the other through water only.

The earth depends mainly on rain to maintain the quantity of fresh water. Sea plays very important role in maintaining the water cycle. Almost 90 % of the water evaporated from the sea, returns as rain to the sea. The remaining 10 % helps to maintain the ecosystem on the Earth.

8.8 Mineral Elements in Soil

The outermost layer of our Earth is called the crust and the minerals found in it supply a variety of nutrients to organisms. Initially these minerals bound up in huge rocks are broken down into the fine particles of soil. Following factors are responsible for the formation of soil :

(1) Sun : During day time sun heats up rock and hence, rocks expand and during night these rocks cool down and contracts. Since all the parts of rocks do not expand and cool at the same rate, this results in the formation of cracks and ultimately the huge rocks break up into smaller pieces.

(2) Water : Water helps in the formation of soil in two ways (a) Water enters in the cracks of rocks and widen them and (b) fast flowing water often carries big and small particles of rocks downstream. As these particles rub against other rocks they become smaller and smaller in size and finally converted into soil particles.

(3) Wind : Like water, strong wind also erode rocks down. Wind also carries soil particles from one place to other.

(4) Lichen : Living organisms like lichens grow on the surface of rocks. While growing they release certain substances that cause the rock surface to powder down and form a thin layer of soil. Thus organisms play important role in soil formation.

Since the beginning of the 19th century, it has been established that plants absorb minerals from the soil, which enter the animal kingdom through food chains and food web. It has been revealed that carbon, hydrogen, nitrogen, oxygen, phosphorous, calcium, sulphur, magnesium, iron, manganese, zinc, boron, copper and molybdenum are important mineral elements for the body structure and functions of living organisms. In addition , certain other elements such as aluminium, sodium, silicon chlorine and cobalt are found to be essential for the healthy growth of plants and animals. In addition to this man also utilizes minerals for certain industrial processes.

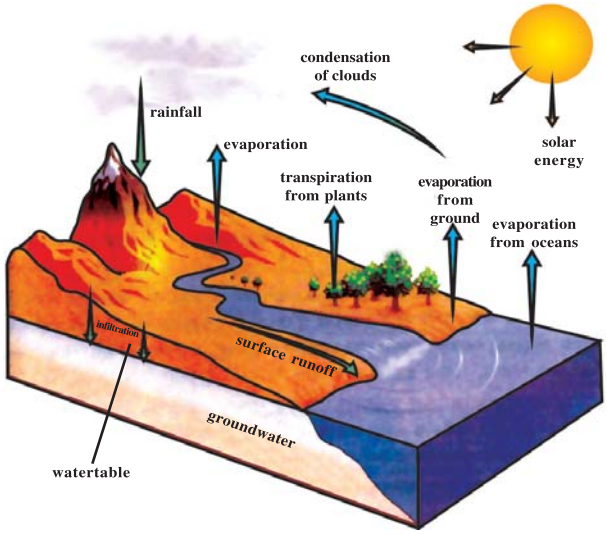
8.9 Biogeochemical Cycles

Ecosystem comprises of biotic components like producers, consumers and decomposers. For the maintenance of life, energy as well as abiotic components are necessary. Abiotic components are obtained from the environment. Several inorganic nutrients are taken up by the producers and are used up by the producers and are used for synthesizing organic compounds like carbohydrates, fats and proteins. Solar energy is stored in the form of these organic substances. These organic substances are utilized by consumers as food. After the death of plants and animals, decomposers act up on dead bodies and inorganic elements are released back to the environment. Thus various elements are constantly cycled in the ecosystem. This cycling of nutrients from the environment to organisms and back to the environment is called biogeochemical cycle.

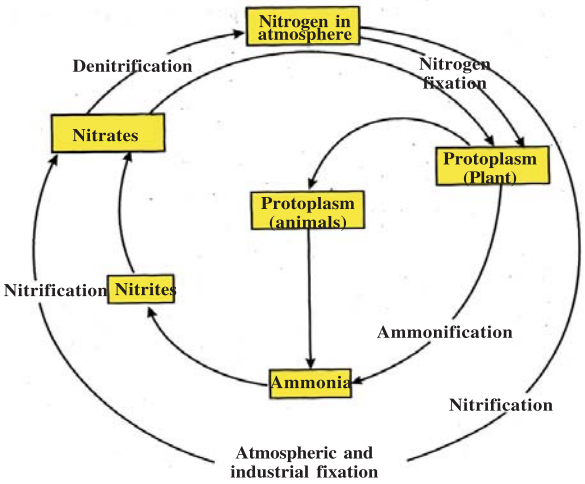
8.9.1 Water Cycle : A circulation of water and moisture among living organisms, atmosphere and earth is referred as water cycle or hydrologic cycle or H_2O cycle.

The sun, which is responsible to drive the water cycle, heats water in oceans and seas. Water evaporates as water vapour into the air. Ice and snow can sublimate directly into water vapour. Due to transpiration in plants water from soil is also evaporated. Condensation of water vapour leads to rain.

All of the water that falls on the land does not immediately flow back into the sea. Some of it infiltrates deep into the soil and becomes the part of underground reservoir of fresh water. Over a time, the water returns to the ocean where our water cycle restart.



8.9.2 The Nitrogen Cycle : Although organisms live in a nitrogen rich atmosphere (78 %) the gaseous form of the nitrogen can be used by very few organisms. Nitrogen is a required nutrient for all living organisms to produce a number of complex organic molecules like amino acids, the building blocks of proteins, and nucleic acids,



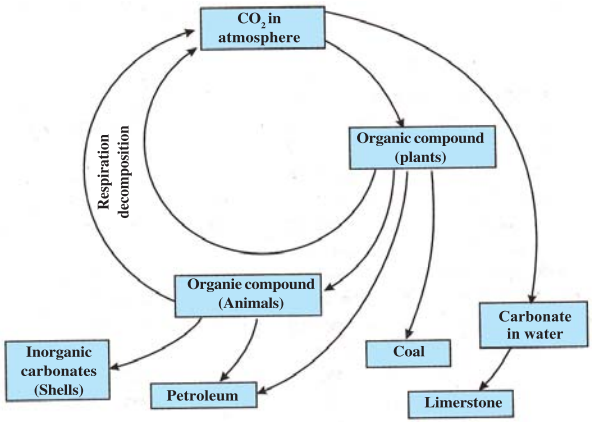
including DNA and RNA. Nitrogen is also found in other important biological compounds such as alkaloids and urea. Hence, the nitrogen cycle represents one of the most important nutrient cycle found in ecosystem.

Various types of bacteria like Rhizobium, found in the root nodules of legumes, Azotobacter and blue green algae are able to fix atmospheric nitrogen and change it to ammonia by the process of ammonification and also to ammonium nitrates and nitrites by the process of nitrification. Plants can utilize nitrates as well as ammonium ions. Atmospheric lightning can also fix nitrogen into oxides of nitrogen by photochemical reactions. These oxides dissolve in water to give nitric and nitrous acids and fall on land along with rain. These are then utilized by various organisms.

Plants generally take up nitrites and nitrates and convert them into amino acids which are used to make proteins. These forms are also utilized for the synthesis of other nitrogen containing complex compounds. These proteins and complex compounds are subsequently consumed by animals. On the death of animals and plants, some other bacteria converts these nitrogen containing complexes back into nitrites and nitrates. Bacteria like Pseudomonas converts nitrites and nitrates to free nitrogen atoms and this process is known as denitrification. The free atmospheric nitrogen is again fixed up by nitrogen fixing microorganisms.

8.9.3 The Carbon Cycle : Carbon is a basic component of all organic compounds, the building materials of which all living organisms are constructed. Carbon is present in the structure of carbohydrates, fats, proteins and nucleic acids. The exoskeleton and endoskeletons of various animals are also formed from carbonate salts.

Carbon cycle is essentially a perfect cycle in the sense that carbon is returned to the environment about as fast as it is removed. Atmosphere is the main reservoir of carbon dioxide and hence, it is a gaseous cycle.

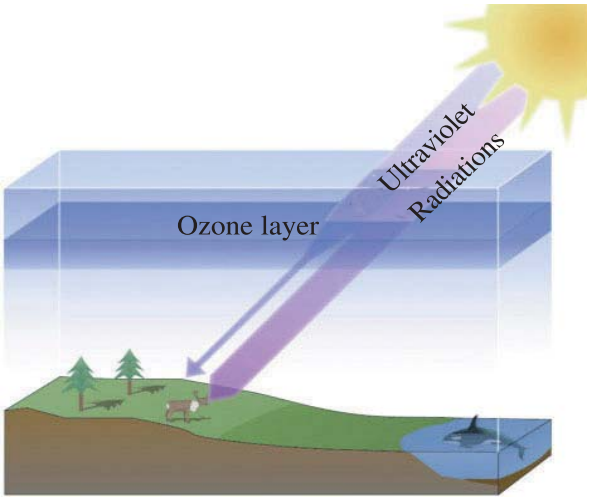


Green plants use CO_2, solar energy and H_2O in the process of photosynthesis and synthesize carbohydrates (glucose molecules). They release oxygen as a byproduct. Carbon is returned to the environment by the respiratory activities of plants and animals. Decomposition of dead bodies also releases CO_2 back into the environment. Besides this, non-biological processes like burning of fossil fuels, wood, coal etc. help in replacing CO_2.

It is interesting to note that the percentage of carbon dioxide became double in the atmosphere since the industrial revolution when human beings started burning fossil fuel on a very large scale.

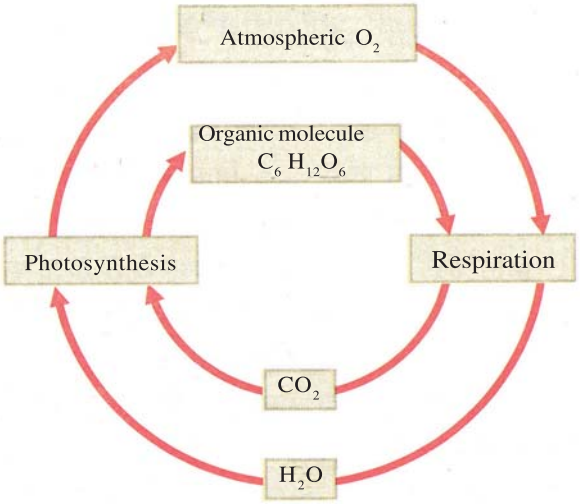
8.10 The Greenhouse Effect

An atmosphere envelops the earth. Sunlight passes through this atmosphere and reaches the surface of the Earth. Under the influence of this light, the atmosphere and surface of the Earth get



heated. The rays which get reflected from the surface of the earth have to pass through this atmosphere to get dissipated in the space. However, the CO_2 present in the atmosphere absorbs the long wavelength infrared rays and reflects them back towards the Earth. As a result, the Earth and its surrounding atmosphere remain warm. This effect is called greenhouse effect and the CO_2 gas which induces such an effect is called greenhouse gas. Moreover, other greenhouse gases are also added to the atmosphere. Amongst them main are methane, nitrous oxide, hydrofluorocarbon (HFC), chlorofluorocarbon (CFC) etc. An increase in the percentage of such gases in the atmosphere would cause the average temperature to increase worldwide leading to global warming.

8.11 Oxygen Cycle



Oxygen is a life supporting portion of the Earth's atmosphere. It constitutes 21 % of the atmospheric gases. It also occurs extensively in the combined form in the Earth's crust as well as in the air in the form of carbon dioxide. It is the basic constituent element of all organic substances like carbohydrates, lipids, proteins and nucleic acids.

Oxygen cycle is very complex. As a component of CO_2, it circulates freely throughout the biosphere. Oxygen combines with nitrogen compounds to form nitrates and with various metals form oxides. Oxygen from the atmosphere is used up in three processes, namely combustion, respiration and in the formation of oxides. Photosynthesis is the only process by which oxygen is returned to the atmosphere.

Though oxygen is essential for the process of respiration, it is interesting to note that some forms of life, especially bacteria, are poisoned by elemental oxygen.

8.12 Ozone Layer

Elemental oxygen is normally found in the form of a diatomic molecule. However, in the upper region of atmosphere a molecule containing three atoms of oxygen is found i.e. O_3. This is called ozone. Ozone layer of the atmosphere acts as a screen and absorbs harmful radiations, emitted from the sun, and prevents them from reaching to the surface of the Earth. The thickness of the ozone layer determines its capacity of absorbing harmful rays. i.e. UV radiations. The greater the thickness, the higher is its capacity. Ozone layer is thick at polar regions and it becomes thinner as one moves towards equatorial region. Recently it is reported that this ozone layer is getting depleted.

Various man-made compounds like chlorofluorcarbons (CFC) used in refrigerator and airconditioners, persist in the atmosphere. When these compounds reach to the ozone layer, they react with the ozone molecules, resulting in the depletion of ozone layer.

A severe decrease in the concentration of ozone in the ozone layer could lead to the following harmful effects :

(1) An increase in the Patients of skin cancer
(2) A large increase in cataracts and Sun burning.
(3) Suppression of immune systems in organisms.
(4) Adverse impact on crops and animals.
(5) Reduction in the growth of phytoplankton found in the Earth's oceans.

What have you learnt ?

- Earth's physical environment is made up of: the atmosphere, the hydrosphere, the lithosphere and the biosphere.
- The natural resources can be classified into two major types namely (1) inexhaustible natural resources and (2) exhaustible natural resources.
- The exhaustible natural resources are subdivided into two sub types : (1) renewable natural resources and (2) non-renewable natural resources.
- The air of normal atmosphere comprises of 78% nitrogen, 21 % oxygen, 0.03 % carbon dioxide, a small amount of carbon monoxide, helium, argon, hydrogen and other gases.
- The atmosphere plays an important role in temperature control. Moon is about at the same distance from the Sun as the Earth is. But as there is no atmosphere on the surface of moon, the temperature ranges from –190° C to –110° C .
- Air in motion is known as wind.
- Water plays a key role in a control of climatic conditions. The water in seas absorbs or releases heat and helps to maintain the atmospheric temperature by keeping it cool or warm.
- The outer most layer of the Earth crust is called soil. The Sun, water, wind and living organisms are responsible for the formation of soil.
- This cycling of nutrients from the environment to organisms and back to the environment is called biogeochemical cycle. Water cycle, nitrogen cycle, carbon cycle and oxygen cycle are included in biogeochemical cycles.
- CO_2 present in the atmosphere absorbs the long wavelength infrared rays and reflects them back towards the Earth . As a result, the earth and its surrounding atmosphere remain warm. This effect is called greenhouse effect and the CO_2 gas which induces such an effect is called greenhouse gas.
- Ozone layer of the atmosphere acts as a screen and absorbs harmful radiations, emitted from the sun, and prevents them from reaching the surface of the Earth.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) What is the chemical formula of ozone ?

(A) CO_2 (B) O_3 (C) O_2 (D) O_4

(2) Conversion of nitrites and nitrates into free nitrogen is known as :

(A) Nitrification (B) Ammonification

(C) Denitrification (D) Nitrogen fixation

(3) Solar radiations heat up :

(A) Land faster than the water resources

(B) Land slower than the water resources

(C) Equally both land and water resources

(D) Neither land nor water resources

(4) Greenhouse is related to :

(A) Terrace gardening (B) Global warming

(C) Kitchen gardening (D) Eutrophication

(5) Which of the following gases plays major role in global warming ?

(A) Carbon monoxide (B) Nitrous oxide

(C) Carbon dioxide (D) Sulphur dioxide

(6) In which sphere of the environment Ozone layer is located ?

(A) Troposphere (B) Stratosphere

(C) Mesosphere (D) Thermosphere

(7) The movement of air is caused due to difference in :

(A) Temperature (B) Rain fall

(C) Moisture (D) Wind

2. Answer the following questions in short :

(1) What is greenhouse effect ?

(2) What is the source of oxygen ?

(3) Mention essential mineral elements

(4) Name chemical substances responsible for depletion in ozone layer.

(5) Mention greenhouse gases.

(6) What is nitrification ?

(7) What is ammonification ?

(8) Name various spheres of environment.

(9) What is the importance of air ?

(10) Name bacteria present in root nodules of legumes.

3. Answer the following questions in detail :

(1) Why is water essential for life ?

(2) What is biogeochemical cycle ? Name any three biogeochemical cycles studied by you.

(3) Classify natural resources giving suitable examples.

(4) How wind is formed ?

(5) Explain oxygen cycle.

(6) Describe Greenhouse effect.

(7) Explain the role of the atmosphere in climate control.

(8) Write a note on rain.

(9) Explain what will be the harmful effects if thickness of ozone layer decreases.

9 Food Resources

9.1 Introduction

For their existence, all living organisms essentially require food. Food supply proteins, carbohydrates, lipids, vitamins and minerals which are essential for the growth and development of living organisms. It also protects the body and provide energy for doing all life functions. Among all the living organisms, only green plants can synthesize their food by the process of photosynthesis and hence, they are autotrophs. While other organisms are dependent on other animals and plants for their food and hence, they are heterotrophs.

Man also depends on plants and animals for food. In the beginning his activities were limited to hunting of animals and gathering of fruits of wild plants but later on (approximately 10,000 years ago) he started farming and rearing animals to meet his food requirement. India is a populous country. It is second in population in word with more than one billion people. According to an estimate the population would reach to 1.343 billion by the year 2020. For such large population we require 241 million tons of grain production per annum to feed our people. This can be done by farming on more lands. But India is already intensively cultivated. As a result, we do not have any major scope for increasing the area of land under cultivation. Therefore, it is necessary to increase production of both, crops and livestock. Earlier also to meet the demand of population our scientists put efforts to increase food production through green revolution and milk production through white revolution.

However, increasing the crop or grain production, which is stored in warehouses, cannot solve the problem of malnutrition and hunger. People should have money to purchase food. In our country majority people are dependent on agriculture for their livelihood. Therefore, increasing the production of crops and animals will help the poor Indian farmers to earn money to meet their day to day requirement for their better livelihood.

9.2 Improvement in Crop Yields

Since the plants are the major sources of food, it becomes necessary to increase the production of crops to meet the food requirements. Cereals like wheat, rice, maize, barley and sorghum provide us carbohydrates for energy requirement; pulses like gram, pea, black gram, green gram, pigeon pea and lentil are the sources of proteins; oil seeds like soyabean, groundnut, sesame, castor, mustard, linseed, niger and sunflower provide us oils and lipids. Vegetables, spices and fruits provide a range of vitamins and minerals in addition to small amount of proteins. In addition to these crops, the fodder crops such as berseem, oat, sudan grass etc., are raised for the livestock.

Different crops require different climatic conditions, temperature and photoperiod for their growth and completion of their life cycle. There are certain crops which grow in rainy season i.e. from June to August. Such type of crops are known as Kharif season crops. For example, paddy maize, arhar, soyabean, millet, cotton, urad, moong etc. While some crops grow in winter season i.e. from November to April. These types of crops are called Rabi season crops. For example, wheat, mustard, peas, linseed, sugarcane, gram etc.

In 1970s there was a huge increase in wheat production that heralded the Green Revolution in the country. This increase in food production has been achieved by following three scientific approaches :

(1) Crop variety improvement
(2) Crop production management/ improvement
(3) Crop protection management

9.2.1 Crop variety improvement : Crop production can be improved by breeding new varieties of crops having higher yield. The art of recognizing valuable strains and incorporating them into future generation is very important in plant breeding.

(1) Introduction of new species from other region
(2) Selection of more useful varieties
(3) Hybridization or cross breeding among various species
(4) Obtaining new plant varieties

Selection : There are many varieties of each crop. Out of several species of plants only the useful ones are selected and cultivated on a large scale. During selection characters such as high yield, rapid growth, reproduction rate, resistance to disease, drought resistance, resistance against temperature, nutritional value and production cost are considered.

Hybridization : This technique is used to improve genetic constitution of crop plants. The new varieties of plants with maximum desired characters can be obtained by cross breeding or hybridization between two or more species of plant with more desirable characters. The hybridization may be :

(1) Intervarietal hybridization : In this type of hybridization between two different varieties subspecies of some species are crossed. Most of the hybrid varieties of cereals have been evolved by this type of hybridization.The hybrid varieties thus evolved give good yield, are resistance to disease, are of better quality and have high nutritive value.

(2) Interspecific hybridization : This type of hybridization is performed between two species of same genus. Several disease, pest and drought resistance varieties of wheat, tomato and sugarcane have been evolved by this method.

(3) Intergeneric hybridization : In this type of hybridization a cross is made between two plants belonging to two different genera.

Some of the improved hybrid varieties of field crops are given in the following table :

Commodities	Crops	Varieties
Cereals	Rice Wheat Maize	Basmati, Kasturi, Sona, Sonalika, Kalyan Ganga-5 Shakti Navjot.
Pulses	Pea Mung	Pusa Ageti, Pusa-84, PS-16, Aasha
Oilseeds	Groundnut Soyabean Sunflower	G-2, GG-11, Pusa 24, Durga, Arun, Paras

Likewise, some varieties which are tolerant to salinity condition have been developed. Some of the factors for which variety improvement is done are :

(1) Higher yield : The main aim of crop improvement is to improve the productivity of the crop. Quality seeds of improved varieties are used for their commercial production.

(2) Improved quality : Quality considerations of crop products vary from crop to crop. Protein quality in pulses, oil quality in oil seeds and preserving quality in fruits and vegetables are important.

(3) Biotic and abiotic resistance : Under different situations crop suffers due to biotic stresses (such as diseases, insects and nematodes) and abiotic stresses (such as drought, salinity, waterlogging, heat, cold and frost). Varieties resistant to these stresses can improve crop production.

(4) Change in maturity duration : The shorter the duration of the crop from sowing to harvesting, the more economic is the variety. Such short durations allow farmers to grow multiple rounds of crops in a year. This will reduce the crop's cost of production. Uniform maturity will make the harvesting process easy and reduce loss of product during harvesting.

(5) Wider adaptability : Development of crop varieties which have wider adaptability will help in stabilizing the crop production under different environmental conditions.

(6) Desirable agronomic characteristics : Development of varieties of fodder crop which have desirable agronomic characteristics such as tallness, high tillering, and profuse branching will help in setting higher production. Similarly dwarfness is desirable in cereals as it consumes less nutrients.

9.2.2 Crop production management :

India has large area under cultivation and three fourth of the population is engaged in cultivation. In India farming ranges from small to very large farms and it is performed by three types of Indian farmers :

(1) Small farmers
(2) Marginal farmers
(3) Progressive farmers.

The above classification is based on the following criteria :

(1) Land holdings of the farmers
(2) Financial condition of the farmers
(3) Use of modern methods by farmers

Nutrient Management : Nutrients are the food of the plants. The food required by plants is provided by certain mineral elements, which are known as plant nutrients. Plants absorb a large number of elements from the soil. From them only 16 are found to be essential for the plant nutrition. Such elements must fulfill the following requirements to be an essential element.

(1) In the absence of the element plant is unable to complete the life cycle.
(2) The deficiency of a particular element can be prevented or corrected only by supplying that nutrient.
(3) Such element exhibits direct influence on the plant nutrition and metabolism.

Sources of essential plant nutrients :

The plants get nutrients from three different sources. These sources are air, water and soil. The nutrients available from these three sources to the plants are shown in the following table.

Air	Water	Soil
Carbon Oxygen	Hydrogen	Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Iron, Boron, Zinc, Copper, Molybdenum and Chlorine

Out of 13 nutrients obtained from the soil nitrogen, phosphorus, potassium, calcium magnesium and sulphur are required by plants relatively in large quantities, hence they are called major or macronutrients. The remaining 7 elements like iron, boron, manganese, zinc, copper, molybdenum, and chlorine used by plants in very small quantities are called minor or micronutrients. These micronutrients are also essential for growth and development of plants as the macronutrients.

Manure :

Manures are organic materials added to the soil to increase the production of crops. They are biological in origin. They contain large quantities of organic matter and also supply small quantities of nutrients to the soil. They have the following effects on the soil.

(1) They enrich the soil with nutrients and make it fertile. Since manure contains nutrients in small quantities, they are needed to be given in large quantities.

(2) The manures add organic matter to the soil which increase the water holding capacity, drainage in clayey soil and improve the texture of soil by making it soft.

(3) The organic manures provide food for soil bacteria, which help in making nutrients available to plants.

Types of manure : Based on the kind of biological material used , manure can be classified as :

(1) Farmyard manure : It is prepared by the decomposition of a mixure of cattle dung and urine along with small quantities of fodder and organic matter.

(2) Compost manure : It is prepared by decomposition of farm and town refuse such as vegetable, animal dung and urine, sewage wastes, weeds, crop stubble etc.

(3) Green Manure : Green manuring is a practice of growing and ploughing in the green crops into the soil. Green manure may include both leguminous and non-leguminous plants. Green manure is used for the purpose of improving physical structure as well as maintenance of soil fertility. It is equally good as farmyard manure.

Fertilizers : Fertilizers are manufactured artificially in the industrial units by the use of chemicals and are used for the commercial purpose. They contain much higher amount of nutrients , hence they are used in very small quantities. Fertilizers supply nitrogen, phosphorus and potassium and are used for good vegetative growth. Fertilizers are divided into four groups according to the availability of nutrients from them:

(1) Nitrogenous fertilizers : These fertilizers contain macronutrient nitrogen. Urea, ammonium nitrate, are the main examples.

(2) Phosphatic fertilizers : These fertilizers supply major nutrient phosphorus. Single superphosphate, triple superphosphate and dicalcium phosphate are the examples.

(3) Potassic fertilizers : Plants obtain the macronutrient potassium from this type of fertilizers. Muriate of potash and sulphate of potash are included as important potassic fertilizers.

(4) Complex fertilizers : When a fertilizer contains at least two or more nutrients is called as complex fertilizer. Nitrophosphate, ammonium phosphate and urea ammonium phosphate are the examples.

Irrigation : To increase food production the water resources of the country's rain is the major and important source of water.

The knowledge of soil texture, modern methods of agriculture and irrigation systems are necessary for the maximum and judicious use of water.

Irrigation system : Keeping in the mind the scarcity of water and varied climate of our country, several irrigation systems are adopted to supply required water to agriculture lands. These systems are as under :

(1) Canal system : This is an elaborate and extensive irrigation system. In this system canal receives water from small or large water reservoirs (dams). Main canal distributes water into several branch canals and each branch canal has distributaries or channels. Finally water is distributed in fields through these channels. This system forms a good arterial distribution system which can be more efficiently controlled by following the rotation system. Rotation system provides adequate irrigation to all the fields when the water supply is short.

(2) Wells : Wells are constructed wherever plenty of exploitable ground water is available. There are two types of wells : dug well and tube well. (bore well)

(i) Dug wells : The dug wells have their bottom below the ground water from the surrounding soil of the well, slowly accumulates in the pit.

(ii) Tube wells : Tube wells or bore wells can be constructed by setting down a porous pipe penetrating through the soil deeply and sunk into the water bearing stratum. Water is lifted from such wells through pumps run by diesel or electricity.

(3) River lift system : In areas where canal flow is insufficient or irregular due to inadequate reservoir release, the lift system is more rational. In this system water is directly drawn from the rivers for irrigation by diesel or electricity run pumps.

(4) Tanks : These are small storage reservoirs, which intercept and store the run-off of smaller catchment areas.

Modern irrigation methods include a method of fountain irrigation and a method of sprinkle irrigation or method of drip irrigation which consume less water. In fountain irrigation system water is supplied to crop like rain water creating high pressure fountain through pipe line. In drip irrigation system water is irrigated drop by drop directly at the root system of the crop through drippers set in small plastic tubes. By these systems about 40 % to 50% water can be saved.

Cropping Pattern

Various ways of growing crops can be used to have maximum benefit.

(1) Mixed cropping : The process of growing two or more crops together in the same piece of land is called mixed cropping. In India, the following combinations of the crops are used by farmers in mixed cropping :

(1) Wheat + Gram
(2) Maize + Urad bean
(3) Cotton + Moong bean
(4) Groundnut + Sunflower
(5) Wheat + Mustard
(6) Sorghum + Pigeon pea

The basic objective of mixed cropping is to minimize the risk of crop failure due to abnormal weather conditions. In mixed cropping seeds of different crops are mixed together and then sown either in lines or they are dispersed widely. Mixed cropping helps in avoiding risk of crop failure, harvesting variety of product, increasing yield and maintaining the fertility of soil.

(2) Intercropping : Intercropping is a practice of growing two or more crops simultaneously in a same field in definite row patterns with the objective of increasing productivity per unit area. In this technique after one row of major crop, one, two or three rows of intercrops can be grown.

Advantages of intercropping :

(i) It makes better use of natural resources, sunlight, land and water
(ii) Soil erosion is effectively arrested.
(iii) Since the seeds of the two crops are not mixed before sowing, fertilization can be placed as per the need of the crops.
(iv) The produce of each crop can be marketed and consumed separately.

(3) Crop rotation : Growing one type of crop continuously in the same piece of land for years together results in depletion of land's fertility due to nutrient deficiencies and increase in disease in crops. Therefore, the rotation of crops is absolutely essential.

Crop rotation is a process of growing different crops in succession on a piece of land in a specific period of time, with an object to get maximum profit from least investment without impairing the fertility of soil. The sequence of crop rotation may be seasonal or yearwise. For example :

Type of crop in rotation	Component crops involved in rotation
1. One year rotation	1. Maize – Mustard 2. Rice – Wheat
2. Two year rotation	1. Maize – Mustard – Sugarcane – Fenugreek (Methi) 2. Maize – Potato – Sugarcane – Peas
3. Three year rotation	1. Rice – Wheat – Moong – Mustard – Sugarcane 2. Cotton – Oat – Sugarcane – Peas – Maize – Wheat

The availability of moisture and irrigation facilities decide the choice of crop to be cultivated after one harvest. If crop rotation is done properly then more than two crops can be grown in a year with good harvest.

9.2. 3. Crop Protection Management : Crops are infested by various pests like insects, weeds and diseases. If pests and weeds are not controlled at proper time, they can destruct the crops so much that most of the crop is lost.

Weed control : Weeds are unwanted plants in cultivated fields. Weeds tend to compete with the crops for food, space and light. In comparison of cultivated crops, the seeds of weeds germinate easily and their seeds grow faster. In fact weeds take up all the nutrients and reduce the growth of crop in various ways. Therefore, removal of weeds from cultivated field in early stage of crop is essential for a good harvest. Weed control method also includes proper seed bed preparation and timely sowing of crops.

Insect-pest control : Insect – pests damage the plants in three ways :

(1) they scrape root, stem and leaf
(2) they suck the cell sap from the organs and
(3) they bore into stem and fruits.

Root scrapping insects (pests) are controlled by mixing insecticide into the soil. A chloropyriphos pesticide is used for this purpose. Stem and leaf eating insects are controlled by insecticides, malathion. All sap sucking insects can be controlled by spraying insecticide such as dimethoate and metasystox.

Disease control : Various pathogens are found in the environment, but they infest the plants in favourable conditions. These pathogens are transmitted by three ways in the crops : (1) seeds and soil (2) water and (3) air.

Diseases of crop include Blast, Rust, Smut, Stem rot, Wilt, White rust etc. Air borne diseases damage all aerial parts of plants such as leaves, flowers and fruits. The seed and soil borne diseases can be controlled by applying coating layer of fungicides on seeds and dusting the drug in soil. Air borne diseases are controlled by spraying fungicide solution on infested parts.

9.3 Storage of Grains (Food Storage)

Besides crop production good crop management involves storage of grains before distribution. The grains are stored mainly for purpose :

(1) To make use of agricultural products as sowing grains for next year.
(2) To make the food stuff regularly available throughout the year.
(3) To maintain the price rate of agriculture product.

During storage grains and seeds are subjected to spoilage by various agencies like :

Biotic : Insects, rodents, birds, fungi, mites and bacteria

Abiotic : Moisture and temperature.

9.4 Animal Husbandry

The branch of agriculture that deals with the feeding, caring and breeding of domestic animals is called animal husbandry. Animal based farming includes cattle, goat, sheep, poultry and fish farming. With the increasing human population in our order to meet these demands, it has become essential to improve the livestock production.

(1) Cattle farming : Cattle farming is done for two purposes : (1) for milk and (2) for drought labour for agricultural work such as tilling, irrigation and carting. Indian cattles belong to two different species viz. Bos indicus (cow) and Bubalus bubalis (buffalo).

Cows are good for providing milk as food. The number of well recognized cow breeds in our country is thirty. They are classified in three categories :

Drought breeds : Animals of these breed are strong and stout. They are used for drawing bullock carts, tilling the soil and transportation and are commonly called the beasts of burden.

Dairy breeds : Cows of these breeds give more milk but their bullocks are weak which are not useful as beasts of burden.

Dual purpose breeds : Cows of these breeds give fairly good amount of milk and bullocks are good for draught work.

Buffalo and cow are excellent dairy animals. There are three varieties of Indian breeds dairy cows; (i) Red Sindhi cow (ii) Shahiwal cow and (iii) Gir cow.

Breeds of buffaloes : There are 10 breeds of buffaloes in our country. The following are the three important breeds that yield more milk :

(i) Murrah : Murrah is a very good milker which is the original native of Haryana and Punjab. The average yield of milk is 1800 to 2000 litres, during its lactation period.

(ii) Mehsana : This buffalo is native of Mehsana and Vadodara districts of Gujarat. It gives 1200 to 2500 litres milk during lactation period.

(iii) Surti : This breed is a native of Kheda and Vadodara districts of Gujarat. The average yield of milk ranges from 1600 to 1800 litres.

The food requirement of dairy animals are of two types :

(i) Maintenance requirement : The required food is provided to fulfil the physiological activities and for healthy life.

(ii) Milk producing requirement : The food necessary for the production of milk is supplied to milch animal during its lactation period. The feed of cattle includes (i) roughage and (ii) concentrates. The roughage consists mainly of natural green plants, fodder and pulse. Cereal plants like millet, maize, pearl millet, oat etc. and protein rich plants such as lucerne, green gram, vigna etc. are included in roughage. Concentrates have low fibre contents and content relatively high proteins and other nutrients. The amount of feed given to an animal during twenty four hours period is called Ration. A milch cow consumes 15 to 20 kg. Green and dry fodder, 4 to 5 kg. Grain mixture and 30 to 40 litres of water per day.

The disease causing parasites may be ectoparasites or endoparasites. The ectoparasites mainly adhere on skin and cause skin diseases. Ticks and mites are ectoparasites. Cattle should be cleaned regularly by rubbing their bodies with brush in order to keep the exoparasites of cattle. The mouth of cattle should be cleaned occasionally by massaging with salt. Worms and flukes are the endoparasites. Worms damage the stomach and intestine while flukes damage the liver of cattle.

The communicable (infectious) diseases in cattle are caused by bacteria, viruses and fungi. By following proper preventive and sanitary measures, the spread of the several infectious diseases can be controlled. The effective vaccines and antisera for all viral and bacterial diseases are developed at various centers in our country and are easily available. There are some diseases of cattle that can be transmitted to human beings. For example – Rabies, Cow pox, Anthrax, Ringworm, Ascariasis etc.

(2) Poultry farming : Poultry farming is undertaken to raise domestic fowl for egg production and meat. The poultry farming has made rapid strides in many parts of our country and has made immense contribution to increase the production of eggs.

Along with many breeds of fowls, ducks, quails and other birds are also included in poultry farming. There are three indigenous breeds of fowls in our country. Among them Aseel is well known and most famous breed, which is also known as Indian game. This breed has three varieties :

(1) Peela-golden red coloured
(2) Yakub (yakhub) black and red coloured
(3) Kajal-black coloured.

Exotic breeds of birds widely used in our country at present are :

(i) White leg horn
(ii) Rhode Island Red

Fowls suffer from diseases caused by bacteria, viruses, fungi, parasites and nutritional deficiencies in their feed. It is necessary that poultry keepers should always be careful against diseases. They should maintain proper cleaning and sanitation of poultry house regularly. The mortality can be controlled by providing protection against infectious diseases through appropriate vaccination during an outbreak of diseases.

Fish Production :

Fish is a valuable and important resource of food, rich in proteins. Fish production included the finned true fishes like mullets, bhetki and pearl spots as well as shell fishes such as prawns and mollusks. There are two ways of obtaining fish. One is from natural resources, which is called capture fishing and other is by fish farming, called culture fishing.

Fishes are aquatic and hence they can be cultured in water. The water source of the fish can be either seawater or fresh water.

(1) Marine fisheries Production : India has a vast scope of marine fishery. Our marine fishery resources include 7500 km coast line and extensive deep sea. The most preferred Indian sea fishes or table fishes are : Pomphrets, Tuna, Bombay duck. Eel, etc. Fishes like Bombay duck and Pomphret are available in large quantity on the seacoast of Saurashtra and Kutch of Gujarat.

Pomphret

Hilsa

(2) Inland Fisheries Production : It deals with fresh water and brackish water fisheries. Rivers, canals, and reservoirs are the fresh water resources while estuaries and lagoons are the brackish water resources. Inland fisheries is well developed for table fish production common and most advantageous culture system is composite fish culture or polyculture of fishes. In this system both local and imported fish species are used. A combination of several fish species is used in a single fishpond. Those fish species which are having different food habits are selected, so all the available food in the pond is effectively utilized. As Catlas are surface feeders, Rohus feed in the middle zone of the pond, Mrigals and Common Carps are bottom feeders and Grass Carps feed on the weeds, together these species use all the food in the pond without competing with each other. This increases the fish yield from the pond. Following factors have to be taken into consideration in fish culture :

(i) Topography or location of pond (ii) Water resources and quality (iii) Soil quality and water temperature.

Bee – Keeping : The practice of bee keeping is called apiculture. It is done to get honey and bee's wax. Since bee-keeping needs low investments, farmers use it as an additional income generative activity. Honey is known to have medicinal value. It is supposed to be blood purifier, a cure against cough and cold, ulcers of the tongue, ulcer of stomach and intestine etc. Honey is rich in iron and calcium and hence, it helps in growth of human body.

Under bee-keeping, honey bee colonies are maintained, commonly in hives, by humans. A bee keeper keeps bees in order to collect honey and bee wax, to pollinate crops, or to produce bees for sale to other beekeepers. A location where bees are kept is called an Apiary.

There are three species of honey bees found.

(1) Apis cerana indica F. (Indian bee)

(2) Apis dorsata F. (Rock bee)

(3) Apis florae F. (Little bee)

An Italian bee variety, *Apis mellifera* has also been brought in to increase yield of honey.

What have you learnt ?

- Increase in food production can be achieved by following three scientific approaches : (1) Crop variety improvement (2) Crop production management/improvement and (3) Crop protection managment.
- Plant breeding technique includes introduction to new species, selection and hybridization like steps.
- Variety improvement is done in order to get higher yield, improved quality, biotic and abiotic resistance, change in maturity duration, wider adaptability and desirable agronomic characteristics.
- The plants get nutrients from three different sources. These sources are air, water and soil.
- On the basis of the requirement of nutrients by the plants, nutrients are classified into macronutrients and micronutrients.
- Manures are organic materials added to the soil to increase the production of crops. They are classified as (1) farmyard manure (2) compost manure and (3) green manure.
- Fertilizers are manufactured artificially in the industrial units by the use of chemicals and are used for the commercial purpose. On the basis of their chemical composition,they are of different types : Nitrogenous fertilizers, Phosphatic fertilizers, Potassic fertilizers and Complex fertilizers.
- Keeping in the mind the scarcity of water and varied climate of our country, several irrigation systems are adopted to supply required water to agriculture lands. These systems are : Canal system, wells, river lift system and tanks.
- Cropping patterns are of following types : Mixed cropping, Intercropping and Croprotation.
- Crops are infested by various pests like insects, weeds and diseases. If pests and weeds are not controlled at proper time, they can destruct the crops so much that most of the crops will be lost.
- Cattle farming is done for two purposes : (1) for milk and (2) for draught labour for agricultural work such as tilling, irrigation and carting. Cows are good for providing milk as food.
- All the breeds of cow are classified into three categories : (1) Draught breeds (2) dairy breeds and (3) dual purpose breeds.

- Poultry farming is undertaken to raise domestic fowl for egg production and chicken meat.
- Fish culture in marine water is called Marine fisheries and in fresh water is called inland fisheries.
- The practice of bee-keeping is called apiculture. It is done to get honey and bee's wax.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Nutrients can be provided to the crops by :

(A) Fertilizers (B) Manures

(C) Both (A) and (B) (D) None of these

(2) The unwanted plants are known as :

(A) Shrubs (B) Weeds

(C) Herbs (D) Grasses

(3) Which of the following is not a macronutrient ?

(A) Potassium (B) Phosphorus

(C) Zinc (D) Calcium

(4) By which system each field is supplied water by rotation ?

(A) River lift system (B) Wells

(C) Canal system (D) Tanks

(5) How many essential elements are obtained by plants from soil ?

(A) 12 (B) 13

(C) 14 (D) 15

(6) What is the source of hydrogen for plants ?

(A) Air (B) Water

(C) Soil (D) Pollutants

(7) Ticks and mites are the examples of

(A) Ectoparasites (B) Endoparasites

(C) Symbiosis (D) Epiphytes

(8) Which of the following breeds of buffalo gives 1200 to 2500 litres milk during lactation period :

(A) Murrah (B) Mehsana

(C) Surti (D) Bhavangari

(9) An Italian bee variety commonly used for commercial honey production is :

(A) Apis cerana indica (B) Apis darsana

(C) Apis florae (D) Apis mellifera

(10) The table fish which is available in large quantity in the coastal area of Saurashtra is

(A) Hilsa (B) Eel

(C) Pomphret (D) Sardine

2. Answer the following questions in short :

(1) What do we get from cereals, pulses and vegetables ?

(2) Give examples of Kharif season crops.

(3) Give examples of Rabi season crops.

(4) What characters should be considered for selection of a plant variety for crop improvement ?

(5) Name some improved hybrid varieties of Rice.

(6) Define manure.

(7) Define micro and macronutrients.

(8) Give examples of phosphatic fertilizers.

(9) Give examples of complex fertilizers.

(10) What is mixed cropping ?

(11) Mention any two advantages of intercropping.

(12) How the insect-pest damage the plants ?

(13) What is an Apiary ?

(14) What are two basic targets of poultry farming ?

3. Answer the following questions in detail :

(1) Explain the types of hybridization

(2) Mention the sources of various plant nutrients.

(3) What are the effects of manure on the soil ?

(4) Write a note on Farmyard manure.

(5) Explain green manure.

(6) What are the purposes behind storage of grains ?

(7) Name two nitrogenous fertilizers.

(8) What is mixed cropping ? State any two advantages of mixed cropping.

(9) Why crop rotation is essential ?

(10) How weeds affect the growth of crop plants ?

(11) Explain the selection and hybridization steps of plants breeding technique.

(12) What is fertilizer ? Explain various types of fertilizers with examples.

(13) Describe various irrigation systems adopted to supply water to agricultural land.

(14) Explain marine and inland fisheries.