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PART – 1

DIGEST

STANDARD X

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PART 1

DIGEST

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9. Scientifically correct and labelled diagrams, wherever necessary.
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★ ★ ★ **Important Feature :**
In this 'Digest', Chapterwise Tests have been given. For these Tests and their model answers, scan the **QR Code** given at the end of each chapter.

By
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Chapterwise weightage

No.	Name of the lesson/Chapter	Marks	Marks with options
1	Gravitation	03	05
2	Periodic Classification of Elements	04	06
3	Chemical reactions and equations	04	06
4	Effects of electric current	05	07
5	Heat	03	05
6	Refraction of light	05	07
7	Lenses	04	06
8	Metallurgy	04	06
9	Carbon compounds	05	07
10	Space Missions	03	05
	Total marks	**40**	**60**

Science and Technology Part-1 : Question Paper Pattern

Time : 2 hours **Total Marks : 40**

Instruction :

(i) *All questions are compulsory.*
(ii) *Use of a calculator is not allowed.*
(iii) *The numbers to the right of the questions indicate full marks.*
(iv) *In case of MCQs (Q. No. 1(A)) only the first attempt will be evaluated and will be given credit.*
(v) *For each MCQ, the correct alternative (A), (B), (C), (D) with subquestion number is to be written as an answer.*
For Eg. : (i) (A), (ii) (B), (iii) (C)
(vi) *Scientifically correct, labelled diagrams should be drawn wherever necessary.*

	Marks	**Marks with option**
Q. 1 (A) 5 **Multiple choice q**uestions of 1 mark each (Textbook based questions) (**Note :** There will be no internal option for this question. You are expected to write only the correct alphabet for the appropriate alternative.)	5	5
Q. 1 (B) 5 Questions of 1 mark each (No fill in the blanks questions) (**Note :** All questions will be of different types.) **Different types of questions :** (1) Find the odd man out : To identify odd component/picture from the given ones. (2) Correlations : By observing the correlation in the first pair, complete the second pair. (3) Match the columns/pairs. (4) Write true or false. (5) Write the name/molecular formula : This question may also include a picture/ figure to be named. (6) Flow chart with a blank to be filled. This question will also not have any internal option. • Any other type of question may be asked.	5	5
Q. 2 (A) 3 Scientific reason questions of 2 marks each (Attempt any 2) (Minimum 1 question from chemistry and 1 from physics)	4	6
Q. 2 (B) 5 Questions of 2 marks each (Attempt any 3) (Minimum 2 question from chemistry and 2 from physics) **Different types of questions :** (1) Solve the numerical problem. (2) Write laws/definitions/principles and explain with examples.	6	10

	(3) Write a short note : Write a note on the concept understood from a given figure/ picture. (4) Write chemical reactions. (5) Complete the flow chart. (6) Distinguish between / Give difference between : 4 points of differences to be written. (7) Write properties/characteristics/uses/advantages/effects : A minimum of 4 statements to be written. (8) Give examples. • Any other type of question may be asked.		
Q. 3	8 Questions of 3 marks each (Attempt any 5) (4 questions from chemistry and 4 from physics) **Different types of questions :** (1) Give explanation using the given statements. (2) Suggest remedies/measures (3) Explanation of diagrams. (4) Complete the table/chart. (5) Explain with the help of examples. (6) Solve the numerical problem. (7) Complete the diagram. (8) Answer questions based on figures. (9) Write answers with explanations. (10) Write laws, theories and explain. (11) Complete the paragraph. • Any other type of question may be asked.	**15**	**24**
Q. 4	2 Questions of 5 marks (Attempt any 1) (1 question from chemistry and 1 from physics) **Different types of questions :** (1) Draw a figure and give explanation (2) To correct the incorrect diagram (3) Classify with detailed explanation (4) Read the given paragraph and answer the questions (5) Complete the given incomplete table/chart and give explanation (6) Answer the questions in detail (7) Draw a concept diagram based on the given item and explain • Any other type of question may be asked.	**5**	**10**
	Total	**40**	**60**

CONTENTS

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1 GRAVITATION

CHAPTER OUTLINE

IMPORTANT POINTS

1.1 Gravitation :

• Can you recall? (Textbook page 1)

(1) What are the effects of a force acting on an object?

(**Note** : a body = an object)

Ans. (i) A force can set a body in motion. For example, if a ball at rest on the floor is pushed, it rolls on the floor. (ii) A force can stop a moving body. For example, a moving bicycle can be brought to rest by application of brakes. (iii) A force acting on a body can change the speed of the body. For example, when brakes are applied to a moving bicycle, its speed decreases due to the friction between the brake shoes and the rim of the tyre. (iv) A force can change the direction of motion of the body. For example, in uniform circular motion of a body, the direction of motion of the body keeps on changing due to the applied force. (v) A force can change the speed as well as the direction of motion of the body. For example, when a ball bowled by a bowler is hit by a batsman, there occurs a change in the speed as well as the direction of motion of the ball. (vi) A force can change the shape and size of the body on which it acts. For example, when a rubber ball is pressed, it gets deformed and hence no longer remains spherical. Also, there can be a decrease in its volume.

(2) What types of forces are you familiar with?

Ans. The gravitational force between the earth and the moon, the electromagnetic force between two charged particles in motion, the nuclear force between a proton and a neutron in the nucleus of an atom.

(3) What do you know about the gravitational force?

Ans. The gravitational force is a universal force, i.e., it acts between any two objects in the universe.

• Can you recall? (Textbook page 1)

Q. What are Newton's laws of motion?

Ans. (1) Newton's first law of motion : An object continues to remain at rest or in a state of uniform motion along a straight line unless an external unbalanced force acts on it.

(2) Newton's second law of motion : The rate of change of momentum is proportional to the applied force and the change of momentum occurs in the direction of the force.

(3) Newton's third law of motion : Every action force has an equal (in magnitude) and opposite (in direction) reaction force which acts simultaneously.

1.2 Circular motion and centripetal force :

• Try this (Textbook page 2)

Tie a stone to one end of a string. Take the other end in your hand and rotate the string so that the stone moves along a circle as shown in figure 1.1 (a). Are you applying any force on the stone? In which direction is this force acting? How will you stop this force from acting? What will be the effect on the stone?

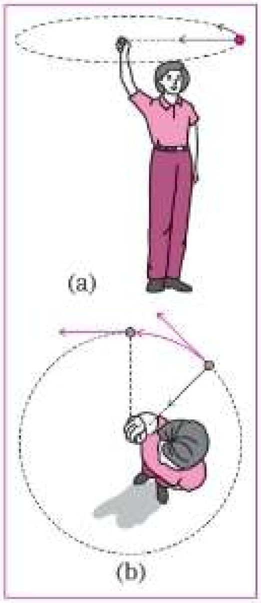


Fig. 1.1 : A stone tied to a string, moving along a circular path and its velocity in tangential direction

Ans. As long as we are holding the string, we are pulling the stone towards us, i.e., towards the centre of the circle and are applying a force towards it. The force stops acting if we release the string. In this case, the stone will fly off along a straight line which is the tangent to the circle at the position of the stone when the string is released, because that is the direction of its velocity at that instant of time [Figure 1.1 (b)]. Thus, a force acts on any object moving along a circle and it is directed towards the centre of the circle. This is called the **centripetal force.** 'Centripetal' means centre seeking, i.e., the object tries to go towards the centre of the circle because of this force.

1.3 Kepler's laws :

• Do you know? (Textbook page 3)

An ellipse is the curve obtained when a cone is cut by an inclined plane. It has two focal points. The sum of the distances to the two focal points from every point on the curve is constant. F_1 and F_2 are two focal points of the ellipse shown in figure 1.2. If A, B and C are three points on the ellipse then, $AF_1 + AF_2 = BF_1 + BF_2 = CF_1 + CF_2$.

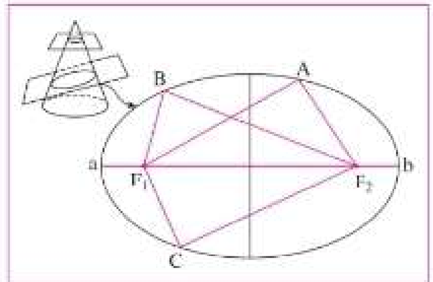


Fig. 1.2 : An ellipse

Kepler's laws of planetary motion : (1) The orbit of a planet is an ellipse with the Sun at one of the foci. (2) The line joining the planet and the Sun sweeps equal areas in equal intervals of time. (3) The square of the period of revolution of a planet around the Sun is directly proportional to the cube of the mean distance of the planet from the Sun.

[Note : Strictly speaking, (period of revolution)$^2 \propto \left(\frac{ab}{2}\right)^3$. (Fig. 1.2)]

1.4 Newton's universal law of gravitation :

Every object in the Universe attracts every other object with a definite force. This force is directly proportional to the product of the masses of the two objects and inversely proportional to the square of the distance between them.

The earth's gravitational force :

The gravitational force on any object due to the earth is always directed towards the centre of the earth. If the object is on the earth's surface, in the usual notation,

$$F = \frac{Gm_1m_2}{r^2} \ .$$

The value of G was first experimentally measured by Henry Cavendish. In SI units its value is 6.673×10^{-11} N·m^2 kg^{-2}.

1.5 Acceleration due to the gravitational force of the earth :

The acceleration produced in a body due to the earth's gravitational force is called the acceleration due to gravity or the earth's gravitational acceleration and its magnitude is denoted by g. It is directed towards the earth's centre.

$g = \frac{GM}{r^2}$ for $r \geqslant R$ (radius of the earth).

It depends on the location of the body.

Change in the value of g with height above the earth's surface (Textbook page 9)

Place	Height (km)	g (m/s^2)
Surface of the earth (average)	0	9.81
Mount Everest	8.8	9.8
Maximum height reached by a man-made balloon	36.6	9.77
Height of a typical weather satellite	400	8.7
Height of a communication satellite	35700	0.225

Mass : The mass of an object is the amount of matter present in it. Its SI unit is kg.

Weight : The weight of an object is defined as the force with which the earth attracts the object. Its magnitude is mg and SI unit is the newton (N).

(Textbook page 9)

Colloquially we use weight for both mass and weight and measure the weight in kilogram which is the unit of mass. But in scientific language when we say that Rajeev's weight is 75 kg, we are talking about Rajeev's mass. What we mean is that Rajeev's weight is equal to the gravitational force on 75 kg mass. As Rajeev's mass is 75 kg, his weight on the earth is $F = mg = 75 \times 9.8 = 735$ N. The weight of 1 kg mass is $1 \times 9.8 = 9.8$ N. Our weighing machines tell us the mass. The two-pan scale balance in a shop compares two weights, i.e., two masses.

• Try this (Textbook page 11)

Q. Take a small stone. Hold it in your hand. What are the forces acting on the stone? Now release the stone. What do you observe? What are the forces acting on the stone after you release it?

Ans. (1) The force exerted by the person holding the stone, the force exerted by air and the earth's gravitational force.

(2) The stone falls to the ground.

(3) The forces exerted by air and the earth's gravitational force.

• Use your brain power! (Textbook page 5)

Q. Is there a gravitational force between two objects kept on a table or between you and your friend sitting next to you? If yes, why don't the two move towards each other?

Ans. Yes. Two objects kept on a table do not move towards each other because there is a force of friction between each object and the table. Similarly, because there is a force of friction between our body and the floor, we (myself and my friend) do not move towards each other.

• Do you know? (Textbook page 6)

High and low tides occur regularly in the sea. The level of sea water at any given location along sea shore increases and decreases twice a day at regular intervals. High and low tides occur at different times at different places. The level of water in the sea changes because of the gravitational force exerted by the moon. Water directly under the moon gets pulled towards the moon and the level of water there goes up causing high tide at that place. At two places on the earth at 90° from the place of high tide, the level of water is minimum and low tides occur there as shown in figure 1.3.

Fig. 1.3 : Low and high tides

1.6 Free fall :

Whenever an object moves under the influence of gravity alone, it is said to be falling freely.

For a freely falling object, with $u = 0$ and $a = g$, we have $v = gt$, $s = \frac{1}{2}gt^2$ and $v^2 = 2gs$ (in the usual notation).

For an object thrown upward, as the object moves upward, the direction of acceleration is opposite to that of the velocity. Hence, the acceleration is negative, with $a = -g$.

• Do you know? (Textbook page 11)

The value of g is the same for all objects at a given place on the earth. Thus, any two objects, irrespective of their masses or any other properties, when dropped from the same height and falling freely will reach the earth at the same time. Galileo is said to have performed an experiment around 1590 in the Italian city of Pisa. He dropped two spheres of different masses from the leaning tower of Pisa to demonstrate that both spheres reached the ground at the same time.

When we drop a feather and a heavy stone at the same time from a height, they do not reach the earth at the same time. The feather experiences a buoyant force and a frictional force due to air and therefore floats and reaches the ground slowly, later than the heavy stone. The buoyant and frictional forces on the stone are much less than the weight of the stone and do not affect the speed of the stone much. Recently, scientists performed this experiment in vacuum and showed that the feather and stone indeed reach the earth at the same time.

https : //www.youtube.com/ watch?v = eRNC5kcvINA

1.7 Escape velocity : $v_{esc} = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$.

For $u = v_{esc}$ (from the earth's surface), the body overcomes the earth's gravitational attraction. It will then move to infinity and come to rest there. The gravitational potential energy of an object at a height h from the earth's surface $= -\frac{GMm}{R+h} = -\frac{mgR^2}{R+h}$.

The total energy of a body revolving around the earth = kinetic energy + potential energy $= \frac{1}{2}mv^2 + \left(-\frac{GMm}{R+h}\right)$.

Uniform circular motion of a planet around the Sun :

(1) Centripetal force acting on the planet, $\frac{mv^2}{r}$ = gravitational force exerted by the Sun on the planet, $\frac{GMm}{r^2}$.

(2) Centripetal acceleration of the planet,
$$a = \frac{v^2}{r} = \frac{(2\pi r/T)^2}{r} = \frac{4\pi^2 r}{T^2}.$$

(3) The period of revolution of the planet,
$$T = \frac{2\pi r}{v} = \frac{2\pi}{\sqrt{GM}}\, r^{3/2} = \frac{2\pi}{\sqrt{gR^2}}\, r^{3/2}.$$

Escape velocity (additional information)

(1) The formula for escape velocity given in the textbook, does not take into account the effect of atmosphere. In practice, the body becomes very hot due to friction with air and may even burn.

(2) Even when a body is projected obliquely from the earth's surface, with $u = v_{esc}$, it will overcome the earth's gravitational influence and move to infinity.

• **Do you know? (Textbook page 14)**

• **Weightlessness in space :**

Space travellers as well as objects in the spacecraft appear to be floating. Though the spacecraft is at a height from the surface of the earth, the value of g there is not zero. In the space station the value of g is only 11 % less than its value on the surface of the earth. Thus, the height of a spacecraft is not the reason for their weightlessness. Their weightlessness is caused by their being in the state of free fall. Though the spacecraft is not falling on the earth because of its velocity along the orbit, the only force acting on it is the gravitational force of the earth and therefore it is in a free fall. As the velocity of free fall does not depend on the properties of an object, the velocity of free fall is the same for the spacecraft, the travellers and the objects in the craft. Thus, if a traveller releases an object from her hand, it will remain stationary with respect to her and will appear to be floating.

• **Do you know? (Textbook page 10)**

• **Gravitational waves :**

Waves are created on the surface of water when we drop a stone into it. Similarly you must have seen the waves generated on a string when its both ends are held in hand and it is shaken. Light is also a wave called the electromagnetic wave. Gamma rays, X-rays, ultraviolet rays, infrared rays, microwave and radio waves are all electromagnetic waves with different frequencies. Astronomical objects emit these waves and we receive them using our instruments. All our knowledge about the universe has been obtained through these waves.

Gravitational waves are a very different type of waves. They have been called the waves on the fabric of space-time. Einstein predicted their existence in 1916. These waves are very weak and it is very difficult to detect them. Scientists have constructed extremely sensitive instruments to detect the gravitational waves emitted by astronomical sources. Among these, LIGO (**L**aser **I**nterferometric **G**ravitational wave **O**bservatory) is the prominent one. Exactly after hundred years of their prediction, scientists detected these waves coming from an astronomical source. Indian scientists have contributed significantly in this discovery. This discovery has opened a new path to obtain information about the Universe.

QUESTIONS & ANSWERS

Q. 1 Fill in the blanks with appropriate words and write the completed sentences :

Note : This type of question is not included in the latest Board question paper pattern. But this type is very important in study of the subject. Hence, it is included in the Digest.

(1) The ratio $g_{(earth)}/g_{(moon)}$ is equal to ....

(2) The value of the acceleration due to gravity ...... as we move from the equator to a pole.

(3) If the earth shrinks to half of its radius, its mass remaining the same, the weight of an object on the earth will become ...... times.

(4) The SI unit of weight is the ....

(5) The CGS unit of weight is the ....

(6) The weight of a body is ...... at the poles.

(7) Outside the earth, the weight of a body varies as ....

(8) Due to the ...... force, the earth attracts all objects towards it.

[**Note :** (1) The questions marked with an asterisk (*) are textual questions. (2) HOTS (Higher Order Thinking Skill Questions)

(9) The acceleration due to gravity does not depend on the ...... of the body.

(10) According to Kepler's first law, the orbit of a planet is ...... with the Sun at one of the ....

(11) According to Kepler's second law, the line joining the planet and the Sun ...... in equal intervals of time.

(12) According to Kepler's third law $T^2 \propto r^n$, where $n =$ ....

(13) For a freely falling object we can write Newton's second equation of motion as ....

Ans.

(1) The ratio $g_{(\text{earth})}/g_{(\text{moon})}$ is equal to 6 (approximately).

(2) The value of the acceleration due to gravity increases as we move from the equator to a pole.

(3) If the earth shrinks to half of its radius, its mass remaining the same, the weight of an object on the earth will become four times.

[**Explanation :**

$$W = mg = \frac{GMm}{R^2}$$

$$\therefore W_1 = \frac{GMm}{R_1^2} \text{ and } W_2 = \frac{GMm}{R_2^2}$$

$$\therefore \frac{W_2}{W_1} = \left(\frac{R_1}{R_2}\right)^2 = \left(\frac{R_1}{R_1/2}\right)^2 = 2^2 = 4$$

$\therefore W_2 = 4W_1$.]

(4) The SI unit of weight is the newton.

(5) The CGS unit of weight is the dyne.

(6) The weight of a body is maximum at the poles.

(7) Outside the earth, the weight of a body varies as $1/(R+h)^2$.

(8) Due to the gravitational force, the earth attracts all objects towards it.

(9) The acceleration due to gravity does not depend on the mass of the body.

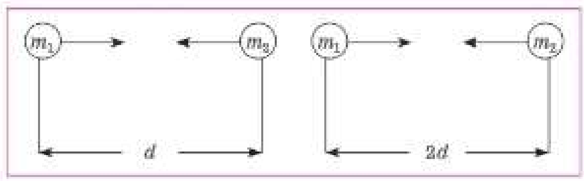
(10) According to Kepler's first law, the orbit of a planet is an ellipse, with the Sun at one of the foci.

(11) According to Kepler's second law, the line joining the planet and the Sun sweeps equal areas in equal intervals of time.

(12) According to Kepler's third law $T^2 \propto r^n$, where $n = 3$.

(13) For a freely falling object we can write Newton's second equation of motion as $s = \frac{1}{2}gt^2$

Q. 2 (A) Write the proper answer in the square.



(i) (ii)

Fig. 1.4 (A)

If this $F = x$ [Fig. 1.4 (A)(i)],

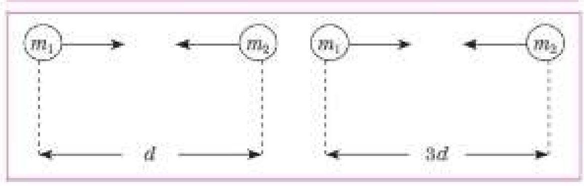
then [Fig. 1.4 (A)(ii)] $F = \boxed{}$

Ans. $F = \boxed{\frac{x}{4}}$

[**Explanation :** $F = G\frac{m_1m_2}{r^2}$ $\therefore F_1 = G\frac{m_1m_2}{d^2}$ and

$F_2 = G\frac{m_1m_2}{(2d)^2} = \frac{1}{4}G\frac{m_1m_2}{d^2} = \frac{1}{4}F_1 = \frac{x}{4}$.]

Q. 2 (B) Write the proper answer in the square. ***(March '19)***



(i) (ii)

Fig. 1.4 (B)

If $F = \frac{G\,m_1m_2}{d^2}$ [Fig. 1.4 (B)(i)],

then [Fig. 1.4 (B)(ii)] $F = \boxed{}$

Ans. $F = \frac{G\,m_1m_2}{9d^2}$.

Q. 3 Choose the correct alternative and write it along with its allotted alphabet : ***(1 mark each)***

Note : In the Board examination, only the alphabet corresponding to the answer to every MCQ should be written. E.g. : (1) (d), 2(c).

(1) The gravitational force between two particles separated by a distance r varies as ....

(a) $\frac{1}{r}$ (b) r (c) r^2 (d) $\frac{1}{r^2}$

(2) In the usual notation, the acceleration due to gravity at a height h from the surface of the earth is ....

(a) $g = \frac{GM}{(R+h)}$ (b) $g = \frac{GM}{\sqrt{R+h}}$

(c) $g = \frac{GM}{(R+h)^2}$ (d) $g = GM(R+h)^2$

(3) The SI unit of the universal constant of gravitation is ....

(a) $N \cdot m^2/kg^2$ (b) $N \cdot kg^2/m^2$

(c) m/s^2 (d) $kg \cdot m/s^2$

(4) The escape velocity of a body from the earth's surface, $v_{esc} = ...$.

(a) $\sqrt{\frac{GM}{R}}$ (b) $2\sqrt{\frac{GM}{R}}$

(c) $\sqrt{\frac{2GM}{R}}$ (d) $\sqrt{\frac{GM}{2R}}$

(5) How much will a person with 72 N weight on the earth, weigh on the moon?

(a) 12 N (b) 36 N (c) 21 N (d) 63 N

(6) What will be the weight of a person on the earth, who weighs 9N on the moon?

(a) 3 N (b) 15 N (c) 45 N (d) 54 N

Ans.

(1) (d) $\frac{1}{r^2}$ (2) (c) $g = \frac{GM}{(R+h)^2}$

(3) (a) $N \cdot m^2/kg^2$ (4) (c) $\sqrt{\frac{2GM}{R}}$

(5) (a) 12 N (6) (d) 54 N.

Q. 4 State whether the following statements are *True* or *False* : (If a statement is false, correct it and rewrite it.) ***(1 mark each)***

Note : Students should write whether the given statement is true or false. There is no need to correct a false statement and rewrite it.

(1) If the separation between two particles is doubled, the gravitational force between the particles becomes half the initial force.

(2) The CGS unit of the universal constant of gravitation is the $dyne \cdot cm^2/gram^2$.

(3) At the centre of the earth, the value of the acceleration due to gravity becomes zero.

(4) The weight of a body is minimum at the poles.

(5) Mass is a vector quantity.

(6) Weight is a vector quantity.

(7) g has maximum value at the equator.

(8) Outside the earth, g varies as $1/(R+h)^2$.

(9) The value of G changes from place to place.

(10) The value of g decreases with depth below the earth's surface.

(11) The escape velocity of a body does not depend on the mass of the body.

(12) The mass of a body is the amount of matter present in it.

(13) The value of g increases with altitude.

Ans.

(1) **False.** (If the separation between two particles is doubled, the gravitational force between the particles becomes $\frac{1}{4}$ times the initial force.)

(2) **True.** (3) **True.**

(4) **False.** (The weight of a body is maximum at the poles.)

(5) **False.** (Mass is a scalar quantity.)

(6) **True.**

(7) **False.** (g has maximum value at the poles.)

(8) **True.**

(9) **False.** (The value of G is the same throughout the universe.)

(10) **True.** (11) **True** (12) **True.**

(13) **False.** (The value of g decreases with altitude.)

*Q. 5 **Study the entries in the following table and rewrite them putting the connected items in a single row :**

I	II	III
Mass	m/s^2	Zero at the centre of the earth
Weight	kg	Measure of inertia
Acceleration due to gravity	$N{\cdot}m^2/kg^2$	Same in the entire universe
Gravitational constant	N	Depends on height

Ans.

I	II	III
Mass	kg	Measure of inertia
Weight	N	Depends on height
Acceleration due to gravity	m/s^2	Zero at the centre of the earth
Gravitational constant	$N{\cdot}m^2/kg^2$	Same in the entire universe

Q. 6 **Match the following :**

Column A	Column B
(1) Escape velocity	(a) $\frac{GM}{r}\ (r \geqslant R)$
(2) Gravitational acceleration	(b) $\sqrt{\frac{2GM}{R}}$
	(c) $\frac{Gm_1m_2}{r^2}$
	(d) $\frac{GM}{r^2}\ (r \geqslant R)$

Ans. (1) Escape velocity : $\sqrt{\frac{2GM}{R}}$

(2) Gravitational acceleration : $\frac{GM}{r^2}\ (r \geqslant R)$

Q. 7 **Answer the following questions :**

***(1) What is centripetal force?** *OR*
Define centripetal force.

Ans. In uniform circular motion of a body, the force acting on the body is directed towards the centre of the circle. This force is called centripetal force.

(2) Give one example of centripetal force.

Ans. The moon revolves around the earth due to the gravitational force exerted on it by the earth. This force is directed towards the centre of the earth and is thus a centripetal force.

(3) Name the force responsible for the motion of a planet around the Sun.

Ans. A planet revolves around the Sun due to the gravitational force exerted on it by the Sun.

***(4) Write the three laws given by Kepler. How did they help Newton to arrive at the inverse square law of gravity?** *OR*

Explain with a diagram : Kepler's three laws. Hence show that gravitational force, $F \propto \frac{1}{r^2}$ (in the usual notation).

Ans. Kepler's first law :

The orbit of a planet is an ellipse with the Sun at one of the foci.

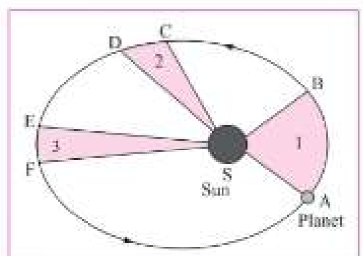


Fig. 1.5 : The orbit of a planet moving around the Sun (Schematic diagram)

Figure 1.5 shows the elliptical orbit of a planet revolving around the Sun (S).

Kepler's second law :

The line joining the planet and the Sun sweeps equal areas in equal intervals of time.

A → B, C → D and E → F are the displacements of the planet in equal intervals of time.

The straight lines AS, CS and ES sweep equal areas in equal intervals of time.

Area ASB = area CSD = area ESF.

Kepler's third law :

The square of the period of revolution of a planet around the Sun is directly proportional to the cube of the mean distance of the planet from the Sun.

Thus, if r is the average distance of the planet from the Sun and T is its period of revolution, then,

$T^2 \propto r^3$, i.e., $\frac{T^2}{r^3} = \text{constant} = K$.

For simplicity we shall assume the orbit to be a circle. In Fig. 1.6, S denotes the position of the Sun, P denotes the position of a planet at a given instant and r denotes the radius of the orbit ($\equiv$ the distance of the planet from the Sun). Here, the speed of the planet is uniform. It is

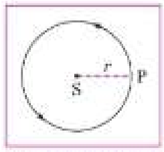


Fig. 1.6 : Circular motion of a planet around the Sun

$$v = \frac{\text{circumference of the circle}}{\text{period of revolution of the planet}}$$

$$= \frac{2\pi r}{T}.$$

If m is the mass of the planet, the centripetal force exerted on the planet by the Sun ($\equiv$ gravitational force), $F = \frac{mv^2}{r}$

$$\therefore\ F = \frac{m(2\pi r/T)^2}{r} = \frac{4\pi^2 mr^2}{T^2 r} = \frac{4\pi^2 mr}{T^2}$$

According to Kepler's third law,

$T^2 = Kr^3$

$$\therefore\ F = \frac{4\pi^2 mr}{Kr^3} = \frac{4\pi^2 m}{K}\left(\frac{1}{r^2}\right)$$

Thus, $F \propto \frac{1}{r^2}$ as $\frac{4\pi^2 m}{K}$ is constant in a particular case.

• **Use your brain power! (Textbook page 4)**

Q. If area ESF in figure 1.5 is equal to area ASB, what will you infer about EF?

Ans. The time taken by the planet to move from E to F equals the time taken by the planet to move from A to B.

(5) In the following figure, an orbit of a planet around the Sun (S) has been shown. AB and CD are the distances covered by the planet in equal time. Lines AS ad CS sweep equal areas in equal intervals of time. Hence, areas ASB and CSD are equal.

(a) Which laws do we understand from the above description?

(b) Write the law regarding area swept.

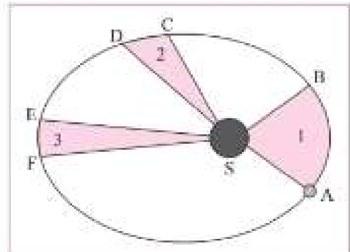


Fig. 1.7 (Schematic diagram)

(c) Write the law $T^2 \propto r^3$ in your words.

Ans. (a) From the given description we understand Kepler's three laws.

(b) Kepler's law of areas : The line joining the planet and the Sun sweeps equal areas in equal intervals of time.

(c) Kepler's law of periods : The square of the period of revolution of a planet around the Sun is directly proportional to the cube of the mean distance of the planet from the Sun.

(6) Observe the given figure (Fig. 1.7) and state which three laws we understand from it. ***(3 marks)*** *OR*

Observe the given figure showing the orbit of a planet moving around the Sun and write the three laws related to it. ***(3 marks) (March '20)***

Ans. *See the answer to Q. 7 (4).*

(7) Explain the term gravitational force. What is gravitation?

Ans. There exists a force of attraction between any two particles of matter in the universe such that the force depends only on the masses of the particles and the separation between them. It is called the gravitational force and the mutual attraction is called gravitation.

***(8) Let the period of revolution of a planet at a distance R from a star be T. Prove that if it was at a distance of $2R$ from the star, its period of revolution will be $\sqrt{8}\,T$.**

Ans. $T = \frac{2\pi}{\sqrt{GM}} \; r^{3/2}$, where T = period of revolution of a planet around the Sun, M = mass of the Sun, G = gravitational constant and r = radius of the orbit assumed to be circular = distance of the planet from the Sun.

For $r = R$, $T = T_1$.

$\therefore T_1 = \frac{2\pi}{\sqrt{GM}} R^{3/2}$

For $r = 2R$, $T = T_2$.

$\therefore T_2 = \frac{2\pi}{\sqrt{GM}} (2R)^{3/2} = \frac{2\pi}{\sqrt{GM}} R^{3/2} \times 2^{3/2} = T_1 \, 2^{3/2}$

$\therefore \; T_2 = T_1\sqrt{8} = \sqrt{8}\,T.$

(9) State Newton's universal law of gravitation. Express it in mathematical form.

Ans. Newton's universal law of gravitation : Every object in the Universe attracts every other object with a definite force. This force is directly proportional to the product of the masses of the two objects and inversely proportional to the square of the distance between them.

Mathematical form : Consider two objects of masses m_1 and m_2. We assume that the objects are very small spheres of uniform density and the distance r between their centres is very large compared to the radii of the spheres (Fig. 1.8).

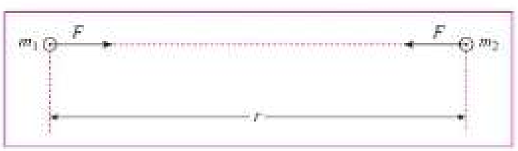


Fig. 1.8 : Gravitational force between two objects

The magnitude (F) of the gravitational force of attraction between the objects is directly proportional to $m_1 m_2$ and inversely proportional to r^2

$\therefore \; F \propto \frac{m_1 m_2}{r^2} \qquad \therefore \; F = G\,\frac{m_1 m_2}{r^2},$

where G is the constant of proportionality, called the universal gravitational constant.

[**Note :** In the textbook, the word object/body is used. Newton's law of gravitation applies to particles.]

(10) (i) Why is the constant of gravitation called a universal constant?

(ii) Newton's law of gravitation is called the universal law of gravitation. Why?

Ans. (i) The value of the constant of gravitation does not change with the nature, mass or the size of the material particles. It does not vary with the distance between the two particles. It is also independent of the nature of the medium between the two particles. Hence, it is called a universal constant.

(ii) As the law of gravitation given by Newton is applicable throughout the universe and to all particles, it is called universal law.

[**Note :** The centre of mass of an object is the point inside or outside the object at which the total mass of the object can be assumed to be concentrated to study the effect of an applied force. The centre of mass of a spherical object having uniform density is at its geometrical centre. The centre of mass of an object having uniform density is at its centroid. If the two bodies are spherical and of uniform density, the gravitational force between them is always along the line joining the centres of the two bodies and the distance between the centres is taken to be r. When the bodies are not spherical or have irregular shape or have nonuniform density, the force is along the line joining their centres of mass and r is taken to be the distance between the two centres of mass.]

(11) State any one characteristic of gravitational force.

Ans. Gravitational force between two particles does not depend on the medium between them.

(12) If the distance between two bodies is increased by a factor of 5, (i) by what factor will the gravitational force change if the masses are kept constant? (ii) by what factor will the mass of one of them have to be altered, keeping the other mass the same, to maintain the same gravitational force between the two bodies?

Ans. If the distance between two bodies is increased by a factor of 5,

(i) the gravitational force between the bodies will decrease by a factor of 25 if the masses of the bodies are kept constant.

(ii) the mass of one of them will have to be increased by a factor of 25, keeping the mass of the other body the same, to maintain the same gravitational force between the two bodies.

[**Note** : Gravitational force $F \propto \frac{1}{r^2}$ and $F \propto m_1m_2$.]

(13) (i) Determine the SI unit of the universal constant of gravitation from the formula for the gravitational force between two particles. Hence, state the CGS unit of the constant of gravitation. (ii) Define G (universal gravitational constant).

Ans. (i) According to Newton's law of gravitation, the gravitational force between two particles is

$$F = G\frac{m_1m_2}{r^2},$$

where m_1 and m_2 are the masses of the two particles, r is the distance between them and G is the universal constant of gravitation.

$$\therefore G = \frac{Fr^2}{m_1m_2}$$

The SI unit of force is the newton (N), that of distance is the metre (m) and that of mass is the kilogram (kg).

$\therefore$ The SI unit of G is $\frac{\mathrm{N{\cdot}m^2}}{\mathrm{kg^2}}$.

The CGS unit of G is $\frac{\mathrm{dyne{\cdot}cm^2}}{\mathrm{g^2}}$.

(ii) $F = G\frac{m_1m_2}{r^2}$ $\therefore$ $G = \frac{Fr^2}{m_1m_2}$. If we take $m_1 = m_2 =$ unit mass and $r =$ unit distance, numerically, $G = F$, i.e., G (universal gravitational constant) represents the magnitude of the gravitational force of attraction between two unit masses, separated by a unit distance.

• Use your brain power! (Textbook page 4)

Q. Show that in SI units, the unit of G is the newton·m^2 kg^{-2}.

See the answer to Q. 7 (13) (i) above.

(14) State the importance of Newton's universal law of gravitation.

Ans. The importance of Newton's universal law of gravitation :

This law explains successfully, i.e., with great accuracy,

(1) the force that binds the objects on the earth to the earth

(2) the motion of the moon and artificial satellites around the earth

(3) the motion of the planets, asteroids, comets, etc., around the Sun

(4) the tides of the sea due to the moon and the Sun.

(15) Compare the gravitational force on a body of mass 1 kg due to the earth with the force on the same body due to another body of mass 1 kg at a distance of 1 m from the first body. (Mass of the earth = 6×10^{24} kg, radius of the earth = 6400 km)

Ans. In the first case, $m_1 = 1$ kg,

$m_2 = 6 \times 10^{24}$ kg and $r = 6400$ km $= 6.4 \times 10^6$ m

Gravitational force on the body,

$$F_1 = \frac{Gm_1m_2}{r^2} = \frac{G \times 1\ \mathrm{kg} \times 6 \times 10^{24}\ \mathrm{kg}}{(6.4 \times 10^6\ \mathrm{m})^2}$$

$$= \frac{G \times 6 \times 10^{24}\ \mathrm{kg^2}}{(6.4)^2 \times 10^{12}\ \mathrm{m^2}}$$

In the second case, $m_1 = 1$ kg,

$m_2 = 1$ kg and $r = 1$ m

Gravitational force on the body,

$$F_2 = \frac{Gm_1m_2}{r^2} = \frac{G \times 1\ \mathrm{kg} \times 1\ \mathrm{kg}}{(1\ \mathrm{m})^2}$$

$$\therefore \frac{F_1}{F_2} = \frac{6 \times 10^{24}}{(6.4)^2 \times 10^{12}} = 1.465 \times 10^{11} \quad OR$$

$$\frac{F_2}{F_1} = 6.826 \times 10^{-12}.$$

Thus, $F_2 \ll F_1$.

(16) Explain the term the earth's gravitational force. *OR*
Write a short note on the earth's gravitational force.

Ans. The earth attracts every object towards it because of the gravitational force. As the earth's centre of mass is at its centre, the gravitational force exerted by the earth on an object is directed towards the earth's centre. Hence, an object released from a point above the earth's surface falls vertically downward towards the earth. If an object is thrown vertically upward, its velocity goes on decreasing due to the earth's gravitational force on the object. At one stage, the velocity of the body becomes zero and later the body falls back to the earth.

(17) Take two balls of different masses, go to the top of a building, drop them simultaneously and observe what happens to the balls.

Ans. The balls reach the ground almost at the same time.

(18) Take two similar pages from your notebook. Crumple one paper and allow this and the other paper to fall on the ground simultaneously. What do you observe?

Ans. The crumpled paper reaches the ground before the other one.

(19) Take a feather and a paper. Allow them to fall to the ground simultaneously. Which will reach the ground earlier? Why?

Ans. There is no unique answer. It depends on the feather and paper. Upthrust due to air and force due to friction with air play very important roles here. The acceleration of a body depends on the resultant of the earth's gravitational force on the body and the upthrust and the force of friction due to air.

• **Use your brain power! (Textbook page 7)**

(1) According to Newton's law of gravitation, every object attracts every other object.

Thus, if the earth attracts an apple towards itself, the apple also attracts the earth towards itself with the same force. Why then does the apple fall towards the earth, but the earth does not move towards the apple?

Ans. The earth and the apple move towards each other, but the magnitude of the displacement of the earth is negligible relative to that of the apple. Also the observer is located on the earth.

[**Note :** The mass of the earth is far greater than that of an apple. Hence, the magnitude of the acceleration of the earth is negligible relative to that of the apple.]

(2) The gravitational force due to the earth also acts on the moon because of which it revolves around the earth. Similar situation exists for the artificial satellites orbiting the earth. The moon and the artificial satellites orbit the earth. The earth attracts them towards itself but unlike the falling apple, they do not fall on the earth, why?

Ans. This is because of the velocity of the moon and the satellites along their orbits. If this velocity was not there, they would have fallen on the earth.

***(20) What is the acceleration due to gravity?**

OR

Define acceleration due to gravity.

Ans. The acceleration produced in a body due to the gravitational force of the earth is called the acceleration due to gravity.

[**Note :** On the earth's surface, the value of the acceleration due to gravity is almost uniform. If a body falls from a low altitude, the value of the acceleration due to gravity is almost the same.]

(21) From Newton's law of gravitation, derive the formula for the acceleration due to gravity.

Ans. Suppose that a body of mass m is released from a distance r from the centre (O) of the earth (Fig. 1.9). Let M be the mass of the earth. According to Newton's law of gravitation, the magnitude of the earth's gravitational force acting on the body is

$$F = G\frac{Mm}{r^2}$$

where G is the universal constant of gravitation.

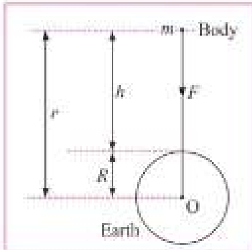


Fig. 1.9 : Gravitational force exerted on a body by the earth

The acceleration produced by this force,

$$g = \frac{\text{force}}{\text{mass}} = \frac{F}{m}$$

$$\therefore\ g = \frac{GM}{r^2}$$

This is the formula for the acceleration due to gravity or the gravitational acceleration due to the earth. This acceleration is directed towards the earth's centre.

If h denotes the altitude, $r = R + h$, where R is the radius of the earth.

$$\therefore\ g = \frac{GM}{(R+h)^2}$$

For a body on the earth's surface, $h = 0$ $\therefore g = \frac{GM}{R^2}$

[**Note** : When we consider the gravitational interaction between the earth and a body on the surface of the earth or at some height above the surface of the earth, for many practical purposes we can assume that the earth behaves as if its mass were concentrated at the earth's centre. The proof is not expected here.]

• Think about it (Textbook page 8)

(1) What would happen if there were no gravity?

Ans. (1) There would be no gravitational attraction between any two particles and hence no formation of the solar system, galaxy, etc.

(2) What would happen if the value of G was twice as large?

Ans. The gravitational force between any two particles would become double, also the value of g would become double.

• Can you tell? (Textbook page 8)

Q. What would be the value of g on the surface of the earth if its mass was twice as large and its radius half of what it is now?

Ans. $g = \frac{GM}{R^2}$ ***(3 marks) (March '19)***

$$\therefore\ g_1 = \frac{GM_1}{R_1^2} \quad \text{and} \quad g_2 = \frac{GM_2}{R_2^2}$$

$$\therefore\ \frac{g_2}{g_1} = \left(\frac{M_2}{M_1}\right)\left(\frac{R_1}{R_2}\right)^2 = 2(2)^2 = 8$$

$$\left(\because M_2 = 2M_1 \text{ and } R_2 = \frac{R_1}{2}\right)$$

$$\therefore\ g_2 = 8\,g_1$$

Thus, the value of g on the surface of the earth would be eight times the present value.

(22) What is the acceleration due to gravity at a height h (= radius of the earth) from the surface of the earth? ($g = 9.8$ m/s^2)

Ans. The acceleration due to gravity at a height h (= radius of the earth) from the surface of the earth is 2.45 m/s^2.

[**Explanation :** $g' = \frac{GM}{(R+h)^2} = \frac{GM}{4R^2} = \frac{g}{4}$

$= \frac{9.8}{4}$ m/s^2 = 2.45 m/s^2 for $h = R$]

(23) Explain the factors affecting the value of g.

Ans. The value of the acceleration due to gravity, g, changes from place to place on the earth. It also varies with the altitude and depth below the earth's surface. The factors affecting the value of g are the shape of the earth, altitude and depth below the earth's surface.

(1) The earth is not perfectly spherical. It is somewhat flat at the poles and bulging at the equator. At the surface of the earth, the value of g is maximum (9.832 m/s^2) at the poles as the polar radius is minimum, while it is minimum (9.78 m/s^2) at the equator as the equatorial radius is maximum.

(2) As the height (h) above the earth's surface increases, the value of g decreases. It varies as $\frac{1}{(R+h)^2}$, where R is radius of the earth.

(3) In the interior of the earth, on the average, the value of g is less than that at the earth's surface. As the depth below the earth's surface increases, the value of g decreases and finally it becomes zero at the centre of the earth.

(24) If $g = GM/r^2$, then where will the value of g be high, at Goa Beach or on the top of the Mount Everest?

Ans. The value of g will be high at Goa Beach.

• Think about it (Textbook page 9)

(1) Will the direction of the gravitational force change as we go inside the earth?

Ans. No.

(2) What will be the value of g at the centre of the earth?

Ans. Zero.

***(25) Explain why the value of g is zero at the centre of the earth.** **[HOTS]**

OR

Does the value of g change while going deep inside the earth? Why? **[HOTS]**

Ans. The value of g changes while going deep inside the earth. It goes on decreasing as we go from the earth's surface towards the earth's centre.

We shall treat the earth as a sphere of uniform density. If we consider a particle of mass m at point P at a distance $(R-d)$ from the earth's centre, where R is the radius of the earth and d is the depth below the earth's surface, the gravitational force on the particle due to the earth is

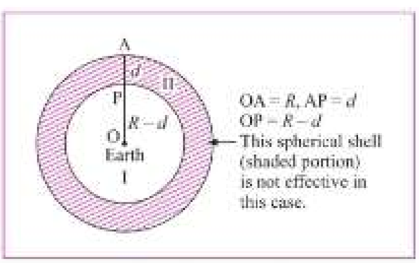


Fig. 1.10 : g inside the earth

$F = \frac{GmM'}{(R-d)^2}$, where M' is the mass of the sphere of radius $(R-d)$.

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$\therefore$ Mass = volume × density

$\therefore M' = \frac{4}{3}\pi (R-d)^3 \times \frac{M}{\frac{4}{3}\pi R^3} = \frac{M(R-d)^3}{R^3}$. This is because the outer spherical shell is not effective (Fig. 1.10). In this case, the acceleration due to gravity is

$$g = \frac{F}{m} = \frac{G}{(R-d)^2} \cdot \frac{M(R-d)^3}{R^3} = \frac{GM(R-d)}{R^3},$$

where M is the mass of the earth. Thus, g decreases as d increases. It is less than that at the earth's surface $\left(\frac{GM}{R^2}\right)$. At the earth's centre, $d = R \therefore g = 0$.

(26) Explain why the value of g changes if we go inside the earth. ***(2 marks) (July '19)***

Ans. The value of g is calculated using the formula $g = \frac{GM}{r^2}$, where G is the universal constant of gravitation, M is the mass of the earth and r is the distance of an object from the earth's centre. However, the part of the earth which exerts the gravitational force on the object decreases as r decreases. The mass (M') of this part is less than M. As we move towards the earth's centre, r decreases, but M' decreases to a greater extent. The combined effect is $g \propto (R-d)$, where d is the distance of the object from the earth's surface. As d, the depth, increases, g decreases, i.e., g changes. At the earth's centre,

$d = R \quad \therefore g = 0.$

(27) Why does an object released from the hand, fall on the earth?

Ans. When an object is held in the hand, the gravitational force acting on the object due to the earth is balanced by the person holding the object. When the object is released from the hand, it falls on the earth due to the earth's gravitational force.

(28) Does the value of g depend on the mass of the falling body? Why?

Ans. The value of g does not depend on the mass of the falling body.

The reason is the gravitational force on a body due to the earth is directly proportional to the mass of the body and for a given force, the acceleration of a body is inversely proportional to the mass of the body.

(29) Define mass. State its SI and CGS units.

Ans. The mass of a body is the amount of matter present in it. Its SI unit is the kilogram (kg) and CGS unit is the gram (g).

[**Note :** Mass has only magnitude, not direction. Thus, it is a scalar quantity.]

(30) Define weight. State its SI and CGS units.

Ans. The weight of a body is defined as the force with which the earth attracts it. Its SI unit is the newton and CGS unit is the dyne.

[**Note :** In the usual notation, the magnitude of the weight of a body on the earth's surface is $W = \frac{GmM}{R^2} = m\frac{GM}{R^2} = mg$. Thus, $W \propto g$. Hence, weight varies just like the acceleration due to gravity. It is maximum at the poles and minimum at the equator. It decreases with altitude (h) and depth (d) below the earth's surface. It becomes zero at the earth's centre. At a height h above the earth's surface, $W = \frac{GmM}{(R+h)^2}$ and at a depth d below the earth's surface, $W = \frac{GmM\,(R-d)}{R^3}$. Weight has magnitude and direction (towards the earth's centre). It is a vector quantity.]

(31) As per the request of one of his friends from the equator, Rahul buys 100 grams of silver at the north pole. He hands it over to his friend at the equator. Will the friend agree with the weight of the silver bought? If not, why?

Ans. The weight of a body is given by $W = mg$, where m is the mass of the body and g is the acceleration due to gravity. g varies from place to place. The value of g at the equator is less than that at the north pole (as well as the south pole). Hence, the weight of the silver bought at the north pole would be less when the silver is weighed at the equator. Therefore, Rahul's friend will disagree about the weight of the silver.

[**Note :** The mass being independent of the value of g, Rahul's friends will agree about the mass of the silver.]

***(32) If the value of g suddenly becomes twice its value, it will become two times more difficult to pull a heavy object along the floor. Why?**

Ans. To pull an object along the floor, it is necessary to do work against the force of friction between the object and the surface of the floor. This force of friction is proportional to the weight, mg, of the object. If the value of g becomes twice its value, the weight of the object and hence the force of friction will become double. Therefore, it will become two times more difficult to pull a heavy object along the floor.

***(33) What is the difference between mass and weight of an object? Will the mass and weight of an object on the earth be the same as their values on Mars? Why?**

Ans. The mass of an object is the amount of matter present in it. It is same everywhere in the Universe and is never zero. It is a scalar quantity and its SI unit is kg. The weight of an object is the force with which the earth (or any other planet/moon/star) attracts it. It is directed towards the centre of the earth. The weight of an object is different at different places on the earth. It is zero at the earth's centre. It is a vector quantity and its SI unit is the newton (N). The magnitude of weight $= mg$.

The mass of an object will be the same on the earth and Mars, but the weight will not be the same because the value of g on Mars is different from that on the earth.

• Use your brain power! (Textbook page 10)

(1) Will your weight remain constant as you go above the surface of the earth?

Ans. No. As we go above the surface of the earth, our weight will go on decreasing.

(2) Suppose you are standing on a tall ladder. If your distance from the centre of the earth is 2*R*, what will be your weight?

Ans. Weight, $W = \frac{GMm}{r^2} = \frac{GMm}{(2R)^2} = \frac{GMm}{4R^2}$

$= \frac{1}{4}\left(\frac{GMm}{R^2}\right)$

$= \frac{\text{weight on the surface of the earth}}{4}$.

*(34) **What is free fall?** *OR*

Define free fall.

Ans. Whenever an object moves under the influence of the force of gravity alone, it is said to be falling freely.

(35) Explain the term free fall and state the corresponding kinematical equations of motion in the usual notation.

Ans. When a body falls in air, there are three forces acting on the body : (1) the gravitational force due to the earth, acting downward (2) the force of buoyancy (upthrust) due to air, acting upward (3) the force due to friction with air (called air resistance), acting upward (being always in the direction opposite to that of the velocity of the body).

Under certain conditions, the force of buoyancy due to air and friction with air can be ignored compared to the gravitational force of the earth. In that case (near the earth's surface) the body falls with almost uniform acceleration (g). Whenever a body moves under the influence of the force of gravity alone, it is said to be falling freely. Strictly speaking, this is true only if the body falls in vacuum.

The kinematical equations of motion, in the usual notation, are

$v = u + gt$, $s = ut + \frac{1}{2}gt^2$ and $v^2 = u^2 + 2gs$.

If the initial velocity (u) of the body is zero, $v = gt$, $s = \frac{1}{2}gt^2$ and $v^2 = 2gs$.

(36) During a free fall, will a heavier object accelerate more than a lighter one?

Ans. No. The two objects will have the same acceleration.

(37) What are the factors on which the maximum height attained by a body thrown upwards depends?

Ans. The initial velocity of the body, the acceleration due to gravity at that place, the buoyant force and frictional force due to air.

(38) If you had to calculate the mass of the earth, how would you do it?

Ans. If the acceleration due to gravity (g), the constant of gravitation (G) and the radius of the earth (R) are known, the mass of the earth (M) can be calculated using the formula $g = \frac{GM}{R^2}$.

• Use your brain power! (Textbook page 12)

Q. According to Newton's law of gravitation, the earth's gravitational force is higher on an object of larger mass. Why doesn't that object fall down with higher velocity as compared to an object with lower mass?

Ans. $F = ma$ and $F = \frac{GMm}{r^2}$

$\therefore$ Acceleration, $a = \frac{GM}{r^2}$. This is independent of the mass (m) of the object. Hence, an object of larger mass and an object of lower mass fall down with the same velocity.

(39) What is gravitational potential energy?

OR

Define gravitational potential energy. Write the formula for it.

Ans. The energy stored in a body due to the gravitational force between the body and the earth is called the gravitational potential energy.

Gravitational potential energy of a body of mass $m = -\frac{GMm}{R+h}$, where G = gravitational constant, M = mass of the earth, R = radius of the earth, h = height of the body from the surface of the earth.

[**Note** : As the body is bound to the earth due to the earth's gravitational force, the gravitational potential energy of the body is negative. If the body is given kinetic energy equal to $\frac{GMm}{R+h}$ the body will overcome the earth's gravitational force. It will then move to infinity and come to rest there.]

***(40) What is escape velocity?** *OR*

Define escape velocity.

Ans. When a body is thrown vertically upward from the surface of the earth, the minimum initial velocity of the body for which the body is able to overcome the downward pull by the earth and can escape the earth forever is called the escape velocity.

(41) Explain the term escape velocity. *OR*

Write a short note on escape velocity.

Ans. In general, when a body is thrown vertically upward from the earth's surface, its velocity goes on decreasing and after some time the body falls back to the ground. If its initial velocity is increased, the maximum height attained by it is more, but it does fall back to the ground. If the initial velocity is increased continuously, for a particular initial velocity, the body can overcome the earth's gravitational force and move to infinity and come to rest there. This velocity is called the escape velocity.

(42) Using the law of conservation of energy, obtain the expression for the escape velocity.

Ans. Here, we shall not consider the effects of air. Suppose a body of mass m is thrown vertically upward from the surface of the earth. Let the initial velocity of the body be the escape velocity (v_{esc}).

When the body is on the earth's surface, its total energy E_1 = kinetic energy + potential energy

$= \frac{1}{2} mv^2_{esc} + \left(-\frac{GmM}{R}\right)$, where G = universal gravitational constant, M = mass of the earth and R = radius of the earth.

Thus, $E_1 = \frac{1}{2} mv^2_{esc} - \frac{GmM}{R}$.

When the body moves to infinity and comes to rest there, its total energy,

$$E_2 = \frac{1}{2}m \text{ (zero)}^2 + \left(-\frac{GmM}{\infty}\right) = 0 + 0 = 0.$$

According to the law of conservation of energy, $E_1 = E_2$.

$$\therefore \frac{1}{2} mv^2_{esc} - \frac{GmM}{R} = 0$$

$$\therefore \frac{1}{2} v^2_{esc} = \frac{GM}{R}$$

$$\therefore v_{esc} = \sqrt{\frac{2GM}{R}}$$

This is the required expression.

(43) Express escape velocity in terms of g and R.

Ans. Escape velocity, $v_{esc} = \sqrt{\frac{2GM}{R}}$

Now, $g = \frac{GM}{R^2}$

$\therefore GM = gR^2$

$$\therefore v_{esc} = \sqrt{\frac{2gR^2}{R}} = \sqrt{2gR}.$$

(44) Express escape velocity in terms of G, R and ρ (the earth's density).

Ans. Escape velocity, $v_{esc} = \sqrt{\frac{2GM}{R}}$

The earth's density, $\rho = \frac{\text{mass}}{\text{volume}} = \frac{M}{\left(\frac{4}{3}\right)\pi R^3}$

$\therefore M = \frac{4}{3}\pi R^3 \rho$

$$\therefore v_{esc} = \sqrt{\frac{2G\ (4/3)\ \pi R^3 \rho}{R}}$$

$$= \sqrt{2G\ (4/3)\ \pi R^2 \rho} = 2R\sqrt{\frac{2}{3}G\pi\rho}$$

Q. 8 Fill in the blanks and complete the following paragraph. (Words given : upward, friction, negligible, downward, gravitational, buoyancy, very large, electric)

When a body falls in air, there are three forces acting on the body : (1) the gravitational force due to the earth, acting .... (2) the force of .... due to air, acting .... (3) the force due to .... with air, acting in the direction opposite to that of the velocity of the body.

Under certain conditions, the force of buoyancy due to air and friction with air can be .... compared to the .... force of the earth. In that case (near the earth's surface) the body falls with almost uniform acceleration (g). Whenever a body moves under the influence of the force of gravity alone, it is said to be falling freely. Strictly speaking, this is true only if the body falls in vacuum.

Ans. Words to be written (in the proper order) : downward, buoyancy, upward, friction, negligible, gravitational.

Q. 9 Give scientific reasons :

(1) If a feather and a stone are released from the top of a building simultaneously, the stone reaches the ground earlier than the feather.

Ans. (1) The motion of a body falling in air is accelerated due to the earth's gravitational force on the body. The force due to buoyancy of air acts on the body in the upward direction. Thus, it opposes the downward motion of the body. As the body falls, the friction with air opposes its motion.

(2) This opposition due to air depends on the size, shape, density and velocity of the body. It is greater for a feather than for a stone. Hence, the stone has greater downward acceleration than the feather. Therefore, the stone reaches the ground earlier than the feather though they are released simultaneously from the same height.

(2) The weight of an object changes from place to place though its mass is constant.

(March '20)

Ans. (1) The mass (m) of an object is the amount of matter present in it. It is a measure of the inertia of the object. Hence, it is constant.

(2) The weight of an object is the force with which the earth attracts the body towards the centre of the earth. Weight, $W = mg$. As the value of the acceleration due to gravity (g) changes from place to place, the weight of an object changes from place to place.

(3) The weight of a body is different on different planets.

Ans. (1) The weight of a body of mass m on the surface of a planet of mass M and radius R is $W = \frac{GmM}{R^2}$ (in the usual notation).

(2) For a given body, its mass is constant. G is the universal constant of gravitation. Different planets have different masses and radii such that the ratio (M/R^2) is not the same. Hence, the weight of a body is different on different planets.

(4) With a specific initial velocity, we can jump higher on the moon than on the earth.

Ans. The acceleration due to gravity on the moon is about $\frac{1}{6}$ of that on the earth. Hence, with a specific initial velocity, we can jump higher on the moon than on the earth. This can be seen from the equation

$h = u^2/2g$.

Q. 10 Distinguish between :

(1) mass and weight (2) universal gravitational constant and gravitational acceleration of the earth.

Ans.

(1) Mass	Weight
1. The mass of a body is the amount of matter present in it.	1. The weight of a body is the force with which the earth attracts it.

2. It has magnitude, but not direction.	2. It has both magnitude and direction.
3. It does not change from place to place.	3. It changes from place to place.
4. It can never be zero.	4. It is zero at the centre of the earth.
5. Its SI unit is the kilogram.	5. Its SI unit is the newton.

(2) Universal gravitational constant	Gravitational acceleration of the earth
1. The universal gravitational constant numerically equals the force of attraction between two unit masses separated by a unit distance.	1. The gravitational acceleration of the earth is the acceleration produced in a body due to the gravitational force of the earth.
2. Its value remains constant throughout the universe.	2. Its value changes from place to place.
3. It has magnitude but not direction.	3. It has both magnitude and direction.
4. Its SI unit is $N \cdot m^2/kg^2$.	4. Its SI unit is m/s^2.

Q. 11 Solve the following examples/ numerical problems :

($G = 6.67 \times 10^{-11}\ N \cdot m^2/kg^2$, $g = 9.8\ m/s^2$)

(1) The time taken by the earth to complete one revolution around the Sun is 3.156×10^7 s. The distance between the earth and the Sun is 1.5×10^{11} m. Find the speed of revolution of the earth.

Solution : Data : $T = 3.156 \times 10^7$ s,

$r = 1.5 \times 10^{11}$ m, $v = ?$

$$v = \frac{2\pi r}{T} = \frac{2 \times 3.142 \times 1.5 \times 10^{11}\ m}{3.156 \times 10^7\ s}$$

$$= \mathbf{2.987 \times 10^4\ m/s = 29.87\ km/s}$$

This is the speed of revolution of the earth.

(2) Assuming that the earth performs uniform circular motion around the Sun, find the centripetal acceleration of the earth. [Speed of the earth = 3×10^4 m/s, distance between the earth and the Sun = 1.5×10^{11} m]

Solution : Data : $v = 3 \times 10^4$ m/s, $r = 1.5 \times 10^{11}$ m

Centripetal force $= \frac{mv^2}{r} = ma$

$\therefore$ Centripetal acceleration of the earth,

$$a = \frac{v^2}{r} = \frac{(3 \times 10^4\ m/s)^2}{1.5 \times 10^{11}\ m} = \frac{3 \times 3}{1.5} \times 10^{-3}\ m/s^2$$

$$= \mathbf{6 \times 10^{-3}\ m/s^2}$$

It is directed towards the centre of the Sun.

(3) What will be the gravitational force on 60 kg man on the Moon, Mars and Jupiter? Are they the same? Why?

M (Moon) = 7.36×10^{22} kg, R (Moon) = 1.74×10^6 m,
M (Mars) = 6.4×10^{23} kg, R (Mars) = 3.395×10^6 m,
M (Jupiter) = 1.9×10^{27} kg. R (Jupiter) = 7.15×10^7 m,
$G = 6.67 \times 10^{-11}\ N \cdot m^2/kg^2$

Solution :

(1) Data : $m_1 = 60$ kg, $m_2 = 7.36 \times 10^{22}$ kg,

$R = 1.74 \times 10^6$ m, $F = ?$

$$F = \frac{Gm_1m_2}{R^2}$$

$$= \frac{6.67 \times 10^{-11}\ N \cdot m^2/kg^2 \times 60\ kg \times 7.36 \times 10^{22}\ kg}{(1.74 \times 10^6\ m)^2}$$

$$= 97.29\ N$$

On the moon's surface, the gravitational force on the man due to the moon = 97.29 N.

(2) Data : $m_1 = 60$ kg, $m_2 = 6.4 \times 10^{23}$ kg,

$R = 3.395 \times 10^6$ m, $F = ?$

$$F = \frac{Gm_1m_2}{R^2}$$

$$= \frac{6.67 \times 10^{-11}\ N \cdot m^2/kg^2 \times 60\ kg \times 6.4 \times 10^{23}\ kg}{(3.395 \times 10^6\ m)^2}$$

$$= 222.2\ N$$

On the surface of Mars, the gravitational force on the man due to Mars = 222.2 N.

(3) Data : $m_1 = 60$ kg, $m_2 = 1.9 \times 10^{27}$ kg,

$R = 7.15 \times 10^7$ m, $F = ?$

$$F = \frac{Gm_1m_2}{R^2}$$

$$= \frac{6.67 \times 10^{-11} \text{ N·m}^2/\text{kg}^2 \times 60 \text{ kg} \times 1.9 \times 10^{27} \text{ kg}}{(7.15 \times 10^7 \text{ m})^2}$$

$$= 1487 \text{ N}$$

On the surface of Jupiter, the gravitational force on the man due to Jupiter = 1487 N.

Thus, the forces on the man are not the same because the ratio (M/R^2) is not the same in the case of the moon, Mars and Jupiter.

***(4) The masses of the earth and moon are 6×10^{24} kg and 7.4×10^{22} kg, respectively. The distance between them is 3.84×10^5 km. Calculate the gravitational force of attraction between the two. Use $G = 6.7 \times 10^{-11}$ N·m² kg⁻².**

Solution : Data : $m_1 = 6 \times 10^{24}$ kg,

$m_2 = 7.4 \times 10^{22}$ kg, $r = 3.84 \times 10^5$ km $= 3.84 \times 10^8$ m,

$G = 6.7 \times 10^{-11}$ N·m² kg⁻², $F = ?$

$$F = \frac{Gm_1m_2}{r^2}$$

$$= \frac{6.7 \times 10^{-11} \text{ N·m}^2 \text{ kg}^{-2} \times 6 \times 10^{24} \text{ kg} \times 7.4 \times 10^{22} \text{ kg}}{(3.84 \times 10^8 \text{ m})^2}$$

$$= \frac{6.7 \times 6 \times 7.4 \times 10^{35}}{3.84 \times 3.84 \times 10^{16}} \text{ N} = \mathbf{2.017 \times 10^{20} \text{ N}}$$

This is (the magnitude of) the gravitational force between the earth and the moon.

(5) Mahendra and Virat are sitting at a distance of 1 metre from each other. Their masses are 75 kg and 80 kg respectively. What is the gravitational force between them? $G = 6.67 \times 10^{-11}$ N·m²/kg².

Solution : Given : $r = 1$ m, $m_1 = 75$ kg, $m_2 = 80$ kg and $G = 6.67 \times 10^{-11}$ N·m²/kg²

$$F = \frac{Gm_1m_2}{r^2} = \frac{6.67 \times 10^{-11} \times 75 \times 80}{1^2} \text{ N}$$

$$= 4.002 \times 10^{-7} \text{ N}$$

The gravitational force between Mahendra and Virat is 4.002×10^{-7} N.

(6) Spheres A and B of uniform density have masses 1 kg and 100 kg respectively. Their centres are separated by 100 m. (i) Find the gravitational force between them. (ii) Find the gravitational force on A due to the earth. (iii) Suppose A and B are initially at rest and A can move freely towards B. What will be the velocity of A one second after it starts moving towards B? How will this velocity change with time? How much time will A take to move towards B by 1 cm? (iv) If A begins to fall, starting from rest, due to the earth's downward pull, what will be its velocity after one second? How much time will it take to fall through 1 cm?

[$M_{(earth)} = 6 \times 10^{24}$ kg, $R_{(earth)} = 6400$ km]

Solution : Data : $m_1 = 1$ kg, $m_2 = 100$ kg, $r = 100$ m,

$M = 6 \times 10^{24}$ kg, $R = 6400$ km $= 6400 \times 10^3$ m,

$t = 1$ s, $s = 1$ cm $= 1 \times 10^{-2}$ m,

$G = 6.67 \times 10^{-11}$ N·m²/kg²

$F_1 = ?$, $F_2 = ?$, $v_1 = ?$, $t_1 = ?$, $v_2 = ?$, $t_2 = ?$

(i) $$F_1 = \frac{Gm_1m_2}{r^2}$$

$$= \frac{6.67 \times 10^{-11} \text{ N·m}^2/\text{kg}^2 \times 1 \text{ kg} \times 100 \text{ kg}}{(100 \text{ m})^2}$$

$$= \mathbf{6.67 \times 10^{-13} \text{ N}}$$

(ii) $$F_2 = \frac{Gm_1M}{R^2}$$

$$= \frac{6.67 \times 10^{-11} \text{ N·m}^2/\text{kg}^2 \times 1 \text{ kg} \times 6 \times 10^{24} \text{ kg}}{(6400 \times 10^3 \text{ m})^2}$$

$$= \frac{40.02 \times 10^{13}}{6.4 \times 6.4 \times 10^{12}} \text{ N} = \mathbf{9.77 \text{ N}}.$$

This is far greater than F_1.

(iii) Ignoring variation of acceleration with distance,

$$v_1 = u_1 + at = 0 + \frac{F_1}{m_1} t = \frac{6.67 \times 10^{-13} \text{ N}}{1 \text{ kg}} \times 1 \text{ s}$$

$$= \mathbf{6.67 \times 10^{-13} \text{ m/s}}$$

This velocity is directed from A to B. As the separation between A and B decreases, the acceleration of A and the velocity of A will increase.

Ignoring variation of acceleration with distance,

$$s_1 = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}\frac{F_1}{m_1}t_1^2$$

$$\therefore t_1^2 = \frac{2m_1s_1}{F_1}$$

$\therefore\ t_1^2 = \frac{2 \times 1 \text{ kg} \times 10^{-2} \text{ m}}{6.67 \times 10^{-13} \text{ N}} = 3 \times 10^{10} \text{ s}^2$

$\therefore\ \boldsymbol{t_1 = 1.732 \times 10^5}$ **s**

(iv) $v_2 = u_2 + at = 0 + gt = \frac{F_2}{m_1} t$

$= \frac{9.77 \text{ N}}{1 \text{ kg}} \times 1 \text{ s} =$ **9.77 m/s (downward)**

$[|v_2| \gg |v_1|]$

$s_2 = ut + \frac{1}{2} at^2 = 0 + \frac{1}{2} gt_2^2 = \frac{1}{2} \frac{F_2}{m_1} t_2^2$

$\therefore\ t_2^2 = \frac{2 s_2 m_1}{F_2} = \frac{2 \times 10^{-2} \text{ m} \times 1 \text{ kg}}{9.77 \text{ N}} = 0.205 \text{ s}^2$

$\therefore\ \boldsymbol{t_2 = 0.453}$ **s** $\quad [t_1 \gg t_2]$.

(7) Two spheres of uniform density have masses 10 kg and 40 kg. The distance between the centres of the spheres is 200 m. Find the gravitational force between them.

Solution : Data : $m_1 = 10$ kg, $m_2 = 40$ kg,

$r = 200$ m, $G = 6.67 \times 10^{-11}$ N·m²/kg², $F = ?$

$F = \frac{Gm_1m_2}{r^2}$

$= \frac{6.67 \times 10^{-11} \text{ N·m}^2/\text{kg}^2 \times 10 \text{ kg} \times 40 \text{ kg}}{(200 \text{ m})^2}$

$= \frac{6.67 \times 10^{-11} \times 4 \times 10^2 \text{ N}}{4 \times 10^4} = 6.67 \times 10^{-13} \text{ N}$

The gravitational force between the two spheres $= \boldsymbol{6.67 \times 10^{-13}}$ **N.**

(8) Find the gravitational force between a man of mass 50 kg and a car of mass 1500 kg separated by 10 m.

Solution : Data : $m_1 = 50$ kg, $m_2 = 1500$ kg,

$r = 10$ m, $G = 6.67 \times 10^{-11}$ N·m²/kg², $F = ?$

$F = \frac{Gm_1m_2}{r^2}$

$= \frac{6.67 \times 10^{-11} \text{ N·m}^2/\text{kg}^2 \times 50 \text{ kg} \times 1500 \text{ kg}}{(10 \text{ m})^2}$

$= 5.0025 \times 10^{-8}$ N

The gravitational force between the man and the car $= \boldsymbol{5.0025 \times 10^{-8}}$ **N.**

• **Use your brain power! (Textbook page 6)**

Q. Assuming the acceleration in Example 2 above remains constant, how long will Mahendra take to move 1 cm towards Virat?

Ans. Here, $u = 0$

$\therefore\ s = ut + \frac{1}{2} at^2 = 0 + \frac{1}{2} at^2$

$\therefore\ t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 1 \times 10^{-2} \text{ m}}{5.34 \times 10^{-9} \text{ m/s}^2}}$

$= \sqrt{0.3745 \times 10^7 \text{ s}^2} = \sqrt{3.745 \times 10^6}$ s

= 1935 s = 32 minutes 15 seconds.

(9) Find the magnitude of the gravitational force between the Sun and the earth. (Mass of the Sun $= \boldsymbol{2 \times 10^{30}}$ **kg, mass of the earth** $= \boldsymbol{6 \times 10^{24}}$ **kg and the distance between the centres of the Sun and the earth** $= \boldsymbol{1.5 \times 10^{11}}$ **m,** $\boldsymbol{G = 6.67 \times 10^{-11}}$ **N·m²/kg²)**

Solution : Data : $m_1 = 2 \times 10^{30}$ kg,

$m_2 = 6 \times 10^{24}$ kg, $r = 1.5 \times 10^{11}$ m,

$G = 6.67 \times 10^{-11}$ N·m²/kg², $F = ?$

$F = G \frac{m_1m_2}{r^2}$

$= \frac{6.67 \times 10^{-11} \text{ N·m}^2/\text{kg}^2 \times 2 \times 10^{30} \text{ kg} \times 6 \times 10^{24} \text{ kg}}{(1.5 \times 10^{11} \text{ m})^2}$

$= \frac{6.67 \times 2 \times 6}{1.5 \times 1.5} \times 10^{21} \text{ N} = 35.57 \times 10^{21} \text{ N}$

$\therefore\ F = 3.557 \times 10^{22}$ N

The magnitude of the gravitational force between the Sun and the earth $= \boldsymbol{3.557 \times 10^{22}}$ **N.**

***(10) The mass of the earth is** $\boldsymbol{6 \times 10^{24}}$ **kg. The distance between the earth and the Sun is** $\boldsymbol{1.5 \times 10^{11}}$ **m. If the gravitational force between the two is** $\boldsymbol{3.5 \times 10^{22}}$ **N, what is the mass of the Sun? (Use** $\boldsymbol{G = 6.7 \times 10^{-11}}$ **N·m² kg⁻²)**

Solution : Data : $m_1 = 6 \times 10^{24}$ kg,

$r = 1.5 \times 10^{11}$ m, $F = 3.5 \times 10^{22}$ N,

$G = 6.7 \times 10^{-11}$ N·m² kg⁻², $m_2 = ?$

$F = \frac{Gm_1m_2}{r^2}$

$$\therefore\ m_2 = \frac{Fr^2}{Gm_1} = \frac{3.5 \times 10^{22}\ \text{N} \times (1.5 \times 10^{11}\ \text{m})^2}{6.7 \times 10^{-11}\ \text{N·m}^2\text{kg}^{-2} \times 6 \times 10^{24}\ \text{kg}}$$

$$= \frac{3.5 \times 1.5 \times 1.5 \times 10^{44}}{6.7 \times 6 \times 10^{13}}\ \text{kg}$$

$$= \mathbf{1.96 \times 10^{30}\ kg}$$ **(mass of the Sun).**

(11) Find the magnitude of the acceleration due to gravity at the surface of the earth.

($M = 6 \times 10^{24}$ kg, $R = 6400$ km)

Solution : Data : $M = 6 \times 10^{24}$ kg,

$R = 6400$ km $= 6.4 \times 10^6$ m,

$G = 6.67 \times 10^{-11}\ \text{N·m}^2/\text{kg}^2$, $g = ?$

$$g = \frac{GM}{R^2}$$

$$= \frac{6.67 \times 10^{-11}\ \text{N·m}^2/\text{kg}^2 \times 6 \times 10^{24}\ \text{kg}}{(6.4 \times 10^6\ \text{m})^2}$$

$$= \frac{66.7 \times 6}{(6.4)^2}\ \text{m/s}^2 = 9.77\ \text{m/s}^2$$

The magnitude of the acceleration due to gravity at the surface of the earth = 9.77 m/s².

(12) The radius of planet A is half the radius of planet B. If the mass of A is M_A, what must be the mass of B so that the value of g on B is half that of its value on A?** ***(2 marks)

Solution : Data : $R_A = R_B/2$, $g_B = \frac{1}{2} g_A$, $M_B = ?$

$$g = \frac{GM}{R^2} \quad \therefore\ g_A = \frac{GM_A}{R_A^2} \text{ and } g_B = \frac{GM_B}{R_B^2}$$

$$\therefore\ \frac{g_B}{g_A} = \left(\frac{M_B}{M_A}\right)\left(\frac{R_A}{R_B}\right)^2$$

$$\therefore\ \frac{1}{2} = \left(\frac{M_B}{M_A}\right)\left(\frac{1}{2}\right)^2 = \frac{1}{4}\left(\frac{M_B}{M_A}\right)$$

$$\therefore\ \frac{M_B}{M_A} = \frac{4}{2} = 2$$

$$\therefore\ \mathbf{M_B = 2M_A}.$$

(13) An object takes 5 s to reach the ground from a height of 5 m on a planet. What is the value of g on the planet?** ***(2 marks) (Nov. '20)

Solution : Data : $u = 0$ m/s, $s = 5$ m, $t = 5$ s, $g = ?$

$$\therefore\ s = \frac{1}{2} gt^2$$

$$\therefore\ 5\ \text{m} = \frac{1}{2} g \times (5\ \text{s})^2 = \frac{1}{2} g \times 5\ \text{s} \times 5\ \text{s}$$

$$\therefore\ g = \frac{2}{5}\ \text{m/s}^2 = \mathbf{0.4\ m/s^2}$$ **(on the planet).**

(14) The mass of a planet is 3 times the mass of the earth. Its diameter is 25600 km and the earth's diameter is 12800 km. Find the acceleration due to gravity at the surface of the planet. **[g (earth) = 9.8 m/s²]**

Solution : Data : $\frac{M_2\ (\text{planet})}{M_1\ (\text{earth})} = 3$,

D_1 (earth) = 12800 km

$$\therefore\ R_1\ (\text{earth}) = \frac{12800\ \text{km}}{2} = 6400\ \text{km}$$

$$= 6.4 \times 10^6\ \text{m}$$

D_2 (planet) = 25600 km

$$\therefore\ R_2\ (\text{planet}) = \frac{25600\ \text{km}}{2} = 12800\ \text{km}$$

$$= 1.28 \times 10^7\ \text{m}$$

g_1 (earth) = 9.8 m/s², g_2 (planet) = ?

$$g = \frac{GM}{R^2} \quad \therefore\ g_1 = \frac{GM_1}{R_1^2},\ g_2 = \frac{GM_2}{R_2^2}$$

$$\therefore\ \frac{g_2}{g_1} = \left(\frac{M_2}{M_1}\right)\left(\frac{R_1}{R_2}\right)^2$$

$$\therefore\ g_2 = g_1\left(\frac{M_2}{M_1}\right)\left(\frac{R_1}{R_2}\right)^2$$

$$= 9.8\ \text{m/s}^2 \times 3 \times \left(\frac{6.4 \times 10^6\ \text{m}}{1.28 \times 10^7\ \text{m}}\right)^2$$

$$= \frac{9.8 \times 3}{4}\ \text{m/s}^2 = 7.35\ \text{m/s}^2$$

The acceleration due to gravity at the surface of the planet = 7.35 m/s².

(15) If the acceleration due to gravity on the surface of the earth is 9.8 m/s², what will be the acceleration due to gravity on the surface of a planet whose mass and radius both are two times the corresponding quantities for the earth?

Solution : Data : $g_e = 9.8$ m/s², $M_p = 2M_e$,

$R_p = 2R_e$, $g_p = ?$

Acceleration due to gravity, $g = \frac{GM}{R^2}$

$\therefore\ g_e = \dfrac{GM_e}{R_e^2}$ and $g_p = \dfrac{GM_p}{R_p^2}$

$\therefore\ \dfrac{g_p}{g_e} = \left(\dfrac{M_p}{M_e}\right)\left(\dfrac{R_e}{R_p}\right)^2 = 2 \times \left(\dfrac{1}{2}\right)^2 = \dfrac{1}{2}$

$\therefore\ g_p = \dfrac{g_e}{2} = \dfrac{9.8\ \text{m/s}^2}{2} = 4.9\ \text{m/s}^2$

The acceleration due to gravity on the surface of the planet = 4.9 m/s^2.

***(16) A stone thrown vertically upwards with initial velocity u reaches a height h before coming down. Show that the time taken to go up is same as the time taken to come down.**

Solution :

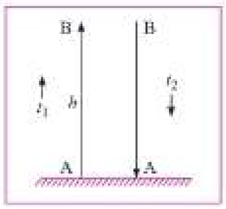


Fig. 1.11 : A → B, the stone moves upward; B → A, the stone moves downward

We have,

$v = u + at$ ... (1)

and $s = ut + \frac{1}{2}at^2$ ... (2)

$\therefore\ s = (v - at)\ t + \frac{1}{2}at^2$

$= vt - at^2 + \frac{1}{2}at^2$

$\therefore\ s = vt - \frac{1}{2}at^2$ ... (3)

As the stone moves upward from A → B, $s = AB = h$, $t = t_1$,

$a = -g$ (retardation),

$u = u$ and $v = 0$

$\therefore$ From Eq. (3), $h = 0 - \frac{1}{2}(-g)\,t_1^2$

$\therefore\ h = \frac{1}{2}gt_1^2$ ... (4)

As the stone moves downward from B → A,

$t = t_2$, $u = 0$, $s = h$ and $a = g$

$\therefore$ from Eq. (2), $h = \frac{1}{2}gt_2^2$ ... (5)

From Eqs. (4) and (5), $t_1^2 = t_2^2$

$\therefore\ t_1 = t_2$ ($\because$ t_1 and t_2 are positive)

***(17) An object thrown vertically upwards reaches a height of 500 m. What was its initial velocity? How long will the object take to come back to the earth? Assume g = 10 m/s^2.**

(3 marks) (July '19)

Solution : Data : $h = 500$ m, $g = 10$ m/s^2, $v = 0$ m/s, $u = ?$, t (for the object going up) + t (for the object coming down) = ?

As the object moves upward,

$v^2 = u^2 + 2as$

$= u^2 + 2(-g)h \quad (\because a = -g)$

Now, $v = 0$ m/s

$\therefore\ u^2 = 2gh = 2 \times 10\ \text{m/s}^2 \times 500\ \text{m}$

$\therefore\ u^2 = (100 \times 100)\ \text{m/s}^2$

$\therefore$ **u = 100 m/s (initial velocity of the body)**

Also, $v = u + at = u - gt$

For $v = 0$ m/s, $u = gt$

$\therefore\ 100\ \text{m/s} = 10\ \text{m/s}^2 \times t$

$\therefore\ t$ (for the object going up) = 10 s

Now, t (for the object coming down) = t (for the object going up) = 10 s

$\therefore\ t$ (for the object going up) + t (for the object coming down)

= 10 s + 10 s = 20 s

It will take 20 s for the object to come back to the earth.

***(18) A ball falls off a table and reaches the ground in 1 s. Assuming g = 10 m/s^2, calculate its speed on reaching the ground and the height of the table.**

Solution : Data : $t = 1$s, $g = 10$ m/s^2, $u = 0$ m/s, $s = ?$, $v = ?$

(i) $s = ut + \frac{1}{2}gt^2$

$= \frac{1}{2}gt^2$ for $u = 0$ m/s

$\therefore\ s = \frac{1}{2} \times 10\ \text{m/s}^2 \times (1\ \text{s})^2$

$= 5$ m

$\therefore$ **The height of the table = 5 m.**

(ii) $v = u + at = u + gt$

$= 0\ \text{m/s} + 10\ \text{m/s}^2 \times 1\ \text{s}$

$= 10$ m/s

$\therefore$ **The velocity of the ball on reaching the ground = 10 m/s.**

(19) A body is released from the top of a building of height 19.6 m. Find the velocity with which the body hits the ground.

Solution : Data : $h = 19.6$ m, $u = 0$ m/s, $g = 9.8$ m/s^2, $s = 19.6$ m, $v = ?$

$v^2 = u^2 + 2gs$

$= 2gs$ ... (as $u = 0$ m/s)

$= 2 \times 9.8 \text{ m/s}^2 \times 19.6 \text{ m}$

$= (19.6 \text{ m/s})^2$

$\therefore v = 19.6$ m/s (downward velocity)

The velocity with which the body hits the ground = 19.6 m/s (downward).

(20) A stone on a bridge on a river falls into the river. If it takes 3 seconds to reach the surface of water, find (i) the velocity of the stone at the instant it touches the surface of water (ii) the height of the bridge from the surface of water.

Solution : Data : $u = 0$ m/s, $t = 3$ s, $g = 9.8$ m/s^2, $v = ?$, $h = ?$

(i) $v = u + gt = 0 \text{ m/s} + 9.8 \text{ m/s}^2 \times 3 \text{ s}$

$= 29.4$ m/s

The velocity of the stone at the instant it touches the surface of water = 29.4 m/s

(ii) $s = ut + \frac{1}{2}gt^2$

$= 0 \text{ m/s} \times 3 \text{ s} + \frac{1}{2} (9.8 \text{ m/s}^2)(3 \text{ s})^2$

$= 4.9 \times 9 \text{ m} = 44.1 \text{ m}$

$\therefore$ **The height of the bridge from the surface of water = 44.1 m.**

(21) A stone is dropped from rest from the top of a building 44.1 m high. It takes 3 s to reach the ground. Use this information to calculate *g*.

Solution : Data : $u = 0$ m/s, $h = 44.1$ m

$\therefore s = 44.1$ m, $t = 3$ s, $g = ?$

$s = ut + \frac{1}{2}at^2 = \frac{1}{2}at^2$ ($\because u = 0$ m/s)

$\therefore a = \frac{2s}{t^2} = \frac{2 \times (44.1 \text{ m})}{(3 \text{ s})^2}$

$= \frac{88.2}{9} \text{ m/s}^2 = 9.8 \text{ m/s}^2.$

It is the acceleration due to gravity.

$\boldsymbol{g = 9.8 \text{ m/s}^2}$.

(22) A metal ball of mass 5 kg falls from a height of 490 m. How much time will it take to reach the ground? ($g = 9.8$ m/s^2)

(2 marks) (March '19)

Solution : Data : $s = 490$ m, $a = g = 9.8$ m/s^2, $u = 0$ m/s, $s = ut + \frac{1}{2}at^2$

$\therefore 490 = 0 \times t + \frac{1}{2} \times 9.8 \times t^2 = 4.9t^2$

$\therefore t^2 = \frac{490}{4.9} = 100$

$\therefore \boldsymbol{t = 10 \text{ s}}$ This is the required time.

(23) An iron ball of mass 3 kg is released from a height of 125 m and falls freely to the ground. Assuming that the value of g is 10 m/s^2, calculate (a) the time taken by the ball to reach the ground (b) the velocity of the ball on reaching the ground. ***(3 marks) (Nov. '20)***

Solution : Data : $s = h = 125$ m, $a = g = 10$ m/s^2, $u = 0$ m/s, $t = ?$, $v = ?$

(a) According to Newton's second equation of motion,

$s = ut + \frac{1}{2}at^2$

$\therefore 125 = 0 \times t + \frac{1}{2} \times 10 \times t^2$

$\therefore 125 = 5t^2$

$\therefore t^2 = \frac{125}{5} = 25$

$\therefore t = 5$ s

The ball takes 5 s to reach the ground.

(b) According to Newton's first equation of motion,

$v = u + at$

$\therefore v = 0 + 10 \times 5 = 50$ m/s

The velocity of the ball on reaching the ground is 50 m/s.

(24) If the weight of a body on the surface of the moon is 100 N, what is its mass?

($g = 1.63$ m/s^2)

Solution : Data : $W = 100$ N, $g = 1.63$ m/s^2, $m = ?$

$\therefore\ W = mg$

$\therefore\ m = \frac{W}{g} = \frac{100\ \text{N}}{1.63\ \text{m/s}^2} = 61.35\ \text{kg}$

The mass of the body = 61.35 kg.

(25) A 100 kg bag of wheat is placed on a plank of wood. What is the weight of the bag and what is the reaction force exerted by the plank?

Solution : Data : $m = 100\,\text{kg}$, $g = 9.8\ \text{m/s}^2$, $W = $ **?**, reaction force = **?**

Magnitude of the weight,

$W = mg = 100\ \text{kg} \times 9.8\ \text{m/s}^2 = 980\ \text{N}$

The weight of the bag = 980 N acting downward.

The reaction force exerted by the plank on the bag = 980 N acting upward.

***(26) The mass and weight of an object on the earth are 5 kg and 49 N respectively. What will be their values on the moon? Assume that the acceleration due to gravity on the moon is 1/6th of that on the earth.**

Solution : Data : $m = 5$ kg, $W = 49$ N, $g_{\text{M}} = \frac{g_{\text{E}}}{6}$, m (on the moon) = ?, W (on the moon) = ?

(i) The mass of the object on the moon = the mass of the object on the earth = **5 kg**

(ii) $W = mg$

$\therefore\ \frac{W_{\text{M}}}{W_{\text{E}}} = \frac{mg_{\text{M}}}{mg_{\text{E}}} = \frac{g_{\text{M}}}{g_{\text{E}}} = \frac{1}{6}$

$\therefore\ W_{\text{M}} = \frac{W_{\text{E}}}{6} = \frac{49\ \text{N}}{6} =$ **8.167 N (weight of the object on the moon).**

(27) Find the gravitational potential energy of a body of mass 10 kg when it is on the earth's surface. [M(earth) = 6×10^{24} kg, R(earth) = 6.4×10^6 m, $G = 6.67 \times 10^{-11}\,\text{N·m}^2/\text{kg}^2$]

Solution : Data : $m = 10$ kg, $M = 6 \times 10^{24}$ kg, $R = 6.4 \times 10^6$ m, $G = 6.67 \times 10^{-11}\ \text{N·m}^2/\text{kg}^2$

The gravitational potential energy of the body

$= -\frac{GMm}{R}$

$= -\frac{6.67 \times 10^{-11}\ \text{N·m}^2/\text{kg}^2 \times 6 \times 10^{24}\ \text{kg} \times 10\ \text{kg}}{6.4 \times 10^6\ \text{m}}$

$= -\frac{6.67 \times 6}{6.4} \times 10^8\ \text{J} = \mathbf{-6.253 \times 10^8\ J.}$

(28) If the body in Ex. (27) performs uniform circular motion around the earth at a height of 3600 km from the earth's surface, what will be its gravitational potential energy?

Solution : Here, $h = 3600\ \text{km} = 3.6 \times 10^6$ m

$\therefore$ The gravitational potential energy of the body

$= -\frac{GMm}{R + h}$

$= -\frac{6.67 \times 10^{-11}\ \text{N·m}^2/\text{kg}^2 \times 6 \times 10^{24}\ \text{kg} \times 10\ \text{kg}}{(6.4 \times 10^6 + 3.6 \times 10^6)\ \text{m}}$

$= -\frac{6.67 \times 6 \times 10^{14}}{10 \times 10^6}\ \text{J} = \mathbf{-4.002 \times 10^8\ J.}$

(29) A body of mass 20 kg is at rest on the earth's surface. (i) Find its gravitational potential energy. (ii) Find the kinetic energy to be provided to the body to make it free from the gravitational influence of the earth.

($g = 9.8$ m/s², $R = 6400$ km) [HOTS]

Solution : Data : $m = 20$ kg, $g = 9.8\ \text{m/s}^2$, $R = 6400\ \text{km} = 6.4 \times 10^6$ m

(i) The gravitational potential energy of the body

$= -\frac{GMm}{R} = -mgR \qquad \left(\because\ g = \frac{GM}{R^2}\right)$

$= -20\ \text{kg} \times 9.8\ \text{m/s}^2 \times 6.4 \times 10^6\ \text{m}$

$= \mathbf{-1.2544 \times 10^9\ J.}$

(ii) To make the body free from the gravitational influence of the earth, it should be provided kinetic energy equal to $\mathbf{1.2544 \times 10^9\ J.}$

(30) If the body in Ex. (29) is moving at 100 m/s on the earth's surface, what will be its (i) kinetic energy (ii) total energy?

Solution : Data : $m = 20$ kg, $v = 100$ m/s

(i) The kinetic energy of the body

$= \frac{1}{2}mv^2 = \frac{1}{2} \times 20\ \text{kg} \times (100\ \text{m/s})^2 = \mathbf{10^5\ J.}$

(ii) The total energy of the body = kinetic energy + potential energy $= 10^5\ \text{J} + (-1.2544 \times 10^9\ \text{J})$

$= (1 - 12544) \times 10^5\ \text{J} = -12543 \times 10^5\ \text{J}$

$= \mathbf{-1.2543 \times 10^9\ J.}$

(31) A satellite of mass 100 kg performs uniform circular motion around the earth at a height of 6400 km from the earth's surface. Find its gravitational potential energy.

[$g = 9.8\ m/s^2$, $R = 6400$ km]

Solution : Data : $m = 100$ kg, $g = 9.8\ m/s^2$,
$R = 6400\ km = 6.4 \times 10^6$ m, $h = 6.4 \times 10^6$ m

The gravitational potential energy of the satellite

$$= -\frac{GMm}{R+h} = -\frac{mgR^2}{R+h} \qquad \left(\because g = \frac{GM}{R^2}\right)$$

$$= -\frac{100\ kg \times 9.8\ m/s^2 \times (6.4 \times 10^6\ m)^2}{(6.4 \times 10^6 + 6.4 \times 10^6)\ m}$$

$$= -\frac{9.8 \times 6.4 \times 6.4 \times 10^{14}}{2 \times 6.4 \times 10^6}\ J = -9.8 \times 3.2 \times 10^8\ J$$

$$= \mathbf{-3.136 \times 10^9\ J.}$$

(32) Find the escape velocity of a body from the earth. [M(earth) $= 6 \times 10^{24}$ kg, R(earth) $= 6.4 \times 10^6$ m, $G = 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$]

Solution : Data : $M = 6 \times 10^{24}$ kg, $R = 6.4 \times 10^6$ m, $G = 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$

The escape velocity of a body from the earth,

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

$$= \sqrt{\frac{2 \times 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2 \times 6 \times 10^{24}\ kg}{6.4 \times 10^6\ m}}$$

$$= \sqrt{\frac{12 \times 6.67 \times 10^8}{64}}$$

$$= \mathbf{1.118 \times 10^4\ m/s = 11.18\ km/s.}$$

(33) Find the escape velocity of a body from the earth. [R (earth) $= 6.4 \times 10^6$ m, ρ(earth) $= 5.52 \times 10^3\ kg/m^3$, $G = 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$]

Solution : Data : $R = 6.4 \times 10^6$ m,
$\rho = 5.52 \times 10^3\ kg/m^3$, $G = 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$

The escape velocity of a body from the earth,

$$v_{esc} = 2R\sqrt{\frac{2}{3}G\pi\rho}$$

$$= 2 \times 6.4 \times 10^6\ m \times$$

$$\sqrt{\frac{2}{3} \times 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2 \times 3.142 \times 5.52 \times 10^3\ kg/m^3}$$

$$= 1.28 \times 10^3 \times \sqrt{\frac{13.34 \times 3.142 \times 5.52}{3}}$$

$$= \mathbf{11.24 \times 10^3\ m/s = 11.24\ km/s.}$$

(34) Calculate the escape velocity of a body from the moon. [g (moon) $= 1.67\ m/s^2$, R(moon) $= 1.74 \times 10^6$ m]

Solution : Data : $g = 1.67\ m/s^2$, $R = 1.74 \times 10^6$ m

The escape velocity of a body from the moon,

$$v_{esc} = \sqrt{2gR}$$

$$= \sqrt{2 \times 1.67\ m/s^2 \times 1.74 \times 10^6\ m}$$

$$= \mathbf{2.411 \times 10^3\ m/s = 2.411\ km/s.}$$

(35) The mass of a planet is four times that of the earth and its radius is double the radius of the earth. The escape velocity of a body from the earth is 11.2×10^3 m/s. Find the escape velocity of a body from the planet.

Solution : Data : $M_2 = 4M_1$, $R_2 = 2R_1$,
$v_{1esc} = 11.2 \times 10^3$ m/s

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

$$\therefore \frac{v_{2esc}}{v_{1esc}} = \sqrt{\frac{M_2}{M_1} \times \frac{R_1}{R_2}} = \sqrt{4 \times \frac{1}{2}} = \sqrt{2}$$

$$\therefore v_{2esc} = \sqrt{2}\,v_{1esc} = 1.414 \times 11.2 \times 10^3\ m/s$$

$$= \mathbf{15.84 \times 10^3\ m/s = 15.84\ km/s}$$

This is the escape velocity of a body from the planet.

NUMERICAL PROBLEMS FOR PRACTICE

[$G = 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$, mass of the earth $= 6 \times 10^{24}$ kg, radius of the earth $= 6.4 \times 10^6$ m]

1. A satellite of mass 1000 kg revolves around the earth in a circular path. If the distance between the satellite and the centre of the earth is 40000 km, find the gravitational force exerted on the satellite by the earth.
(**Ans.** 250.1 N)
2. The masses of two spheres are 10 kg and 20 kg respectively. If the distance between their centres is 100 m, find the magnitude of the gravitational force between them.
(**Ans.** 1.334×10^{-12} N)

3. A satellite revolves around the earth along circular path. If the mass of the satellite is 1000 kg and its distance from the centre of the earth is 20000 km, find the magnitude of the earth's gravitational force acting on the satellite. (**Ans.** 1000.5 N)

4. Find the acceleration due to gravity at a distance of 20000 km from the centre of the earth. (**Ans.** 1.0 m/s^2)

5. What is the weight of a body of mass 100 kg at the south pole? ($g = 9.832 \text{ m/s}^2$) (**Ans.** 983.2 N downward)

6. What is the weight of a body of mass 20 kg at the equator? ($g = 9.78 \text{ m/s}^2$) (**Ans.** 195.6 N downward)

7. A body is released from the top of a tower of height 50 m. Find the velocity with which the body hits the ground. ($g = 9.8 \text{ m/s}^2$) [**Ans.** 31.3 m/s (downward)]

8. A body is thrown vertically upward with a velocity of 9.8 m/s. Calculate the maximum height attained by the body. ($g = 9.8 \text{ m/s}^2$) (**Ans.** 4.9 m)

9. A particle of mass 10^{-6} kg performs uniform circular motion. Its period is 10 s and the radius of the circle is 2 m. Find (i) the speed of the particle (ii) the centripetal acceleration of the particle (iii) the centripetal force on the particle. [**Ans.** (i) 1.257 m/s (ii) 0.79 m/s^2 (iii) 7.9×10^{-7} N]

10. Find the gravitational potential energy of a body of mass 200 kg on the earth's surface. [M(earth) $= 6 \times 10^{24}$ kg, R(earth) $= 6400$ km] (**Ans.** -1.251×10^{10} J)

11. Find the gravitational potential energy of a body of mass 10 kg when it is at a height of 6400 km from the earth's surface. [Given: mass of the earth and radius of the earth. See Ex. 10 above.] (**Ans.** -3.127×10^8 J)

12. Find the escape velocity of a body from the moon. [M(moon) $= 7.36 \times 10^{22}$ kg, R(moon) $= 1.74 \times 10^6$ m] (**Ans.** 2.375 km/s)

PROJECT

*Take weights of five of your friends. Find out what their weights will be on the moon and Mars.

Help : The weight of a body :

(i) On the earth, $W_1 = mg_1$ (ii) on the moon, $W_2 = mg_2$ (iii) on Mars, $W_3 = mg_3$

$\therefore \; W_2 = W_1 \times \frac{g_2}{g_1}$ and $W_3 = W_1 \times \frac{g_3}{g_1}$

Now, $g_1 = 9.81 \text{ m/s}^2$, $g_2 = 1.67 \text{ m/s}^2$ and $g_3 = 3.72 \text{ m/s}^2$

If $W_1 = 500$ N,

$W_2 = 500 \times \frac{1.67}{9.81}$ N $= 85.12$ N (approx.)

and $W_3 = 500 \times \frac{3.72}{9.81}$ N $= 189.6$ N (approx.)

MEMORY MAP / CONCEPT MAP

(1)

Planetary motion : Kepler's laws

- Elliptical orbit with the Sun at one of the foci
- The line joining the planet and the Sun sweeps equal areas in equal intervals of time
- $T^2 \propto r^3$

(2)

Newton's law of gravitation

- $F = G\dfrac{m_1 m_2}{r^2}$ Universal law G : universal gravitational constant
- Gravitational acceleration $g = \dfrac{GM}{r^2}$ $(r \geqslant R)$
- $W = mg = \dfrac{GmM}{R^2}$ (on the surface of a planet)
- Gravitational potential energy $-\dfrac{GMm}{R+h}$
- Escape velocity $v_{esc} = \sqrt{\dfrac{2GM}{R}} = \sqrt{2gR}$
- g changes from place to place. On the earth's surface, maximum at the poles, minimum at the equator, g varies with altitude, depth below the earth's surface, becomes zero at the centre of the earth
- Explains the motion of the falling bodies, motion of the moon around the earth, motion of the planets, asteroids, comets around the Sun, tides due to the moon and the Sun

(3)

Kinematical equations of motion

$v = u + at$, $s = ut + \dfrac{1}{2}at^2$, $v^2 = u^2 + 2as$ (When a body moves vertically upward, $a = -9.8 \text{ m/s}^2$)

Did you study the lesson/chapter from the **Navneet Digest**? Now, solve the self-test to ensure solid learning. Scan this **QR Code** for the test and its model answers.

2 PERIODIC CLASSIFICATION OF ELEMENTS

CHAPTER OUTLINE

IMPORTANT POINTS

2.1 Elements and their classification :

Can you recall? (Textbook page 16)

(1) What are the types of matter?

Ans. The types of matter are solid, liquid, gas and plasma.

(2) What are the types of elements?

Ans. The types of elements are metals, nonmetals and metalloids.

(3) What are the smallest particles of matter called?

Ans. The smallest particles are called atoms.

(4) What is the difference between the molecules of elements and compounds?

Ans. (1) Elements contain only one kind of atoms in the free state or combined state. (2) An element cannot be decomposed into simple substances by any chemical reaction or simple physical process, e.g. copper, iron, oxygen. (3) A compound is produced by a chemical reaction of two or more elements. (4) The constituents of a compound can be separated by a chemical process, e.g. salt, water and sugar.

2.2 Dobereiner's Triads :

- **Dobereiner's Triads :** In the year 1817 Dobereiner (a German scientist) proved that the properties of elements are related to their atomic masses. He made groups of three elements each, showing similar chemical properties and called them triads. He arranged the three elements in a triad in an increasing order of atomic mass and showed that the atomic mass of the middle element was approximately equal to the mean of the atomic masses of the other two elements.

Sr. No.	Triad	Element – 1 Actual atomic mass (a)	Element–2		Element–3 Actual atomic mass (c)
			mean $= \frac{a+c}{2}$	Actual atomic mass	
1.	Li, Na, K	Lithium (Li) 6.9	Sodium $\frac{6.9+39.1}{2} = 23.0$	(Na) 23.0	Potassium (K) 39.1
2.	Ca, Sr, Ba	Calcium (Ca) 40.1	Strontium $\frac{40.1+137.3}{2} = 88.7$	(Sr) 87.6	Barium (Ba) 137.3
3.	Cl, Br, I	Chlorine (Cl) 35.5	Bromine $\frac{35.5+126.9}{2} = 81.2$	(Br) 79.9	Iodine (I) 126.9

2.3 Newlands Law of Octaves :

1. **Newlands' Law of Octaves :** In the year 1866, Newlands arranged the elements known at that time in an increasing order of their atomic masses, he found that every eighth element had properties similar to those of the first. For example, sodium is the eighth element from lithium and both have similar properties.

2. Limitations of Newlands' Octaves :

(1) Newlands could arrange 56 elements only up to calcium in an increasing order of their atomic masses.

(2) This arrangement started with the lightest element hydrogen and ended up with thorium.

(3) Newlands placed the metals Co and Ni under the note Do along with halogens, while Fe having similarity with Co and Ni, away from them along with the nonmetals O and S under the note Ti.

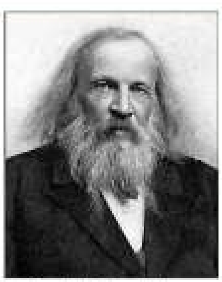
(4) The properties of the new elements discovered later did not fit in the Newlands' law of octaves.

2.4 Mendeleev's Periodic Table :

1. Mendeleev's Periodic table : The most important step in the classification of elements in Mendeleev's periodic table is the fundamental property of elements, namely, the atomic mass, as standard. He arranged 63 elements known at that time in an increasing order of their atomic masses. Then he transformed this into the periodic table of elements according to their physical and chemical properties. Mendeleev found that the elements with similar physical and chemical properties repeat after a definite interval.

2. Mendeleev's periodic law : The elements with physical and chemical properties are a periodic function of their atomic masses.

Introduction to scientist :
Dmitri Mendeleev (1834–1907) was a professor in the St. Petersburg University. He made a separate card for every known element showing its atomic mass. He arranged the cards in accordance with the atomic masses and properties of the elements which resulted in the invention of the periodic table of elements.



Dmitri Mendeleev

The vertical columns in the periodic table are called groups while the horizontal rows are called periods.

3. Merits of Mendeleev's periodic table :

(1) To give the proper place in the periodic table, atomic masses of some elements were revised in accordance with their properties. For example, the previously determined atomic mass of beryllium, 14.09, was changed to the correct value 9.4, and beryllium was placed before boron.

(2) Mendeleev had kept some vacant places in the periodic table for elements that were yet to be discovered. Three of these unknown elements were given the names eka-boron, eka-aluminium and eka-silicon from the known neighbours and their atomic masses were indicated as 44, 68 and 72, respectively. Their properties were also predicted. Later on these elements were discovered subsequently and were named as scandium (Sc), gallium (Ga) and germanium (Ge) respectively. The properties of these elements matched well with those predicted by Mendeleev. Due to this success all were convinced about the importance of Mendeleev's periodic table.

(3) When noble gases such as helium, neon and argon were discovered, Mendeleev created the 'zero group' without disturbing the original periodic table in which the noble gases were placed very well.

4. Demerits of Mendeleev's periodic table :

(1) The elements cobalt (Co) and nickel (Ni) have the same whole number atomic mass. As a result there was an ambiguity regarding their sequence in Mendeleev's periodic table.

(2) Isotopes were discovered long time after Mendeleev put forth the periodic table. A challenge was posed in placing isotopes in Mendeleev's periodic table as isotopes have

the same chemical properties but different atomic masses.

(3) The rise in atomic mass does not appear to be uniform when elements are arranged in an increasing order of atomic masses. It was not possible, therefore, to predict the number of elements that could be discovered between two heavy elements.

(4) Position of hydrogen : Hydrogen shows similarity with halogens (group VII). It is difficult to decide the correct position of hydrogen whether it is in the group of alkali metals (group I) or in the group of halogens (group VII).

2.5 Modern Periodic Table :

1. **Modern Periodic Law :** Henry Moseley showed that the atomic number of an element is the most fundamental property and not its atomic mass. Accordingly Mendeleev's Periodic law was modified into Modern Periodic law and it can be stated as : The chemical and physical properties of elements are a periodic function of their atomic numbers.

In the modern periodic table, the elements are arranged in the order of their increasing atomic numbers. There are seven horizontal rows called periods 1 to 7. There are eighteen vertical columns called groups 1 to 18. The arrangement of the periods and groups results into formation of boxes. Each box corresponds to the place for one element. There are two series of elements placed separately at the bottom of the periodic table. These are called lanthanide series and actinide series. There are 118 boxes in the periodic table including the two series.

The elements in the modern periodic table are divided into four blocks : the *s*-block, the *p*-block, the *d*-block and the *f*-block. The groups, 1 and 2 together with hydrogen form the *s*-block elements. The groups 13 to 18 form the *p*-block elements. The groups 3 to 12 together form the *d*-block elements. The two series (the lanthanides and actinides) at the bottom of the periodic table together form the *f*-block elements.

The *d*-block elements are called transition elements. A zig-zag line is seen in the *p*-block of the periodic table. The metalloid elements lie along the border of this zig-zag line. All the metals lie on the left side of zig-zag line while all the nonmetals lie on the right side.

2. **Modern Periodic Table and electronic configuration of the elements :** The characteristics of the groups and periods in the modern periodic table are because of electronic configuration of the elements. It is the electronic configuration of an element which decides the group and the period in which it is to be placed. The neighbouring elements within a period differ slightly in their properties while distant elements differ widely in their properties. Elements in the same group show similarity and gradation in their properties.

3. **Groups and electronic configuration :**

Textbook page 22

Characteristics of the Groups and Periods.

Various properties of all the elements in a group show similarity and gradation. However, the properties of elements change slowly while going from one end to the other (for example, from left to right) in a particular period.

The number of valence electrons in all these elements from the group 1, i.e. the family of alkali metals, is the same. Similarly, the element from any other group, the number of their valence electrons to be the same. For example, the elements beryllium (Be), magnesium (Mg) and calcium (Ca) belong to the group 2, i.e. the family of alkaline earth metals. There are two electrons in their outermost shell the number of valence electrons are 2. Similarly, there are seven electrons in the outermost shell of the elements such as fluorine (F) and chlorine (Cl) from the group 17, i.e., the family of halogens. While going from top to bottom within any group, one electronic shell is added at a time. From this, the electronic configuration of the outermost shell is characteristics of a particular group.

In the modern periodic table :

(1) Elements are arranged in an increasing order of their atomic numbers.

(2) Vertical columns are called groups. There are 18 groups. The chemical properties of the elements in the same group show similarity and gradation.

• Do you know? (Textbook page 22)

Uranium has atomic number 92. All the elements beyond uranium (with atomic numbers 93 to 118) are manmade. All these elements are radioactive and unstable, and have a very short life.

4. Periods and electronic configuration :

(1) In modern periodic table, there are seven horizontal rows called periods. In a period, the change in valency of an element varies with electronic configuration.

(2) In a period, while going from left to right, the atomic number increases by one at a time and number of valence electrons also increases by one at a time. In a period, there is gradation in properties of elements.

(3) The elements with the same number of shells occupied by electrons belong to the same period. The elements in the second period, have electrons in the two shells, K and L. The elements in the third period have electrons in the three shells; K, L and M.

The chemical reactivity of an element is determined by the number of valence electrons in it and the shell number of the valence shell.

Periodic trends in the modern periodic table : When the properties of elements in a period or a group of the modern periodic table are compared, certain regularity is observed in their variations. It is called the periodic trends in the modern periodic table. Valency, atomic size and metallic-nonmetallic character are some properties which show periodic trends in the modern periodic table.

Valency : The valency of an element is determined by the number of electrons present in the outermost shell of its atoms, that is, the valence electrons.

Can you recall? (Textbook page 24)

Shell	n	$2n^2$	Electron capacity
K	1	2×1^2	2
L	2	2×2^2	8
M	3	2×3^2	18
N	4	2×4^2	32

(1) What are the values of n for the shells K, L and M?

Ans. For the shell K, the value of n is 1.

For the shell L, the value of n is 2.

For the shell M, the value of n is 3.

(2) What is the maximum number of electrons that can be accommodated in a shell? Write the formula.

Ans. The maximum number of electrons that can be accommodated in a shell is 32 electrons. The formula is $2n^2$.

(3) Deduce the maximum electron capacity of the shells K, L and M.

Ans. For the shell K, the maximum electron capacity is 2 electrons.

For the shell L, the maximum electron capacity is 8 electrons.

For the shell M, the maximum electron capacity is 18 electrons.

5. Atomic size : The size of an atom is indicated by its radius. Atomic radius is the distance between the nucleus of the atom and its outermost shell. Atomic radius is expressed in the unit picometre (pm) which is smaller than nanometre ($1 \text{ pm} = 10^{-12}$ m).

Atomic size depends on number of shells of an atom. More the number of shells larger is the atomic size.

While going down a group the atomic size goes on increasing. This is because while going down a group a new shell is added. Therefore the distance between the outermost electrons and the nucleus goes on increasing. As a result of this the atomic size increases.

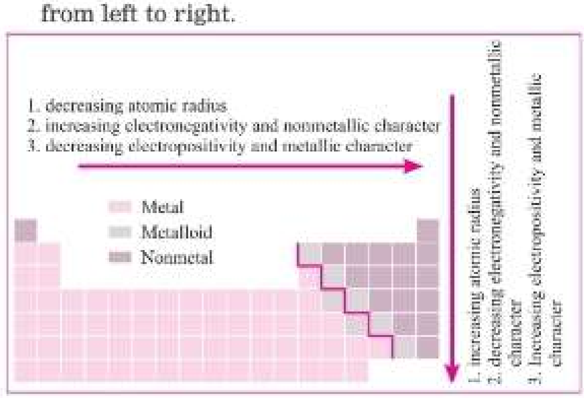
While going from left to right within a period atomic radius goes on decreasing and the atomic number increases one by one, that means positive charge on the nucleus increases by one unit at a time. However, the additional electron gets added to the same outermost shell. Due to the increased nuclear charge the electrons are pulled towards the nucleus to a greater extent and thereby the size of the atom decreases.

6. **Metallic-Nonmetallic character :** It is observed that the metallic elements like sodium, magnesium are towards the left. The nonmetallic elements such as sulphur, chlorine are towards the right. The metalloid element silicon lies in between these two types.

> (1) While going downwards in any group the electropositivity of elements goes on increasing while their electronegativity goes on decreasing. (2) While going from left to right in any period the electronegativity of elements goes on increasing while their electropositivity goes on decreasing. (3) Larger the electropositivity or electro-negativity of the element higher the reactivity.

The periodic trend in the metallic character of elements is clearly understood from their position is the modern periodic table. In a group, while going down a group a new shell is added, resulting in an increase in the distance between the nucleus and the valence electrons. This results in lowering the effective nuclear charge and thereby lowering the attractive force on the valence electrons. As a result of this the tendency of the atom to lose electrons increases. Also the penultimate shell becomes the outermost shell on losing valence electrons. The penultimate shell is a complete octet. Therefore, the resulting cation attains special stability. The metallic character of an atom is its tendency to lose electrons. Therefore, the following trend is observed : The metallic character of elements increases while going down the group.

While going from left to right within a period the outermost shell remains the same. However, the positive charge on the nucleus goes on increasing while the atomic radius goes on decreasing and thus the effective nuclear charge goes on increasing. Therefore valence electrons are held with greater attractive force. This is called electronegativity. As a result of this the tendency of atom to lose valence electrons decreases within a period from left to right, i.e. electronegativity increases. Thus, non metallic character of elements increases within a period from left to right.



Periodic Trends in elements

7. **Gradation in Halogen Family :** The group 17 contains the members of the halogen family. All of them have the general formula X_2. A gradation is observed in their physical state down the group. Thus, fluorine (F_2) and chlorine (Cl_2) are gases, bromine (Br_2) is a liquid while iodine (I_2) is a solid.

8. Reaction of alkaline earth metal with water :

A general chemical equation indicating the reaction of alkaline earth metals is $M + 2H_2O \rightarrow M(OH)_2 + H_2$. While going down the second group as Be → Mg → Ca → Sr → Ba, the gradation in this chemical property of the alkaline earth metals is observed. While going down the second group the reactivity of the alkaline earth metals goes on increasing and thereby the ease with which this reaction takes place also goes on increasing. Thus beryllium (Be) does not react with water. Magnesium (Mg) reacts with steam, while calcium (Ca), strontium (Sr) and barium (Ba) react with water at room temperature with increasing rates.

QUESTIONS & ANSWERS

Q. 1 Fill in the blanks :

(1) Using Dobereiner's law of triads, find the missing number. $\frac{Li}{7}, \frac{Na}{\ldots\ldots}, \frac{K}{39}$.

(2) In the Mendeleev's periodic table, properties of elements are periodic function of their ....

(3) The vertical columns in the Mendeleev's periodic table are called ....

(4) Eka-aluminium is called ....

(5) Zero group elements are called ....

(6) In the modern periodic table, the elements are the periodic functions of ....

(7) The d-block elements are called ....

(8) The group ...... contains the members of the halogen family.

(9) ...... is the distance between the nucleus of the atom and its outermost shell.

(10) The number of electrons in an atom is equal to the same of ....

(11) Henry Moseley showed that the atomic number (Z) of an element corresponds to the positive charge on the nucleus or the number of ....

(12) The ...... -block contains the group 1 and 2.

(13) The elements are arranged in such a way that ...... are on left side of zig-zag line and ...... on the right side.

Ans.

(1) Using Dobereiner's law of triads, the missing number is $\frac{Li}{7}, \frac{Na}{\underline{23}}, \frac{K}{39}$.

(2) In the Mendeleev's periodic table, properties of elements are periodic function of their atomic masses.

(3) The vertical columns in the Mendeleev's periodic table are called groups.

(4) Eka-aluminium is called gallium.

(5) Zero group elements are called noble gases.

(6) In the modern periodic table, the elements are the periodic functions of atomic numbers.

(7) The d-block elements are called transition elements.

(8) The group 17 contains the members of the halogen family.

(9) Atomic radius is the distance between the nucleus of the atom and its outermost shell.

(10) The number of electrons in an atom is equal to the same of atomic number.

(11) Henry Moseley showed that the atomic number (Z) of an element corresponds to the positive charge on the nucleus or the number of protons.

(12) The *s*-block contains the group 1 and 2.

(13) The elements are arranged in such a way that metals are on left side of zig-zag line and nonmetals on the right side.

Q. 2 Choose the correct alternative and write it along with its allotted alphabet : *(1 mark each)*

*(1) The number of electrons in the outermost shell of alkali metals is ______.

(a) 1 (b) 2 (c) 3 (d) 7

*(2) Alkaline earth metals have valency 2. This means that their position in the modern periodic table is in ______.

(a) Group 2 *(b) Group 16*
(c) Period 2 *(d) d-block*

*(3) Molecular formula of the chloride of an element X is XCl. This compound is a solid having high melting point. Which of the following elements be present in the same group as X.

(a) Na (b) Mg (c) Al (d) Si

*(4) In which block of the modern periodic table are the nonmetals found?

(a) s-block *(b) p-block*
(c) d-block *(d) f-block*

(5) Which of the following triads does not follow Dobereiner's law of triads?

(a) Li, Na, K *(b) Ca, Sr, Ba*
(c) Be, Mg, Ca *(d) Cu, Ag, Au*

(6) During Newlands' time ______ elements were known.

(a) 56 (b) 65 (c) 63 (d) 36

(7) Halogens belong to group ______ in the modern periodic table.

(a) 15 (b) 16 (c) 17 (d) 18

(8) Noble gases belong to group ______ in the modern periodic table.

(a) 15 (b) 16 (c) 17 (d) 18

(9) The law of octaves was given by ______.

(a) Dobereiner *(b) Newlands*
(c) Mendeleev *(d) Moseley*

(10) Eka-boron was subsequently named as ______.

(a) gallium *(b) germanium*
(c) scandium *(d) molybdenum*

(11) The halogen which is liquid at room temperature is ________.

(Practice Activity Sheet – 3)

(a) fluorine (b) astetine (c) bromine (d) iodine

(12) ________ is used in balloons and in scuba diving.

(a) Helium *(b) Oxygen*
(c) Nitrogen *(d) Ozone*

(13) The number of electrons in the outermost shell of alkaline earth metals is ________

(a) 1 (b) 2 (c) 3 (d) 7

(Board's Model Activity Sheet)

(14) According to Mendeleev's periodic law, properties of elements are periodic function of their ________

(a) atomic numbers *(b) atomic masses*
(c) densities *(d) boiling points*

(March '20)

(15) Lithium (Li), ________ and potassium (K) is Dobereiner's triad.

(a) magnesium (Mg) *(b) aluminium (Al)*
(c) sodium (Na) *(d) calcium (Ca)*

(Nov. '20)

Ans.

(1) (a) 1 (2) (a) Group 2 (3) (a) Na (4) (b) *p*-block (5) (d) Cu, Ag, Au (6) (a) 56 (7) (c) 17 (8) (d) 18 (9) (b) Newlands (10) (c) scandium (11) (c) bromine (12) (a) Helium (13) (b) 2 (14) (b) atomic masses (15) (c) sodium (Na)

Q. 3 State whether the following statements are *True* or *False* : *(1 mark each)*

(1) Newlands was the first to classify elements having similar chemical properties into groups of three.

(2) Dobereiner named the group of elements having similar properties as Triads.

(3) Dobereiner stated the law of octet.

(4) Newlands stated the law of triads.

(5) Eka-aluminium was later named as germanium.

(6) Mendeleev's periodic table is more useful because it gives information about known and unknown elements.

(7) Mendeleev arranged elements in the increasing order of their atomic masses.

(8) Mendeleev was the first who successfully classified all known elements.

(9) In the modern periodic table, properties of the elements are a periodic function of their atomic numbers.

(10) The *d*-block elements are called transition elements.

(11) There are 7 periods in the long form of the periodic table.

(12) Elements are classified on the basis of their atomic numbers.

(13) The chemical properties of the elements in the same group show similarity.

(14) Lanthanides and actinides are also called the *d*-block elements.

(15) All the elements of a group have the same number of valence electrons.

(16) In a period, atomic sizes increases from left to right.

(17) In a period, the metallic character increases from left to right.

(18) In a group, the metallic character decreases from top to bottom.

(19) The zig-zag line separates the metals from nonmetals in the periodic table i.e. metals are on the left side and nonmetals are on the right side.

Ans.

(1) **False.** (Dobereiner was the first to classify elements having similar chemical properties into groups of three.)

(2) **True.**

(3) **False.** (Dobereiner stated the law of triads.)

(4) **False.** (Newlands stated the law of octaves.)

(5) **False.** (Eka-aluminium was later named as gallium.)

(6) **True.** (7) **True.** (8) **True.**

(9) **True.** (10) **True.** (11) **True.**

(12) **False.** (Elements are classified on the basis of their electronic configuration.)

(13) **True.**

(14) **False.** (Lanthanides and actinides are also called the *f*-block elements.)

(15) **True.**

(16) **False.** (In a period, atomic size decreases from left to right.)

(17) **False.** (In a period, the metallic character decreases from left to right.)

(18) **False.** (In a group, the metallic character increases from top to bottom.)

(19) **True.**

Q. 4 By observing the correlation in the first pair, complete the second pair :

(1) Dobereiner : Triad : : Newlands law : ______.

(2) Mendeleev's periodic table : Atomic mass : : Modern periodic table : ______.

(3) Group-1 : Alkali metals : : ______ : Halogens.

(4) Solid : Iodine : : ______ : Bromine.

(5) Chlorine : 2, 8, 7 : : Fluorine : ______

(6) Horizontal row : Periods : : ______ : Groups.

Ans. (1) Octaves (2) Atomic number (3) Group 17 (4) Liquid (5) 2, 7 (6) Vertical columns.

Q. 5 Find the odd one out. Give proper explanation :

(1) Newlands, Moseley, Dobereiner, Mendeleev.

(2) Fluorine, Sulphur, Bromine, Iodine.

(3) Sodium, Aluminium, Chlorine, Carbon.

(4) Nitrogen, Neon, Argon, Helium.

Ans.

(1) **Moseley.** (Moseley brought out the importance of atomic number, while the other tried to classify the elements on the basis of atomic mass.)

(2) **Sulphur.** (Others are halogens.)

(3) **Carbon.** (Carbon belongs to the second row, while the others belong to the third row.)

(4) **Nitrogen.** (The others are inert gases.)

Q. 6 Complete the flow chart : *(2 marks each)*

(1) Na → ... → ... → Si → ... → ... → Cl → Ar

Ans. Na → **Mg** → **Al** → Si → **P** → **S** → Cl → Ar

(2) ... → ... → Ar → ... → ... → Rn → Og

Ans. **He** → **Ne** → Ar → **Kr** → **Xe** → Rn → Og

(3) Shell

Shell	...	...	...	...
Electron capacity	2	8	18	32

Ans.

Shell	K	L	M	N
Electron capacity	2	8	18	32

***Q. 7 Rearrange the columns 2 and 3 so as to match with the column 1 :**

Column 1	Column 2	Column 3
i. Triad	a. Lightest and negatively charged particle in all the atoms	1. Mendeleev
ii. Octave	b. Concentrated mass and positive charge	2. Thomson
iii. Atomic number	c. Average of the first and the third atomic mass	3. Newlands
iv. Period	d. Properties of the eighth element similar to the first	4. Rutherford
v. Nucleus	e. Positive charge on the nucleus	5. Dobereiner
vi. Electron	f. Sequential change in molecular formulae	6. Moseley

Ans.

Column 1	Column 2	Column 3
i. Triad	Average of the first and the third atomic mass	Dobereiner
ii. Octave	Properties of the eighth element similar to the first	Newlands
iii. Atomic number	Positive charge on the nucleus	Moseley
iv. Period	Sequential change in molecular formulae	Mendeleev
v. Nucleus	Concentrated mass and positive charge	Rutherford
vi. Electron	Lightest and negatively charged particle in all the atoms	Thomson

Q. 8 Match the columns :

[1] Column I	Column II
(1) Modern periodic table	(a) Group 17
(2) Vertical columns	(b) Period 2
	(c) Atomic number
	(d) Group

Ans. (1) Modern periodic table – Atomic number
(2) Vertical columns – Group

[2] Column I	Column II
(1) Dobereiner	(a) Atomic number
(2) Newlands	(b) Triads
	(c) Atomic mass
	(d) Octaves

Ans. (1) Dobereiner – Triads
(2) Newlands – Octaves

[3] Column I	Column II
(1) Eka-silicon	(a) Scandium
(2) Eka-boron	(b) Gallium
	(c) Germanium
	(d) Ceasium

Ans. (1) Eka-silicon – Germanium
(2) Eka-boron – Scandium.

[4] Column I	Column II
(1) Noble gas	(a) 18 elements
(2) First period	(b) Eight elements
	(c) Two elements
	(d) Helium

Ans. (1) Noble gas – Helium
(2) First period – Two elements

[5] Column I	Column II
(1) *s*-block elements	(a) Lanthanides and actinides
(2) *p*-block elements	(b) Groups 1, 2
	(c) Groups IIIA to VIIA and zero group
	(d) Groups 13 to 18

Ans. (1) *s*-block elements – Groups 1, 2
(2) *p*-block elements – Groups 13 to 18

[6] Column I	Column II
(1) Helium	(a) Alkali metal
(2) Horizontal row	(b) Alkaline earth metal
	(c) Period
	(d) Zero group

Ans. (1) Helium – Zero group

(2) Horizontal row – Period.

Q. 9 Write the names from the description :

*(1) **The period with electrons in the shells K, L and M.**

Ans. Third period.

*(2) **The group with valency zero.**

Ans. Group 18.

*(3) **The family of nonmetals having valency one.**

Ans. Halogen family.

*(4) **The family of metals having valency two.**

Ans. Group 2.

*(5) **The metalloids in the second and third period.**

Ans. Boron, silicon.

*(6) **The family of metals having valency one.**

Ans. Group 1.

*(7) **Nonmetals in the third period.**

Ans. Phosphorus, sulphur and chlorine and argon.

*(8) **Two elements having valency 4.**

Ans. Carbon, silicon.

(9) First three noble gases.

Ans. Helium, neon and argon.

Q. 10 Name the following :

(1) Horizontal rows in modern periodic table.

Ans. Periods.

(2) Two elements having a single electron in their outermost shell.

Ans. Hydrogen, sodium.

(3) Three elements with filled outermost shell.

Ans. (1) Helium (2) Neon (3) Argon.

(4) Three elements having 7 electrons in their outermost shell.

Ans. (1) Fluorine (2) Chlorine (3) Bromine.

(5) An alkali metal in the period 2.

Ans. Lithium.

(6) An alkaline earth metal in the period 3.

Ans. Magnesium.

(7) Halogen in the period 3.

Ans. Chlorine.

(8) Three nonmetallic elements in the period 2.

Ans. (1) Nitrogen (2) Oxygen (3) Fluorine.

(9) The element with electronic configuration (2, 7).

Ans. Fluorine.

(10) The elements in periods 2 and 3 having stable electronic configuration.

Ans. (1) Neon (2) Argon.

(11) The three metals in the third period of the modern periodic table.

Ans. (1) Sodium (2) Magnesium (3) Aluminium.

(12) The names of blocks in modern periodic table. ***(Nov. '20)***

Ans. *s*-Block, *p*-Block, *d*-Block and *f*-Block.

***Q. 11 Write the name and symbol of the element from the description :**

(1) The atom having the smallest size.

Ans. Helium (He).

(2) The atom having the smallest atomic mass.

Ans. Hydrogen (H_2).

(3) The most electronegative atom.

Ans. Fluorine (F_2).

(4) The noble gas with the smallest atomic nucleus.

Ans. Helium (He).

(5) The most reactive nonmetal.

Ans. Fluorine (F_2).

***Q. 12 (a) An element has its electron configuration as 2, 8, 2. Answer the following questions :**

(March '20) (Nov. '20)

(1) What is the atomic number of this element?

Ans. The atomic number of this element is 12.

(2) What is the valency of this element?

Ans. The valency of this element is 2.

(3) What is the group of this element?

Ans. The group of this element is 2.

(4) To which period does this element belong?

Ans. This element belongs to a period 3.

(5) With which of the following elements would this element resemble? (Atomic numbers are given in brackets) N(7), Be(4), Ar(18), Cl(17).

Ans. This element resembles Be(4).

(b) An element has its electron configuration as 2, 8, 8, 2. Now answer the following questions :

(1) What is the atomic number of this element?

Ans. The atomic number of this element is 20.

(2) What is the group of this element?

Ans. The group of this element is 2.

(3) To which period does this element belong?

Ans. The element belongs to a period 4.

Q. 13 Answer the following questions :

(1) State Dobereiner's law of triads giving one example.

Ans. Dobereiner made groups of three elements each, having similar chemical properties and called them triads. He arranged the three elements in a triad in an increasing order of atomic mass and showed that the atomic mass of the middle element was approximately equal to the mean of the atomic masses of the other two elements.

Examples : Lithium (Li), Sodiun (Na), Potassium (K) form Dobereiner's triad.

(2) Give a suitable illustration of Dobereiner's law of triads.

Ans. (1) Lithium, sodium and potassium form Dobereiner's triad. They show similar chemical properties. Their atomic masses are as follows :

Element	Li	Na	K
Atomic mass	6.9	23	39.1

According to Dobereiner's law of triads, the atomic mass of the middle element is approximately arithmetic mean of the atomic masses of the other two elements.

$\frac{6.9 + 39.1}{2}$ which is approximately the 23.0 atomic mass of sodium.

Thus, the atomic mass of sodium (23) is the average of the atomic masses of lithium (6.9) and potassium 39.1.

(2) Another triad of elements : Calcium (40.1), strontium (87.6) and barium (137.3).

(3) (A, B, C) is a Dobereiner's triad. Complete the following chart and give reason for the answer :

Element	**A**	**B**	**C**
Atomic mass	**10.08**	**12.01**	**...**

Ans.

Element	A	B	C
Atomic mass	10.08	12.01	**13.94**

Let the atomic mass of C be x. As (A, B, C) is a Dobereiner's triad, $\frac{x + 10.08}{2} = 12.01$

$\therefore\ x = 24.02 - 10.08 = 13.94$

$\therefore$ atomic mass of C = 13.94.

(4) Identify Dobereiner's triads from the following groups of elements having similar chemical properties :

(Can you tell?) (Textbook page 16)

(i) Mg (24.3), Ca (40.1), Sr (87.6)

(ii) S (32.1), Se (79.0), Te (127.6)

(iii) Be (9.0), Mg (24.3), Ca (40.1)

Ans. Dobereiner's triads :

(i) S (32.1), Se (79.0), Te (127.6)

(ii) Be (9.0), Mg (24.3), Ca (40.1)

(5) From the following set of the elements and their atomic masses obtain Dobereiner's triad :

Element	**Br**	**K**	**I**	**Cl**
Atomic mass	**79.9**	**39**	**126.9**	**35.5**

Ans. Among the given four elements, the three elements in the increasing order of atomic masses and having similar properties are :

Element	Cl	Br	I
Atomic mass	35.5	79.9	126.9

Hence, the above three elements represent Dobereiner's triad.

(6) In Dobereiner's triad containing Li, Na, K, if atomic masses of lithium and potassium are 6.9 and 39.1, then what will be the atomic mass of sodium? ***(March '19)***

Ans. The atomic mass of sodium is the average of the atomic masses of Li and K i.e. $\frac{6.9 + 39.1}{2} = 23.$

(7) State the limitations of Dobereiner's law of triads.

Ans. (1) During Dobereiner's period all elements were not known and also atomic mass was not known accurately.

(2) Dobereiner discovered few triads among all the elements.

(3) He could not classify all known elements into triads.

(8) State Newlands' law of octaves.

Ans. When the elements are arranged in an increasing order of their atomic masses, the properties of the eighth element are similar to those of the first.

It is found that Na is the eighth element from Li and both of them have similar properties.

(9) Illustrate Newlands' law of octaves with a suitable example.

Ans. (1) Newlands' law of octaves states that when the elements are arranged in the order of their increasing atomic masses, every eighth element has properties similar to those of the first.

(2) **Illustration :** If the first 21 elements, except inert gases, are arranged in the order of their increasing atomic masses we have octaves as given below :

H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe

It is found that Na is the eighth element from Li and both of them have similar properties. Similarly, the elements, in the following pairs show similar properties : C and Si, Na and K, Mg and Ca, F and Cl.

(10) Explain the limitations of Newlands' law of octaves.

Ans. (1) Newlands' law of octaves i.e. applicable to only the first few elements i.e., only up to calcium out of total 56 elements known at that time.

(2) Newlands placed two elements each in some boxes to accommodate all known elements e.g. Co and Ni, Ce and La. He placed some elements with different properties under the same note in the octave. For example, Co and Ni under the note Do along with halogens, while Fe having similarity with Co and Ni away from them along with the nonmetals O and S under the note Ti.

(3) Newlands' octaves did not have provision to accommodate the newly discovered elements.

***(11) Write short note on Mendeleev's periodic law.** *OR*

State Mendeleev's periodic law.

Ans. When the elements are arranged in the order of their increasing atomic masses, Mendeleev found that the elements with similar physical and chemical properties repeat after a definite interval. On the basis of these finding Mendeleev stated the periodic law.

The physical and chemical properties of elements are a periodic function of their atomic masses.

(12) Describe the merits of Mendeleev's periodic table. ***(March '19)***

Ans. (1) To give the proper place in the periodic table, atomic masses of some elements were revised in accordance with their properties. For example, the previously determined atomic mass of beryllium, 14.09, was changed to the correct value 9.4, and beryllium was placed before boron.

(2) Mendeleev had kept some vacant places in the periodic table for elements that were yet to be discovered. Three of these unknown elements were given the names eka-boron, eka-aluminium and eka-silicon from the known neighbours and their atomic masses were indicated as 44, 68 and 72, respectively. Their properties were also predicted. Later on these elements were discovered subsequently and were named as scandium (SC), gallium (Ga) and germanium (Ge) respectively. The properties of these elements matched well with those predicted by Mendeleev. Due to this success all were convinced about the importance of Mendeleev's periodic table.

(3) There was no place reserved for noble gases in Mendeleev's original periodic table. When noble gases such as helium, neon and argon were discovered, Mendeleev created the 'zero group' without disturbing the original periodic table in which the noble gases were placed very well.

(13) What are the demerits of Mendeleev's periodic table?

Ans. (1) The elements cobalt (Co) and nickel (Ni) have the same whole number atomic mass. As a remit there was an ambiguity regarding their sequence in Mendeleev's periodic table.

(2) Isotopes were discovered long time after Mendeleev put forth the periodic table. A challenge was posed in placing isotopes in Mendeleev's periodic table as isotopes have the same chemical properties but different atomic masses.

(3) The rise in atomic mass does not appear to be uniform when elements are arranged in an increasing order of atomic masses. It was not possible, therefore, to predict how many elements could be discovered between two heavy elements.

(4) Position of hydrogen : Hydrogen shows similarity with halogens (group VII). For example, the molecular formula of hydrogen is H_2 while the molecular formulae of fluorine and chlorine are F_2 and Cl_2, respectively. In the same way, there is a similarity in the chemical properties of hydrogen and alkali metals (group I). There is a similarity in the molecular formulae of the compounds of hydrogen alkali metals (Na, K, etc.) formed with chlorine and oxygen. On considering the above properties it is difficult to decide the correct position of hydrogen whether it is in the group of alkali metals (group I) or in the group of halogens (group VII).

Compounds of H	Compounds of Na
HCl	NaCl
H_2O	Na_2O
H_2S	Na_2S

Similarity in hydrogen and alkali metals

Element (Molecular formula)	Compounds with metals	Compounds with nonmetals
H_2	NaH	CH_4
Cl_2	NaCl	CCl_4

Similarity in hydrogen and halogens

(14) Write the molecular formulae of oxides of the following elements by referring to the Mendeleev's periodic table. Na, Si, C, Rb, P, Ba, Cl, Sn.

(Use your brain power!) (Textbook page 20)

Ans.

Elements	Oxides of Elements	
Na	Na_2O	Sodium oxide
Si	SiO_2	Silicon dioxide
C	CO_2	Carbon dioxide
Rb	Rb_2O	Rubidium oxide (yellow solid)
P	P_2O_5	Phosphorus pentaoxide
Ba	BaO	Barium oxide
Cl	Cl_2O	Chlorine monoxide
Sn	SnO_2	Tin dioxide (stannic oxide)

(15) Write the molecular formulae of the compounds of the following elements with hydrogen by referring to the Mendeleev's periodic table. C, S, Br, AS, F, O, N, Cl

(Use your brain power!) (Textbook page 20)

Ans.

Elements	Compounds (with hydrogen)	
C	CH_4	Methane
S	H_2S	Hydrogen sulphide
Br	HBr	Hydrogen bromide
As	AsH_3	Arsine
F	HF	Hydrogen fluoride
O	H_2O	Water
N	NH_3	Ammonia
Cl	HCl	Hydrogen chloride

(16) Write a short note on : Moseley's contribution and the modern periodic table.

Ans. The English scientist Henry Moseley demonstrated, with the help of the experiments done using X-ray tube, that the atomic number (Z) of an element corresponds to the positive charge on the nucleus or the number of the protons in the nucleus of the atom of that element. He suggested that 'atomic number' is a more fundamental property of an element rather than its atomic mass. On the basis of this research, elements were arranged in the order of their increasing atomic numbers in a more systematic way. Accordingly the statement of the modern periodic law was stated.

(17) State the modern periodic law. ***(Nov. '20)***

Ans. The chemical and physical properties of elements are a periodic function of their atomic numbers.

(18) What is meant by modern periodic table?

Ans. The classification of elements resulting from an arrangement of the elements in an increasing order of their atomic numbers (Z) is the modern periodic table.

(19) Describe the structure of the modern periodic table. *OR*

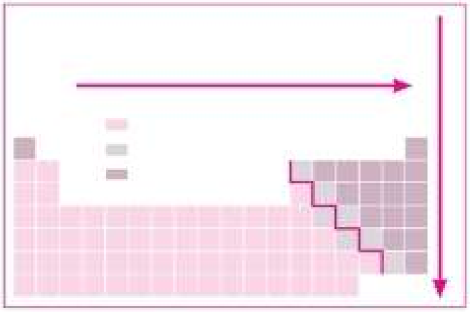
*** Write a note on structure of the modern periodic table.**

Ans. (1) In the modern periodic table, the elements are arranged in the order of their increasing atomic number. In the modern periodic table there are seven horizontal rows called periods and eighteen vertical columns (1 to 18) called groups. The arrangement of the periods and groups results into formation of boxes. Atomic numbers are serially indicated in the upper part of these boxes.

(2) Each box represents the place for one element. Apart from these seven rows, there are two rows of elements placed separately at the bottom of the periodic table. They are lanthanides and actinides series. There are 118 boxes in the periodic table including the two series that means there are 118 places for elements in the modern periodic table. The formation of a few elements was established experimentally very recently and thereby the modern periodic table is now completely filled with 118 elements.

(3) On the basis of the electronic configuration, the elements in the modern periodic table are divided into four blocks, viz. *s*-block, *p*-block, *d*-block and *f*-block. The *s*-block constitute groups 1 and 2. The groups 13 to 18 constitute the *p*-block. Groups 3 to 12 constitute the *d*-block, while the lanthanide and actinide series at the bottom form the *f*-block. The *d*-block elements are called transition elements. A zig-zag line is shown in the *p*-block of the periodic table. This zig-zag line shows the three traditional types of elements, i.e. metals, nonmetals and metalloids. The metalloid elements lie along the border of zig-zag line. All the metals lie on the left side of the zig-zag line while all the nonmetals lie on the right side.

(20) Write the answers of the questions with reference to the structural of the periodic table.



(a) Which points are considered for the modern periodic table?

(b) How are blocks indicated?

(c) Which elements are present near the zig-zag line?

(d) Draw the electronic configuration of the second row elements of first group in the periodic table.

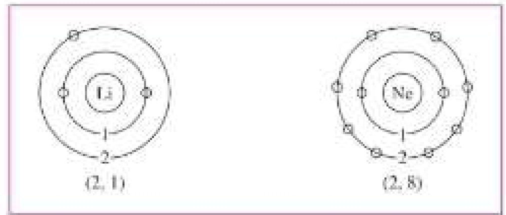
(e) In a periodic table while going from left to right atomic radius decreases. Explain.

Ans. (a) In the modern periodic table, the elements are arranged in the order of their increasing atomic number. In the modern periodic table there are seven horizontal rows called periods and eighteen vertical columns (1 to 18) called groups. The arrangement of the periods and groups results into formation of boxes. Atomic numbers are serially indicated in the upper part of these boxes.

(b) On the basis of the electronic configuration, the elements in the modern periodic table are divided into four blocks, viz. s-block, p-block and f-clock, The s-block constitutes the groups 1 and 2. Groups 13 to 18 constitute the p-block. Groups 3 to 12 constitute the d-block, while the lanthanide and actinide series at the bottom form the f-block. The d-block elements are called transition elements. A zig-zag line is shown in the p-block of the periodic table.

(c) The zig-zag line shows the three traditional types of elements, i.e. metals, nonmetals and metalloids. The metalloid elements lie along the border of the zig-zag line. All the metals lie on the left side of the zig-zag line while all the nonmetals lie on the right side.

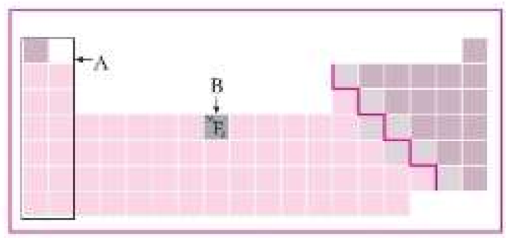
(d) The electronic configuration of the second row elements of the first group in the periodic table is shown below :



(e) (1) In a period while going from left to right, atomic radius goes on decreasing and the atomic number goes on increasing one by one, It means the positive charge on the nucleus increases by one unit at a time.

(2) However, the additional electron gets added to the same outermost shell. Due to the increased nuclear charge the electrons are pulled towards the nucleus to a grater extent. As a result the size of atom decreases i.e. the atomic radius decreases.

(21) Observe the figure and answer the following questions.



(a) Identify the block shown by box A and write an electronic configuration of any one element of this block.

(b) Identify the block of element denoted by letter B and write its period number.

(2 marks) (Board Model Activity Sheet)

Ans. (a) The block shown by box A is the s-block. Electronic configuration of Mg : 2, 8, 2.

(b) The block of element denoted by letter B is the d-block and its period number is 4.

(22) Give two examples of metalloids.

Ans. Metalloids : Boron (B) and Silicon (Si).

*(23) **Write a short note on : Position of isotopes in the Mendeleev's and the modern periodic table.**

Ans. Isotopes were discovered long time after Mendeleev put forth the periodic table. A challenge was posed in placing isotopes in Mendeleev's periodic table, as isotopes have the same chemical properties but different atomic masses. Isotopes do not find separate places in this table.

Moseley found out that atomic number is a fundamental property of an element rather than its atomic mass. The atomic number of any element is increased by one unit (number) from the atomic number of subsequent element. In the modern periodic table, the elements are arranged in the order of their increasing atomic numbers, that time the problem of discrepancy in the pairs of isotopes of elements observed in Mendeleev's periodic table was solved. The isotopes of ${}_{17}Cl^{35}$ and ${}_{17}Cl^{37}$ were placed in the same group as both have the same atomic number.

(24) Write a short note on the zig-zag line in the modern periodic table.

Ans. (1) A zig-zag line is shown in the *p*-block of the periodic table.

(2) The zig-zag line shows the three traditional types of elements is metals, nonmetals and metalloids.

(3) The metalloid elements lie along the border of this zig-zag line.

(4) All the metals lie on the left side of the zig-zag line.

(5) All the nonmetals lie on the right side of the zig-zag line.

(25) Classify the following elements into group 1, 16 and 17 :

Chlorine, Hydrogen, Oxygen, Bromine.

Ans. Group 1 : Hydrogen.

Group 16 : Oxygen

Group 17 : Chlorine and Bromine.

(26) Classify the following elements into – Alkali metals, Halogens, Alkaline earth metals : (Cl^- Br^- I^-), (Ca, Sr, Mg), (Li, Na, K).

Ans. Alkali metals : (Li, Na, K)

Halogens : (Cl^- Br^- I^-).

Alkaline earth metals : (Ca, Sr, Mg).

(27) Classify the following elements into – Metals, Nonmetals, Metalloids : (P, C, N), (Ca, Fe, Al), (Si, Ge, Sn), (K, Mg, Na).

Ans. Metals : (Ca, Fe, Al), (K, Mg, Na).

Nonmetals : (P, C, N).

Metalloids : (Si, Ge, Sn).

(28) Identify the electronic configuration of the inert gas elements, third row elements, seventeen group elements, second group elements :

(i) (2, 8, 2) (ii) (2, 8, 8) (iii) (2, 8, 1) (iv) (2, 7)

(v) (2, 2) (vi) (2, 8) (vii) (2, 8, 7)

Ans. Inert gas elements : (2, 8, 8), (2, 8).

Third row elements : (2, 8, 2), (2, 8, 7), (2, 8, 8).

Second group elements : (2, 8, 2), (2, 2).

Seventeen group elements : (2, 7), (2, 8, 7).

[**Note :** (1) The outermost shell of all noble gases contain 8 electrons (except He). (2) Atoms of all 3rd row elements contain 3 shells. Out of which first shell contains 2 and 2nd shell contains 8 electrons. (3) The elements of group 17 contains 7 electrons in the outermost shell. (4) The elements of group 2 contains 2 electrons in the outermost shell.]

(29) Define : (i) Group (ii) Period.

Ans. (i) **Group :** The vertical column of elements in the periodic table of elements is called a group.

(ii) **Period :** The horizontal row of the elements in the periodic table of the elements is called a period.

(30) Write the numbers of vertical columns (groups) and horizontal rows (periods) in the long form of the periodic table.

Ans. There are 18 vertical columns or groups and seven horizontal rows or periods of the elements in the long form of the periodic table.

(31) How many elements are there in the second and the third periods of the periodic table?

Ans. There are eight elements in the second and the third periods of the periodic table.

(32) State the number of elements in the shortest period.

Ans. There are two elements in the shortest (first period) period.

(33) State the number of elements in the modern periodic table.

Ans. There are 118 elements in the modern periodic table.

(34) Which column is known as the zero group in the modern periodic table?

Ans. The last column, i.e. 18th column on the right side of the modern periodic table is known as the zero group in the modern periodic table.

(35) Which group elements have seven electrons in the outermost shell?

Ans. Group 17 elements have seven electrons in the outermost shell.

(36) How many electrons are there in the outermost shell of group 2 elements?

Ans. There are 2 electrons in the outermost shell of group 2 elements.

(37) How many electrons are there in the outermost shell of group 18 elements?

Ans. There are 8 electrons in the outermost shell of group 18 elements, except He, which has 2 electrons.

(38) Which block of the modern periodic table separates metals and nonmetals with the help of zig-zag line?

Ans. *p*-block of the modern periodic table separates metals and nonmetals with the help of zig-zag line.

(39) Name the group to which the most reactive metals belong.

Ans. The most reactive metals belong to group IA.

(40) Name the element having one shell and one valence electron.

Ans. Hydrogen has one shell and one valence electron.

(41) How many valence electrons are there in the outermost shell of silicon?

Ans. There are four valence electrons present in the outermost shell of silicon.

(42) State the electronic configuration of nitrogen and phosphorus.

Ans. Electronic configuration of nitrogen (N) : 2, 5. Electronic configuration of phosphorus (P) : 2, 8, 5.

(43) Write the electronic configuration : $_{13}Al$

Ans. Electronic configuration of $_{13}Al$: 2, 8, 3

(44) Name the group containing highly reactive nonmetals only.

Ans. Group 17 contains highly reactive non-metals, namely, fluorine, chlorine, bromine and iodine.

(45) Depending on electronic configuration the properties of the elements vary in different groups. Explain why?

Ans. (1) There are 18 vertical columns in the modern periodic table and are called groups. These groups are 1 and 2, 13 to 18 and 3 to 12.

(2) The number of valence electrons in all these elements from the group 1, i.e. the family of alkali metals, is the same. Similarly, the elements from any other group, the number of their valence electrons to be the same. For example, the elements beryllium (Be), magnesium (Mg) and calcium (Ca) belong to the group 2, i.e. the family of alkaline earth metals. There are two electrons in their outermost shell the number of valence electrons are 2. Similarly, there are seven electrons in the outermost shell of the elements such as fluorine (F) and chlorine (Cl) from the group 17, i.e. the family of halogens the number of valence electron is 1. As a result all elements belonging to the same group have the same valence electrons and show similar chemical properties.

(3) While going from top to bottom within any group, one electronic shell is added at a time. Atomic radius and atomic size increases and hence, shows gradation of properties of the elements down the

group. From this, the electronic configuration of the outermost shell is characteristic of a particular group.

(46) Go through the modern periodic table and write the names one below the other of the elements of group 1.

(Can you tell?) **(Textbook page 22)**

Ans. Four elements of group 1 : Hydrogen (H)
Lithium (Li)
Sodium (Na)
Potassium (K)

(47) Write the electronic configuration of first four elements in this group.

(Can you tell?) **(Textbook page 22)**

Ans.

Elements	Electronic configuration
Hydrogen	1
Lithium	2, 1
Sodium	2, 8, 1
Potassium	2, 8, 8, 1

(48) Which similarity do you find in their configuration?

(Can you tell?) **(Textbook page 22)**

Ans. The similarity is observed in valence electrons of these elements. The valence electron in these elements is one.

(49) How many valence electrons are there in each of these elements?

(Can you tell?) **(Textbook page 22)**

Ans. There is one valence electron in all these elements.

(50) Depending on electronic configuration the properties of elements vary in different periods. Explain why?

Ans. (1) In modern periodic table there are seven horizontal rows called periods.

(2) In a period, change in valency of an elements varies electronic configuration.

(3) The number of valence electrons is different in these elements. However, the number of shells is the same. In a period, while going from left to right, the atomic number increases by one at a time and the number of valence electrons also increases by one at a time. In a period, there is gradation in properties of elements.

(4) The elements with the same number of shells occupied by electrons belong to the same period. The elements in the second period, namely, Li, Be, B, C, N, O, F and Ne have electrons in the two shells, K and L. The elements in the third period, namely, Na, Mg, Al, Si, P, S, Cl and Ar have electrons in the three shells; K, L and M.

(5) The chemical reactivity of an element is determined by the number of valence electrons in it and the shell number of the valence shell. In a period, while going from left to right, the atomic number increases by one at a time as a result atomic radius gradually decreases. Hence, atomic size decreases.

(51) On going through the modern periodic table it is seen that the elements Li, Be, B, C, N, O, F and Ne belong to the period-2. Write down electronic configuration of all of them.

(Can you tell?) **(Textbook page 23)**

Ans.

Elements	Electronic configuration
Li	2, 1
Be	2, 2
B	2, 3
C	2, 4
N	2, 5
O	2, 6
F	2, 7
Ne	2, 8

(52) Is the number of valence electrons same for all these elements?

(Can you tell?) **(Textbook page 23)**

Ans. The number of valence electrons is different for all these elements.

(53) Is the number of shells the same in these? (Can you tell?) **(Textbook page 23)**

Ans. The number of shells is the same.

(54) The elements in the third period, namely, Na, Mg, Al, Si, P, S, Cl and Ar have electrons in the three shells, K, L, M. Write down the electronic configuration of these elements.

(Textbook page 24)

Ans.

Elements	K Shell	L Shell	M Shell	Electronic Configuration
Na	2	8	1	2, 8, 1
Mg	2	8	2	2, 8, 2
Al	2	8	3	2, 8, 3
Si	2	8	4	2, 8, 4
P	2	8	5	2, 8, 5
S	2	8	6	2, 8, 6
Cl	2	8	7	2, 8, 7
Ar	2	8	8	2, 8, 8

(55) What is meant by periodic trends in the modern periodic table?

Ans. When the properties of elements in a period or a group of the modern periodic table are compared, certain regularity is observed in their variations. It is called the periodic trends in the modern periodic table. The periodic trends is observed in properties of elements, namely, valency, atomic size and metallic-nonmetallic character.

(56) What is meant by valency?

Ans. The valency of an element is determined by the number of electrons present in the outermost shell of its atoms, i.e. valence electrons.

(57) Define atomic size. How does it vary in a period and a group?

Ans. (1) The distance between the centre of the atom and the outermost shell of the atom is called the atomic radius. The size of an atom is indicated by its radius. Atomic radius is expressed in unit picometre (pm). (1 pm = 10^{-12} m). The size of atom depends on number of shells, more the number of shells larger is the atomic size.

(2) In a group, while going down a group the atomic size goes on increasing, because while going down a group newer shells are successively added. This increases the distance between the outermost electron and the nucleus. Hence, the nuclear attraction on these electrons goes on decreasing. Thus in a group atomic size increases.

(3) While going from left to right within a period, atomic radius goes on decreasing and the atomic number goes on increasing one by one. The positive charge on the nucleus increases by one unit at a time. However, the additional electron gets added to the same outermost shell. Due to the increased nuclear charge the electrons are pulled towards the nucleus to a greater extent, as a result, the size of the atom decreases.

(58) Discuss the trends in the variation of metallic and nonmetallic properties in a period and in a group.

Ans. (1) Metals have a tendency to loose the valence electrons to form cations having a stable noble gas configuration. This tendency of an element is called electropositivity is the metallic character of that element.

(2) Nonmetals have a tendency to accept the valence electrons to form anions having a stable noble gas configuration. This tendency of an element is called electronegativity is the nonmetallic character of that element.

(3) In a group, while going down a group a new shell is added, resulting in an increase in the distance between the nucleus and the valence electrons. This results in lowering the effective nuclear charge and thereby lowering the attractive force on the valence electrons. As a result of this the tendency of the atom to lose electrons increases. Also the penultimate shell becomes the outermost shell on losing valence electrons. The penultimate shell is a complete octet. Therefore, the resulting cation attains special stability. The metallic character of an atom is its tendency to lose electrons. Therefore, the following trend is observed : The metallic character of elements increases while going down the group.

(4) While going from left to right within a period the outermost shell remains the same. However, the

positive charge on the nucleus goes on increasing while the atomic radius goes on decreasing and thus the effective nuclear charge goes on increasing. Therefore, valence electrons are held with greater attractive force. This is called electronegativity. As a result of this the tendency of atom to lose valence electrons decreases within a period from left to right, i.e., electronegativity increases. Thus, nonmetallic character of elements increases within a period from left to right.

(59) Name the elements, group, formulae and physical state belonging to the halogen family.

Ans.

Group	Elements	Formula	Physical state
17	Fluorine	F_2	Gas
	Chlorine	Cl_2	Gas
	Bromine	Br_2	Liquid
	Iodine	I_2	Solid

(60) There are some vacant places in the Mendeleev's periodic table. In some of these places the atomic masses are seen to be predicted. Enlist three of these predicted atomic masses along with their group and period.

(Think about it) (Textbook page 19)

Ans.

Atomic mass	Group	Period
44	III	4
72	IV	5
100	VII	6

(61) Due to uncertainty in the names of some of the elements, a question mark is indicated before the symbol in the Mendeleev's period table. What are such symbols?

(Think about it) (Textbook page 19)

Ans. Symbols : Yt, Di, Ce, Er, La.

(62) Chlorine has two isotopes, viz. Cl-35 and Cl-37. Their atomic masses are 35 and 37 respectively. Their chemical properties are same. Where should these be placed in Mendeleev's periodic table? In different places or in the same place?

(Use your brain power!) (Textbook page 19)

Ans. The arrangement of elements is done on the basis of atomic mass. Since the atomic masses of chlorine (isotopes) are different i.e. 35 and 37, they should be kept in different places in Mendeleev's periodic table.

(63) How is the problem regarding the position of cobalt (^{59}Co) and nickel (^{59}Ni) in Mendeleev's periodic table resolved in modern periodic table?

(Use your brain power!) (Textbook page 21)

Ans. Mendeleev arranged the elements in their increasing order of atomic masses. But some elements with higher atomic masses are placed before those having lower atomic masses, e.g. cobalt (Co) with atomic mass 58.93 is placed before nickel (Ni) having atomic mass 58.71. Modern periodic table was prepared on the basis of the atomic number of elements. The atomic number of Co is 27 and that of Ni is 28. So nickel is placed after cobalt.

(64) How did the position of $^{35}_{17}Cl$ get fixed in the modern periodic table?

(Use your brain power!) (Textbook page 21)

Ans. In Mendeleev's periodic table, the difference between atomic masses of two consecutive elements is not the same ^{35}Cl and ^{37}Cl. Moseley found out the atomic number of the elements. The atomic number of any element is increased by one unit (number) from the atomic number of subsequent element.

Isotopes $^{35}_{17}Cl$ and $^{37}_{17}Cl$ occupy the same position in the modern periodic table. Both isotopes have the same atomic number.

In the modern periodic table, the elements are arranged in the order of their increasing atomic numbers, that the problem of discrepancy in the pairs of isotopes elements observed in Mendeleev's periodic table was solved. The isotopes of $^{35}_{17}Cl$ and $^{37}_{17}Cl$ were placed in the same group as both have the same atomic number.

(65) Can there be an element with atomic mass 53 or 54 in between the two elements, chromium $^{52}_{24}Cr$ and Manganese $^{55}_{25}Mn$?

(Use your brain power!) (Textbook page 21)

Ans. In Mendeleev's periodic table, the difference between atomic masses of two consecutive elements is not the same (^{52}Cr and ^{55}Mn). Moseley found out the atomic number of the elements. The atomic number of any element is increased by one unit (number) from the atomic number of subsequent element. $^{52}_{24}Cr \rightarrow {}^{55}_{25}Mn$ that means in between two elements (Cr and Mn), element with mass 53 or 54 do not exist.

(66) What do you think? Should hydrogen be placed in the group 17 of halogens or group 1 of alkali metals in the modern periodic table?

(Use your brain power!) (Textbook page 21)

Ans. (1) Hydrogen is placed in group 1 and in group 17 as it resembles alkali metals as well as halogens. Thus, no fixed position was given to hydrogen in Mendeleev's periodic table.

(2) On the other hand, hydrogen easily donates the electron and forms a stable cation (H^+), but it does not easily form a stable anion (H^-), hydride ion). Hence, it is better placed in group 1 rather than in group 17 in the modern periodic table.

(67) The elements in the second period : Li, Be, B, C, N, O, F and Ne have electrons in the two shells K and L. Write down the electronic configuration of these elements.

(Textbook page 24)

Ans.

Element	Electronic configuration	
	K shell	L shell
Li	2	1
Be	2	2
B	2	3
C	2	4
N	2	5
O	2	6
F	2	7
Ne	2	8 Octet complete

(68) The elements in the third period : Na, Mg, Al, Si, P, S, Cl and Ar have electrons in the third shell K, L and M. Write down the electronic configuration of these elements.

(Textbook page 24)

Ans. *For reference see the answer to Q. 13 (54).*

(69) What is the relationship between the electronic configuration of an element and its valency? (Think about it) (Textbook page 24)

Ans. The valency of an element is determined by the number of electrons in the outermost shell.

(70) The atomic number of beryllium is 4, while that of oxygen is 8. Write down the electronic configuration of the two and deduce the valency from the same.

(Think about it) (Textbook page 24)

Ans.

Element	Atomic number	Electronic configuration	Valency
Beryllium (Be)	4	2, 2	2
Oxygen (O)	8	2, 6	2

(71) The table given below is based on modern periodic table. Write in it the electronic configuration of the first 20 elements below the symbol and write the valency (as shown in a separate box)

(Think about it) (Textbook page 24)

Ans.

Group

↓	1	2	13	14	15	16	17	18
1	H 1							He 2 0
2	Li 2, 1 1	Be 2, 2 2	B 2, 3 3	C 2, 4 4	N 2, 5 3	O 2, 6 2	F 2, 7 1	Ne 2, 8 0
3	Na 2, 8, 1 1	Mg 2, 8, 2 2	Al 2, 8, 3 3	Si 2, 8, 4 4	P 2, 8, 5 3	S 2, 8, 6 2	Cl 2, 8, 7 1	Ar 2, 8, 8 0
4	K 2, 8, 8, 1 1	Ca 2, 8, 8, 2 2						

(72) What is the periodic trend in the variation of valency while going from left to right within a period? Explain your answer with reference to the period 2 and period 3.

(Think about it) (Textbook page 24)

Ans.

Period								
2	Li 2, 1	Be 2, 2	B 2, 3	C 2, 4	N 2, 5	O 2, 6	F 2, 7	Ne 2, 8
3	Na 2, 8, 1	Mg 2, 8, 2	Al 2, 8, 3	Si 2, 8, 4	P 2, 8, 5	S 2, 8, 6	Cl 2, 8, 7	Ar 2, 8, 8

(1) In a period, change in valency of an element varies electronic configuration. The number of valence electrons is different in these elements. However, the number of shells is the same.

(2) In a period, while going from left to right, the atomic number increases by one at a time and the number of valence electrons also increases by one at a time.

(3) In periods 2 and 3, while going from left to right, valency varies.

Elements	Li	Be	B	C	N	O	F	Ne
Valency	1	2	3	4	3	2	1	0

Elements	Na	Mg	Al	Si	P	S	Cl	Ar
Valency	1	2	3	4	3	2	1	0

(73) Considering the elements of period 3 in the modern periodic table, answer the following questions :

(1) Name the 'element' in which all the shells are completely filled with electrons.

(2) Name the element which has one electron in the outermost shell.

(3) State the most electronegative element in this period.

Ans. (1) The element in which all the shells are completely filled with electrons is argon. (2, 8, 8).

(2) The element which has one electron in the outermost shell is sodium (2, 8, 1).

(3) The most electronegative element in this period is chlorine (Cl).

(74) What is the periodic trend in the variation of valency while going down a group? Explain your answer with reference to the group 1, group 2 and group 18.

(Think about it) (Textbook page 24)

Ans.

Group 1	Group 2		Group 18
H 1			He 2
Li 2,1	Be 2,2		Ne 2,8
Na 2,8,1	Mg 2,8,2		Ar 2,8,8
K 2,8,8,1	Ca 2,8,8,2		

(1) The valency of an element is determined by the number of valence electron in the outermost shell of an atom of an element.

(2) All the elements in a group have the same number of valence elements. Therefore, elements in the same group should have the same valency. For example, the elements of group 1 (H, Li, Na, K etc.) contain only one valence electron, the valency of elements of group 1 is one. Similarly for group 2, (Be, Mg, Ca) contain two valence electrons, the valency of elements of group 2 is two.

(3) The elements of group 18 1 (Ne, Ar) contain 8 electrons (exception, Helium contain 2 electrons). Since the octet is completed their valency is zero.

Taking into consideration the period of the elements given below, answer the following questions : ***(March '19)***

Element	O	B	C	N	Be	Li
Atomic radius (pm)	66	88	77	74	111	152

(1) Arrange the above elements in a decreasing order of their atomic radii.

Ans. The above elements are arranged in a decreasing order of their atomic radii :

Li	Be	B	C	N	O
152	111	88	77	74	66

(2) State the period to which the above elements belong.

Ans. The above elements belong to period 2.

(3) Why this arrangement of elements is similar to the above period of modern periodic table?

Ans. As we move from left to right within a period, the atomic number increases one by one means the position charge on the nucleus increases by one unit at a time, but the electrons are added to the same orbit thereby increasing the pull towards the nucleus which decreases the size of the atom.

(4) Which of the above elements have the biggest and the smallest atom?

Ans. The biggest atom : Lithium (Li)

The smallest atom : Oxygen (O)

(5) What is the periodic trend observed in the variation of atomic radius while going from left to right within a period?

Ans. While going from left to right in a period, atomic number increases, atomic radius decreases. Therefore, atomic size gradually decreases.

• **Use your brain power! (Textbook page 25)**

Element	K	Na	Rb	Cs	Li
Atomic radius (pm)	231	186	244	264	152

(1) By referring to the modern periodic table find out the groups to which above the elements belong.

Ans. The above elements belong to group 1.

(2) Arrange the above elements vertically downwards in an increasing order of atomic radii.

Ans. The above elements arranged vertically downward in an increasing order of atomic radii :

Li	Na	K	Rb	Cs
152	186	231	244	262

(3) Does this arrangement match with the pattern of the group 1 of the modern periodic table?

Ans. This arrangement match with the pattern of the group 1 of the modern periodic table in an increasing order of atomic radii.

(4) Which of the above elements have the biggest and the smallest atom?

Ans. The biggest atom : Cs

The smallest atom : Li

(5) What is the periodic trend observed in the variation of atomic radii down a group?

Ans. While going down a group, atomic number increases, atomic radius increases. Therefore atomic size gradually increases.

(75) Look at the elements of third period. Classify them into metals and nonmetals.

(Use your brain power!) (Textbook page 26)

Ans. Third row : Na, Mg, Al, Si, P, S, Cl, Ar

Metals : Na, Mg, Al

Nonmetals : P, S, Cl, Ar

(76) On which side of the period are the metals? Left or right?

(Use your brain power!) (Textbook page 26)

Ans. Left side of the period are the metals.

(77) On which side of the period did you find the nonmetals?

(Use your brain power!) (Textbook page 26)

Ans. Right side of the period are the nonmetals.

(78) What is the cause of nonmetallic character of elements?

(Use your brain power!) (Textbook page 27)

Ans. The tendency of an element to form anion or electronegativity is the nonmetallic character of element.

(79) What is the expected trend in the variation of nonmetallic character of elements from left to right in a period?

(Use your brain power!) (Textbook page 27)

Ans. In a period, as the atomic number increases from left to right, electronegativity increases, nonmetallic character increases. This is due to a decrease in the atomic size.

(80) What would be the expected trend in the variation of nonmetallic character of elements down a group?

(Use your brain power!) (Textbook page 27)

Ans. In a group as the atomic number increases, electropositivity increases while electronegativity decreases, nonmetallic character decreases.

(81) Write down the electronic configuration of the following elements from the given atomic numbers. Answer the following question with explanation.

(1) $_3Li$, $_{14}Si$, $_2He$, $_{11}Na$, $_{15}P$. Which of these elements belong to the period 3?

Ans.

Elements	Electronic configuration
(i) $_3Li$	2, 1
(ii) $_{14}Si$	2, 8, 4
(iii) $_2He$	2
(iv) $_{11}Na$	2, 8, 1
(v) $_{15}P$	2, 8, 5

Elements belong to the 3rd period : $_{14}Si$, $_{11}Na$ and $_{15}P$.

(2) $_1H$, $_7N$, $_{20}Ca$, $_{16}S$, $_4Be$, $_{18}Ar$. Which of these elements belong to the second group?

Ans.

Elements	Electronic configuration
(i) $_1H$	1
(ii) $_7N$	2, 5
(iii) $_{20}Ca$	2, 8, 8, 2
(iv) $_{16}S$	2, 8, 6
(v) $_4Be$	2, 2
(vi) $_{18}Ar$	2, 8, 8

Elements belongs to the 2nd group : $_4Be$ and $_{20}Ca$.

(3) $_7N$, $_6C$, $_8O$, $_5B$, $_{13}Al$. Which is the most electronegative element among these?

Ans.

Elements	Electronic configuration
(i) $_7N$	2, 5
(ii) $_6C$	2, 4
(iii) $_8O$	2, 6
(iv) $_5B$	2, 3
(v) $_{13}Al$	2, 8, 3

Among these, $_8O$ is the most electronegative element.

(4) $_4Be$, $_6C$, $_8O$, $_5B$, $_{13}Al$. Which is the most electropositive element among these?

Ans.

Elements	Electronic configuration
(i) $_4Be$	2, 2
(ii) $_6C$	2, 4
(iii) $_8O$	2, 6
(iv) $_5B$	2, 3
(v) $_{13}Al$	2, 8, 3

Among these, $_{13}Al$ is the most electropositive element.

(5) $_{11}Na$, $_{15}P$, $_{17}Cl$, $_{14}Si$, $_{12}Mg$. Which of these has largest atoms?

Ans.

Elements	Electronic configuration
(i) $_{11}Na$	2, 8, 1
(ii) $_{15}P$	2, 8, 5
(iii) $_{17}Cl$	2, 8, 7
(iv) $_{14}Si$	2, 8, 4
(v) $_{12}Mg$	2, 8, 2

$_{11}Na$ has the largest atomic size.

(6) $_{19}K$, $_3Li$, $_{11}Na$, $_4Be$. Which of these atoms has smallest atomic radius?

Ans.

Elements	Electronic configuration
(i) $_{19}K$	2, 8, 8, 1
(ii) $_3Li$	2, 1
(iii) $_{11}Na$	2, 8, 1
(iv) $_4Be$	2, 2

$_4Be$ has smallest atomic radius.

(7) $_{13}Al$, $_{14}Si$, $_{11}Na$, $_{12}Mg$, $_{16}S$. Which of the above elements has the highest metallic character?

Ans.

Elements	Electronic configuration
(i) $_{13}Al$	2, 8, 3
(ii) $_{14}Si$	2, 8, 4
(iii) $_{11}Na$	2, 8, 1
(iv) $_{12}Mg$	2, 8, 2
(v) $_{16}S$	2, 8, 6

$_{11}Na$ has the highest metallic character.

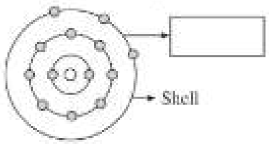
(8) $_6C$, $_3Li$, $_9F$, $_7N$, $_8O$. Which of the above elements has the highest nonmetallic character?

Ans.

Elements	Electronic configuration
(i) $_6C$	2, 4
(ii) $_3Li$	2, 1
(iii) $_9F$	2, 7
(iv) $_7N$	2, 5
(v) $_8O$	2, 6

$_9F$ has the highest nonmetallic character.

***(82) The atomic number of aluminium is 13. With the help of diagram, write the electronic configuration and valency.**

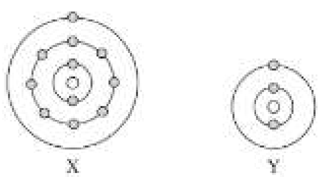


∴ The valency of aluminium = $\boxed{}$

Ans. The electronic configuration of aluminium = 2, 8, 3

The valency of aluminium = 3

(83) Observe the following diagram and answer the following questions :



(i) Identify elements X and Y.

(ii) Do these elements belong to the same group? Explain.

(iii) Which element is more electropositive in nature? Why?

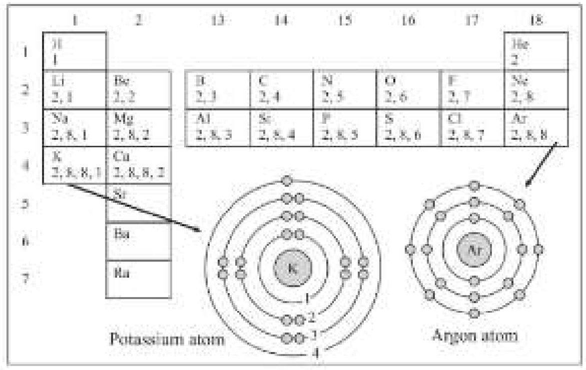
Ans. (i) An element X is Sodium (Na).

An element Y is Lithium (Li).

(ii) Yes, these elements belong to the same group as they have the same number of valence electrons.

(iii) Element X is more electropositive than Y. This is because while going down the group, electropositivity increases with increase in atomic size.

(84) Observe the following diagram and write the answer of the following questions :



(a) Write the atomic numbers of first two elements in the second group.

(b) Write the number of valence electrons of the elements in the halogen group.

(c) Draw the diagram of electronic configuration of magnesium atom.

(d) After completion of a period, what change does take place in the electronic configuration of the next element?

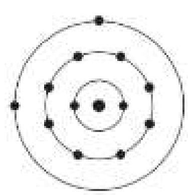
(e) Write the names of any two elements from the diagram which do not take part in chemical reaction. ***(5 marks) (July '19)***

Ans. (a) The atomic numbers of first two elements in the second group :

Elements	Atomic number
(1) Beryllium (Be)	4
(2) Magnesium (Mg)	12

(b) The number of valence electrons of the elements in the halogen group is 7.

(c) The diagram of electronic configuration of magnesium.



(d) As a period is completed, a new shell of electrons is added to the next element.

(e) He, Ne, Ar (Any two).

Q. 14 Give scientific reasons : *(2 marks each)*

***(1) Atomic radius goes on decreasing while going from left to right in a period.**

Ans. (1) In a period while going from left to right, atomic radius goes on decreasing and the atomic number increases one by one, that means positive charge on the nucleus increases by one unit at a time.

(2) However, the additional electron is added to the same outermost shell. Due to the increased nuclear charge the electrons are pulled towards the nucleus to a greater extent, as a result the size of atom decreases i.e., atomic radius decreases.

***(2) Metallic character goes on decreasing while going from left to right in a period.**

Ans. (1) Metals have a tendency to loose the valence electrons to form cations. This tendency of an element is called the metallic character of the element.

(2) While going from left to right within a period the outermost shell remains the same and electrons are added to the same shell. However, the positive charge on the nucleus goes on increasing while the atomic radius goes on decreasing and thus the effective nuclear charge goes on increasing. As a result of this the tendency of atom to lose electrons decreases, i.e., electropositivity decreases. Thus, metallic character goes on decreasing within a period from left to right.

***(3) Atomic radius goes on increasing down a group.**

Ans. The size of an atom is indicated by its radius. While going down a group a new shell is added. Therefore, the distance between the outermost electron and the nucleus goes on increasing. These electrons experience lesser pull from the nucleus. Thus, atomic radius goes on increasing down a group.

***(4) Elements belonging to the same group have the same valency.**

(Board Model Activity Sheet; March '20)

Ans. (1) The valency of an element is determined by the number of valence electron in the outermost shell of an atom of an element.

(2) All the elements in a group have the same number of valence electrons. Therefore, elements in the same group should have the same valency. For example, the elements of group I contain only one valence electron; the valency of elements of group I is one. Similarly for group II, the valency is two.

(5) Zero group elements (inert gases) are called noble gases.

Ans. (1) In the atoms of the inert gas elements (zero group elements), all the electronic shells, including the outermost shell, are completely filled.

(2) The electronic configuration is stable, and these elements do not lose or accept electrons. These elements do not take part in chemical reactions. These elements are gases. Hence, they are called noble gases.

(6) While going down the second group, the reactivity of the alkaline earth metals increases.

Ans. The reaction of alkaline earth metal with water is $M + 2H_2O \rightarrow M(OH)_2 + H_2$. While going down the second group as Be → Mg → Ca → Sr → Ba, the gradation in this chemical property of the alkaline earth metals is seen. While going down the second group the reactivity of the alkaline earth metals goes on increasing thereby the ease with which this reaction takes place also goes on increasing. Thus, Beryllium (Be) does not react with water. Mg (Magnesium) reacts with steam. Whereas calcium (Ca), strontium (Sr) and barium (Ba) reacts with water at room temperature with increasing rates.

***(7) The third period contains only eight elements even though the electron capacity of the third shell is 18.**

Ans. (1) In the modern periodic table, there are seven horizontal rows called periods. In a periods elements are arranged in an increasing order of their atomic numbers. The third row contains 8 elements and the electron capacity of the third shell is 18.

(2) In the third period, while moving from left to right, atomic number increases, number of electrons increases in the shell. The number of elements present in 3rd period is decided on the basis of electronic configuration and octet rule.

Atomic number	11	12	13	14	15	16	17	18
Elements	Na	Mg	Al	Si	P	S	Cl	Ar

Argon (Ar) is the last element of the third period and has a capacity of maximum 18 electrons. Its octet of electrons is completed and as argon belongs to zero group, the third shell contains 18 electrons.

(8) Fluorine is the most reactive among the halogens.

Ans. (1) Fluorine has the electronic configuration (2, 7). (2) It requires only one electron to complete the octet. (3) The atomic size of fluorine is the smallest among the halogens. Hence, the nuclear attraction on the outermost electrons is maximum. Hence, fluorine is the most reactive among the halogens.

(9) Sodium is more metallic than aluminium.

Ans. (1) Metals give electrons. Sodium has electronic configuration (2,8,1). It has only one electron in the outermost shell. (2) It can easily give the single electron in the outermost shell. Hence, Sodium is a strong metal. (3) Aluminium has electronic configuration (2,8,3). It has three electrons in the outermost shell. (4) Donation of three electrons is more difficult than the donation of one electron. Hence, sodium is more metallic than aluminium.

Q. 15 Distinguish between :

Mendeleev's periodic table and Modern periodic table.

Ans.

Mendeleev's periodic table	Modern periodic table
1. In this table, the elements are arranged in the order of their increasing atomic weights.	1. In this table, the elements are arranged in the order of their increasing atomic number.
2. In this table, the position of an element is based on its properties and atomic weight.	2. In this table, the position of an element is based on its electronic configuration.
3. There are 8 groups in this table.	3. There are 18 groups in this table.
4. In this table, some elements having similar properties are found in different groups, while those having different properties are sometimes found in the same group.	4. In this table, the elements belonging to the same group show similar chemical properties.
5. Isotopes do not find separate places in this table.	5. Isotopes of an element can be placed at the same place as their atomic number is the same.

PROJECT

*1. Find out the applications of all the inert gases, prepare a chart and display it in the class.
2. Find out the properties and uses of group 1 and group 2 elements.
3. Find out the properties and uses of period 2 and period 3 elements.

MEMORY MAP / CONCEPT MAP

(1)

Classification of Elements

Dobereiner's Triads	Limitations led to →	**Newlands' Octaves**	Modified to →	**Mendeleev's Periodic Table**	Research led to →	**Dobereiner's Triads**
Arranged in order of increasing atomic mass		Arranged in order of increasing atomic mass		Arranged in order of increasing atomic mass		Arranged in order of increasing atomic number

(2)

Modern Periodic Table

Trend in Periodic table	**Group and electronic configuration**	**Period and electronic configuration**
Valency –	the same valency	the valency varies
Atomic size –	Atomic radius increases Atomic size increases	Atomic radius decreases Atomic size decreases
Metallic–nonmetallic properties –	Electropositivity increases Metallic character increases	Electronegativity increases Nonmetallic character increases

3 CHEMICAL REACTIONS AND EQUATIONS

CHAPTER OUTLINE

IMPORTANT POINTS

• Can you recall? (Textbook page 16)

(1) What are the types of molecules of elements and compounds?

Ans. Elements are divided into three classes i.e. metals, nonmetals and metalloids. When two or more elements combine chemically in a fixed proportion by weight, a compound is formed. The properties of a compound are altogether different from those of the constitutional elements.

(2) What is meant by valency of element?

Ans. The number of electrons that an atom of an element gives away or takes up while forming an ionic bond, is called the valency of that element.

(3) What is the requirement for writing molecular formulae of different compounds? How are the molecular formulae of the compounds written?

Ans. While writing the molecular formulae of different compounds, the symbol of the radicals and their valence should be known.

The number of the ions is written as subscript on the right of the symbol of the ion. By cross multiplication of valencies chemical formula is obtained.

3.1 Chemical reactions :

During chemical reactions composition of the matter changes and that change remains permanent and during physical change only the state of matter changes and this change is often temporary in nature.

Identify physical and chemical changes from the phenomena given in the following table.

(Textbook page 30)

Phenomenon	Physical change	Chemical change
(1) Transformation of ice into water	✓	
(2) Cooking of food		✓
(3) Ripening of fruit		✓
(4) Milk turned into curd		✓
(5) Evaporation of water	✓	
(6) Digestion of food in the stomach		✓
(7) Size reduction of naphtha balls exposed to air		✓
(8) Staining of Shahbadi or Kadappa tile by lemon juice		✓
(9) Breaking of a glass object on falling from a height		✓

- **Chemical reaction :** A process in which some substances undergo bond breaking and are transformed into new substances by formation of new bonds is called a chemical reaction.

3.2 Rules writing chemical reaction :

1. **Chemical equation :** The representation of a chemical reaction in a condensed form using chemical formulae is called as the chemical equation.
2. **Rules used in writing a chemical equation :**
   (1) The reactants are written on the left hand side (LHS), while the products are written on the right hand side (RHS).

(2) Whenever there are two or more reactants, a plus sign (+) is written between each two of them. Similarly, if there are two or more products, a plus sign is written between each two of them.

(3) Reactant side and product side are connected with an arrow (→) pointing from reactants to products. The arrow represents the direction of the reaction. Heat is to be given from outside to the reaction, it is indicated by the sign △ written above the arrow.

(4) The conditions like temperature, pressure, catalyst, etc., are mentioned above the arrow (→) pointing towards the product side.

(5) The physical states of the reactants and products are also mentioned in a chemical equation. The notations g, l, s, and aq are written in brackets as a subscript along with the symbols /formulae of reactants and products. The symbols g, l, s, and aq stand for gaseous, liquid, solid and aqueous respectively. If the product is gaseous, instead of (g) it can be indicated by an arrow ↑ pointing upwards. If the product formed is insoluble solid, then instead of (s) it can be indicated by an arrow ↓ pointing downwards.

(6) Special information or names of reactants/ products are written below their formulae.

3.3 Balancing a chemical equation :

In a chemical reaction, the number of atoms of the elements in the reactants is same as the number of atoms of those elements in the product, such an equation is called a balanced equation.

Example : $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$

In the above reaction, the number of atoms of the elements in the reactants is same as the number of atoms of elements in the products.

3.4 Types of chemical reactions :

Types of chemical reactions :

(1) Combination reaction

(2) Decomposition reaction

(3) Displacement reaction

(4) Double displacement reaction.

(1) Combination reaction : When two or more reactants combine in a reaction to form a single product, it is called a combination reaction.

An example of combination reaction :

The ammonia gas reacts with hydrogen chloride gas to form the salt in gaseous state, immediately it condenses at room temperature and gets transformed into the solid state.

$$\underset{\text{Ammonia}}{NH_{3(g)}} + \underset{\substack{\text{Hydrogen} \\ \text{chloride}}}{HCl_{(g)}} \rightarrow \underset{\substack{\text{Ammonium chloride} \\ \text{(a single product)}}}{NH_4Cl_{(s)}}$$

(2) Decomposition reaction : The chemical reaction in which two or more products are formed from a single reactant is called decomposition reaction.

Examples of decomposition :

(1) **Thermal decomposition :** The reaction in which a compound is decomposed by heating it to a high temperature is called thermal decomposition.

At high temperature, calcium carbonate decomposes into calcium oxide and carbon dioxide.

$$CaCO_{3(s)} \xrightarrow{\text{Heat}} CaO_{(s)} + CO_{2(g)}$$

(2) **Electrolytic decomposition :** The reaction in which a compound is decomposed by passing an electric current through its solution or molten mass is called an electrolytic decomposition.

When an electric current is passed through acidulated water, it is electrolysed giving hydrogen and oxygen.

$$2H_2O_{(l)} \xrightarrow[\text{current}]{\text{electric}} 2H_2\uparrow + O_2\uparrow$$

• Can you recall? (Textbook page 37)

Is it possible to produce hydrogen by decomposition of water by mean of heat, electricity or light?

Ans. It is possible to produce hydrogen by decomposition of water by means of heat, electricity or light.

(3) Displacement reaction : The reaction in which the place of the ion of a less reactive element in a compound is taken by another more reactive element by formation of its own ions, is called displacement reaction.

An example of displacement reaction :

When zinc granules are added to the blue coloured copper sulphate solution, the zinc ions formed from zinc atoms take the place of Cu^{2+} ions in $CuSO_4$, and copper atoms, formed from Cu^{2+} ions comes out i.e. the more reactive zinc displaces the less reactive Cu from copper sulphate.

$$\underset{\text{zinc}}{Zn_{(s)}} + \underset{\text{Copper sulphate}}{CuSO_{4(aq)}} \rightarrow \underset{\text{zinc sulphate (colourless)}}{ZnSO_{4(aq)}} + \underset{\text{Copper}}{Cu_{(s)}} + \text{Heat}$$

(4) Double displacement reaction : The reaction in which the ions in the reactants are exchanged to form a precipitate are called double displacement reaction.

An example of double displacement reaction :

Solutions of sodium chloride and silver nitrate react with each other forming a precipitate of silver chloride and a solution of sodium nitrate.

$$\underset{\text{Silver nitrate}}{AgNO_3} + \underset{\text{Sodium chloride}}{NaCl} \rightarrow \underset{\text{Silver chloride (precipitate)}}{AgCl_{(s)}} + \underset{\text{Sodium nitrate}}{NaNO_3}$$

White precipitate of AgCl is formed by exchange of ions Ag^+ and Cl^- between the reactants.

(5) Exothermic process : The process in which heat is given out is called an exothermic process.

When $NaOH_{(s)}$ dissolves in water, there is evolution of heat leading to a rise in temperature.

$$NaOH_{(s)} + H_2O_{(l)} \rightarrow NaOH_{(aq)} + \text{Heat}$$

(6) Endothermic process : The reaction in which heat is absorbed is called an endothermic process.

When $KNO_{3(s)}$ dissolves in water, there is absorption of heat during the reaction and the temperature of the solution falls.

$$KNO_{3(s)} + H_2O_{(l)} + \text{Heat} \rightarrow KNO_{3(aq)}$$

(7) Rate of chemical reaction : Some reactions are completed in short time, i.e., occur rapidly, while some other require long time for completion, i.e, occur slowly. It means that the rate of different reaction is different.

(1) One or more chemical reactions take place during every chemical change.

(2) Strong acid and strong base react instantaneously.

(3) In our body, enzymes increase the rate of physiological reactions.

(4) If the rate of the chemical reaction is fast, it is profitable for the chemical factories.

(5) The rate of chemical reaction is important with respect to environment.

(6) The ozone layer in the earth's atmosphere protects the life on earth from the ultraviolet radiation of the sun. The process of depletion or maintenance of this layer depends upon the rate of production or destruction of ozone molecules.

(8) Factors affecting the rate of a chemical reaction : (1) Nature of reactants (2) Size of the particles of reactants (3) Concentration of the reactants (4) Temperature of the reaction (5) Catalyst.

(9) Oxidation : The chemical reaction in which a reactant combines with oxygen or loses hydrogen to form the product is called oxidation reaction. The chemical substances which bring about an oxidation reaction by making oxygen available are called oxidants or oxidizing agents. In the combustion of carbon, oxygen is an oxidant.

Examples : $C + O_2 \xrightarrow{\Delta} CO_2 \uparrow$

$$\underset{\text{Ethane}}{CH_3 - CH_3} \xrightarrow{\Delta} \underset{\text{Ethane}}{CH_2 = CH_2} + H_2 \uparrow$$

A variety of oxidants :

$K_2Cr_2O_7/H_2SO_4$, $KMnO_4/H_2SO_4$ are the commonly used chemical oxidants. Hydrogen peroxide (H_2O_2) is used as a mild oxidant. Ozone (O_3) is also a chemical oxidant. Nascent oxygen is generated by chemical oxidants and it is used for the oxidation reaction.

$O_3 \rightarrow O_2 + [O]$

$H_2O_2 \rightarrow H_2O + [O]$

$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$

$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$

Nascent oxygen is a state prior to the formation of the O_2 molecule. It is the reactive form of oxygen and is represented by writing the symbol as [O].

(10) Reduction : The chemical reaction in which a reactant gains hydrogen or loses oxygen to form the product is called reduction. The chemical substance that brings about reduction is called a reductant, or a reducing agent.

When hydrogen gas is passed over black copper oxide a reddish coloured layer of copper is formed.

$CuO + H_2 \rightarrow Cu + H_2O$

(11) Redox reaction : The reaction which involves simultaneous oxidation and reduction is called an oxidation-reduction or redox reaction.

In a redox reaction, one reactant gets oxidised while the other gets reduced during a reaction.

Redox reaction = Reduction + Oxidation

In redox reaction, the reductant is oxidized by the oxidant and the oxidant is reduced by the reductant.

Examples : $CuO_{(s)} + H_{2(g)} \rightarrow Cu_{(s)} + H_2O_{(g)}$

$\underset{\text{Hydrogen Sulphide}}{2H_2S} + \underset{\text{Sulphur}}{SO_2} \rightarrow 3S + 2H_2O$

$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2 \uparrow$

(12) Corrosion : Due to various components of atmosphere, oxidation of metals takes place, consequently resulting in their damage. This is called 'corrosion'. Iron rusts and a reddish coloured layer is collected on it. This is corrosion of iron. This is also termed as rusting of iron. Its formula is $Fe_2O_3.H_2O$.

Prevention of corrosion : Corrosion damages buildings, bridges, automobiles, ships, iron railings and other articles made of iron. It can be prevented by using an anti-rust solution, coating surface by the paint by processes like galvanising and electroplating with other metals.

(13) Rancidity : Fats and oils in food, is kept for a long time, gets oxidised, it is found to have foul odour called rancidity.

QUESTIONS & ANSWERS

Q. 1 Fill in the blanks :

(1) Organic waste is decomposed by microorganism and as a result manure and .... are formed.

(2) .... is formed on mixing yeast in glucose solution under proper condition.

(3) The chemical reaction during which $H_{2(g)}$ is lost is termed as ....

(4) Corrosion can be prevented by using ....

(5) The chemical reactions in which heat is liberated are called .... reactions.

(6) The chemical formula of rust is ....

(7) A reaction in which heat is absorbed is called .... reaction.

(8) The process of rusting of iron is .... process.

(9) When oil and fats are oxidised or even allowed to stand in air for a long time, they become ....

(10) .... are used to prevent oxidation of food.

(11) Carbon dioxide is passed through water. The reaction is a .... reaction.

(12) Calcium carbonate is heated. The reaction is a .... reaction.

(13) Zinc strip is dipped in a $CuSO_4$ solution. The reaction is a .... reaction.

(14) Silver nitrate solution is added to NaCl solution. The reaction is a .... reaction.

(15) The slow process of decay or destruction of a metal due to effect of air, moisture and acids on it is known as ....

Ans.

(1) Organic waste is decomposed by micro-organism and as a result manure and bio gas are formed.

(2) Alcohol is formed on mixing yeast in glucose solution under proper condition.

(3) The chemical reaction during which $H_{2(g)}$ is lost is termed as oxidation.

(4) Corrosion can be prevented by using antirust solution.

(5) The chemical reactions in which heat is liberated are called exothermic reactions.

(6) The chemical formula of rust is $Fe_2O_3.H_2O$.

(7) A reaction in which heat is absorbed is called endothermic reaction.

(8) The process of rusting of iron is oxidation process.

(9) When oil and fats are oxidised or even allowed to stand in air for a long time, they become rancid.

(10) Antioxidants are used to prevent oxidation of food.

(11) Carbon dioxide is passed through water. The reaction is a combination reaction.

(12) Calcium carbonate is heated. The reaction is a decomposition reaction.

(13) Zinc strip is dipped in a $CuSO_4$ solution. The reaction is a displacement reaction.

(14) Silver nitrate solution is added to NaCl solution. The reaction is a double displacement reaction.

(15) The slow process of decay or destruction of a metal due to effect of air, moisture and acids on it is known as corrosion.

Q. 2 Choose the correct alternative and write it along with its allotted alphabet : ***(1 mark each)***

(1) The reaction of iron nail with copper sulphate solution is ...... reaction.

(a) double displacement *(b) displacement*
(c) combination *(d) decomposition*

(March '19)

(2) Reddish brown deposit formed on iron nails kept in a solution of copper sulphate is :

(a) Cu_2O *(b)* Cu *(c)* CuO *(d)* CuS

(3) The reaction $CuSO_{4\,(aq)} + Zn_{(s)} \rightarrow ZnSO_{4\,(aq)} + Cu_{(s)}$ is a ...... reaction.

(a) displacement *(b) double displacement*
(c) decomposition *(d) combination*

(4) ...... is a combination reaction.

(a) $Cu + H_2SO_4 \rightarrow CuSO_4 + H_2$

(b) $H_2 + Cl_2 \rightarrow 2HCl$

(c) $2HgO \xrightarrow{\Delta} 2Hg + O_2$

(d) $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

(5) ...... is a decomposition reaction.

(a) $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

(b) $H_2O + CO_2 \rightarrow H_2CO_3$

(c) $CaS + 2HCl \rightarrow CaCl_2 + H_2S$

(d) $2H_2 + O_2 \rightarrow 2H_2O$

(6) In a chemical equation the ...... are written on the left hand side.

(a) products *(b) reactants*
(c) catalysts *(d) elements*

(7) The $\triangle$ sign written above the arrow indicates ...... of the reaction.

(a) reactant *(b) product*
(c) heat *(d) direction of the reaction*

(8) The reaction $KNO_{3(s)} + H_2O_{(l)} + \text{Heat} \rightarrow KNO_{3(aq)}$ is a/an .... reaction.

(a) exothermic *(b) endothermic*
(c) oxidation *(d) reduction*

(9) The reaction $NaOH_{(s)} + H_2O_{(l)} \rightarrow NaOH_{(aq)}$ is a/an ...... reaction.

(a) exothermic *(b) endothermic*

(c) oxidation *(d) reduction*

(10) A solution of $Al_2(SO_4)_3$ in water is ......

(a) blue *(b) pink* *(c) green* *(d) colourless*

(11) Carbon dioxide ......

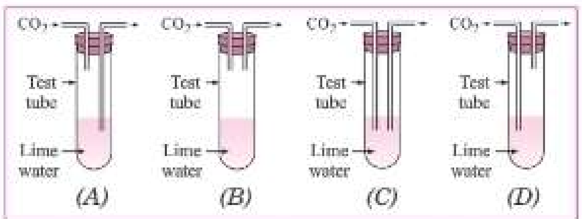
(a) turns lime water milky

(b) is odourless

(c) is colourless

(d) All the three (a), (b) and (c) are correct

(12) ...... is the correct set up to pass CO_2 through lime water.



(13) When ...... is passed through fresh lime water, it turns milky.

(a) H_2 *(b)* CO *(c)* CO_2 *(d)* SO_2

(14) Magnesium reacts with con. HCl to form ...... salt.

(a) copper chloride *(b) ferrous chloride*

(c) calcium chloride *(d) magnesium chloride*

(15) Zinc reacts with hydrochloric acid. The reaction is a ...... reaction.

(a) combination *(b) decomposition*

(c) displacement *(d) double decomposition*

(16) In a double displacement reaction, ...

(a) ions remain at rest

(b) ions get liberated

(c) ions are exchanged

(d) ions are not created

(17) Combustion of coal in air is a .... reaction.

(a) combination *(b) displacement*

(c) decomposition *(d) double displacement*

(July '19)

(18) The crystals of ferrous sulphate are ......

(a) blue in colour *(b) pink in colour*

(c) pale green in colour *(d) colourless*

(July '19)

(19) Identify the type of following chemical reaction of carbon compound.

$C_{12}H_{22}O_{11} \xrightarrow{\Delta} 12C + 11H_2O$

(a) Combination reaction

(b) Displacement reaction

(c) Decomposition reaction

(d) Double displacement

(20) The conversion of ferrous sulphate into ferric sulphate is ...... reaction. ***(Nov. '20)***

(a) oxidation *(b) displacement*

(c) electrolysis *(d) reduction*

Ans. (1) (b) displacement

(2) (b) Cu

(3) (a) displacement

(4) (b) $H_2 + Cl_2 \rightarrow 2HCl$

(5) (a) $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

(6) (b) reactants

(7) (c) heat

(8) (b) endothermic

(9) (a) exothermic

(10) (d) colourless

(11) (d) All the three (a), (b) and (c) are correct

(12) correct set up (D) (13) (c) CO_2

(14) (d) magnesium chloride

(15) (c) displacement

(16) (c) ions are exchanged

(17) (a) combination

(18) (c) pale green in colour

(19) (c) Decomposition reaction

(20) (a) oxidation

Q. 3 Choose the correct option from the bracket and explain the statement giving reasons : *(1 mark each)

(Oxidation, displacement, electrolysis, reduction, zinc, copper, double displacement, decomposition)

(1) To prevent rusting, a layer of ...... metal is applied on iron sheets.

(2) The conversion of ferrous sulphate to ferric sulphate is ...... reaction.

(3) When electric current is passed through acidulated water ...... of water takes place.

(4) Addition of an aqueous solution of $ZnSO_4$ to an aqueous solution of $BaCl_2$ is an example of ...... reaction.

Ans.

(1) To prevent rusting, a layer of **zinc** metal is applied on iron sheets.

The rusting of iron is an oxidation process. Due to corrosion of an iron a deposit of reddish substance ($Fe_2O_3.H_2O$) is formed on it. This substance is called rust. To prevent corrosion, a layer of zinc metal (galvanisation) is applied on iron sheets.

(2) The conversion of ferrous sulphate to ferric sulphate is an **oxidation** reaction.

When ferric ion is formed from ferrous ion, the positive charge is increased by one unit. While this happens the ferrous ion loses one electron. A process in which a metal or its ion loses one or more electrons is called an oxidation.

$$2FeSO_4 \rightarrow Fe_2(SO_4)_3$$

$$Fe^{2+} + SO_4^{2-} \rightarrow 2Fe^{3+} + 3SO_4^{2-}$$

Net reaction : $\underset{\text{Ferrous}}{Fe^{2+}} \rightarrow \underset{\text{Ferric}}{Fe^{3+}} + e^-$

(3) When electric current is passed through acidulated water **decomposition** of water takes place. In this reaction, hydrogen and oxygen gas are formed.

This decomposition takes place with the help of an electric current, it is also called electrolytic decomposition.

$$2H_2O_{(l)} \xrightarrow{\text{electric current}} 2H_2\uparrow + O_2\uparrow$$

(4) Addition of an aqueous solution of $ZnSO_4$ to an aqueous solution of $BaCl_2$ is an example of **double displacement** reaction.

$$\underset{\substack{\text{Barium}\\\text{chloride}}}{BaCl_{2(aq)}} + \underset{\substack{\text{Zinc}\\\text{sulphate}}}{ZnSO_{4(aq)}} \rightarrow \underset{\substack{\text{Barium}\\\text{sulphate}}}{BaSO_4\downarrow} + \underset{\substack{\text{Zinc}\\\text{chloride}}}{ZnCl_{2(aq)}}$$

Barium chloride reacts with zinc sulphate to form a white precipitate of barium sulphate. White precipitate is formed by exchange of ions Ba^{++} and SO_4^{--} between the reactants.

Q. 4 State whether the following statements are *True* or *False* : *(1 mark each)*

(1) Rusting of iron is a fast reaction.

(2) Milk is set into curd is a chemical change.

(3) The reaction between salt and water is an example of exothermic reaction.

(4) The speed of a chemical reaction depends on the catalyst used in the chemical reaction.

(5) The simple form of representation of a chemical reaction in words is known as word reaction.

(6) Nascent oxygen is always denoted by showing the symbol of oxygen.

(7) Antioxidants are used to prevent oxidation of food containing fats and oils.

(8) When oils and fats are allowed to stand for a long time, they become rancid.

(9) The chemical formula of rust is $Fe_3O_4 . xH_2O$.

(10) Glucose combines with oxygen in our body and provides energy. The reaction is an endothermic reaction.

(11) Chemical reactions in which reactants gain oxygen are reduction reactions.

(12) $CuSO_{4(aq)} + Zn_{(s)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$ is an example of decomposition reaction.

(13) The chemical reactions in which heat is liberated are called endothermic reactions.

(14) The product or insoluble solid in chemical reaction is indicated by an arrow $\uparrow$ pointing upwards.

(15) The rate of a reaction increases on increasing the temperature.

(16) The digestion of food is a chemical decomposition process.

(17) The reaction between sodium hydroxide and hydrochloric acid is a slow reaction.

(18) When calcium carbonate is heated, it decomposes into calcium oxide and oxygen gas.

(19) The rate of a chemical reaction changes in presence of catalyst.

(20) Chlorine is an oxidant.

Ans.

(1) **False.** (Rusting of iron is a slow reaction.)

(2) **True.**

(3) **False.** (The reaction between salt and water is an example of endothermic reaction.)

(4) **True.** (5) **True.**

(6) **False.** (Nascent oxygen is always denoted by showing symbol of oxygen [O] in square brackets.)

(7) **True.** (8) **True.**

(9) **False.** (The chemical formula of rust is $Fe_2O_3 . xH_2O$.)

(10) **False.** (Glucose combines with oxygen in our body and provides energy. The reaction is an exothermic reaction.)

(11) **False.** (Chemical reactions in which reactants gain oxygen are oxidation reactions.)

(12) **False.** (It is an example of displacement reaction.)

(13) **False.** (The chemical reactions in which heat is liberated are called exothermic reactions.)

(14) **False.** (The product or insoluble solid in chemical reaction is indicated by an arrow ↓ pointing downwards.)

(15) **True.** (16) **True.**

(17) **False** (The reaction between sodium hydroxide and hydrochloric acid is a fast reaction.)

(18) **False** (When calcium carbonate is heated, it decomposes into calcium oxide and carbon dioxide gas.

(19) **True.** (20) **True.**

Q. 5 Taking into consideration the relationship in the first pair, complete the second pair.

OR **Complete the following :**

(1 mark each)

(1) $2H_2 + O_2 \rightarrow 2H_2O$: Combination reaction : : $2HgO \rightarrow 2Hg + O_2$: ......

(2) $NH_3 + HCl \rightarrow NH_4Cl$: Combination reaction : : $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$: ......

(3) $2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2$: Oxidation : : $CuO + H_2 \rightarrow Cu + H_2O$: ......

(4) $CuCl_2 + 2KI \rightarrow CuI_2 + 2KCl$: Double displacement : : $Zn + 2HCl \rightarrow ZnCl_2 + H_2$: ......

(5) $C_{12}H_{22}O_{11} \xrightarrow[\Delta]{heat} 12C + 11H_2O$: Decomposition reaction : : $H_2O + CO_2 \rightarrow H_2CO_3$: ......

(6) CuI_2 : Brown : : $AgCl$: ......'

(7) Molecular formula of beryllium oxide : BeO : : Molecular formula of beryllium chloride : ......

(July '19)

Ans. **(1)** Decomposition reaction **(2)** Displacement reaction **(3)** Reduction **(4)** Displacement reaction **(5)** Combination reaction **(6)** White **(7)** $BeCl_2$.

Q. 6 Match the column in the following table :

*(1) Reactants	Products	Type of chemical reaction
$BaCl_{2(aq)} + ZnSO_{4(aq)}$	$H_2CO_{3(aq)}$	Displacement
$2AgCl_{(s)}$	$FeSO_{4(aq)} + Cu_{(s)}$	Combination
$CuSO_{4(aq)} + Fe_{(s)}$	$BaSO_4\downarrow + ZnCl_{2\,(aq)}$	Decomposition
$H_2O_{(l)} + CO_{2(g)}$	$2Ag_{(s)} + Cl_{2(g)}$	Double displacement

Ans.

Reactants	Products	Type of chemical reaction
$BaCl_{2(aq)} + ZnSO_{4(aq)}$	$BaSO_4\downarrow + ZnCl_{2\,(aq)}$	Double displacement
$2AgCl_{(s)}$	$2Ag_{(s)} + Cl_{2(g)}$	Decomposition
$CuSO_{4(aq)} + Fe_{(s)}$	$FeSO_{4(aq)} + Cu_{(s)}$	Displacement
$H_2O_{(l)} + CO_{2(g)}$	$H_2CO_{3(aq)}$	Combination

(2) Reactants	Products	Type of chemical reaction
$Fe + S$	$NaCl + H_2O$	Oxidation
$CuSO_4 + Zn$	$2CuO$	Neutralization
$2Cu + O_2$	$ZnSO_4 + Cu$	Displacement
$HCl + NaOH$	FeS	Combination

Ans.

Reactants	Products	Type of chemical reaction
$Fe + S$	FeS	Combination
$CuSO_4 + Zn$	$ZnSO_4 + Cu$	Displacement
$2Cu + O_2$	$2CuO$	Oxidation
$HCl + NaOH$	$NaCl + H_2O$	Neutralization

Q. 7 Rewrite the second column so as to match the item from first column or Match the following :

(1) Column I	Column II
(1) Reduction	(a) Type of chemical reaction
(2) Oxidation	(b) Combination with hydrogen
	(c) Losing hydrogen
	(d) Exchange of ions

Ans. (1) Reduction – Combination with hydrogen

(2) Oxidation – Losing hydrogen.

(2) Column I	Column II
(1) Oils and fats are allowed to stand in air for a long time	(a) Slow reaction
(2) NaOH dissolves in water	(b) Rancid
	(c) Exothermic reaction
	(d) Colourless solution

Ans. (1) Oils and fats are allowed to stand in air for a long time – Rancid

(2) NaOH dissolves in water – Exothermic reaction

(3) Column I	Column II
(1) Combination reaction	(a) $Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$
(2) Double displacement reaction	(b) $C_{12}H_{22}O_{11(s)} \xrightarrow{\Delta} 12C_{(s)} + 11H_2O_{(g)}$
	(c) $2Cu + O_2 \rightarrow 2CuO$
	(d) $AgNO_3 + NaCl \rightarrow AgCl\downarrow + NaNO_3$

Ans.

(1) Combination reaction – $2Cu + O_2 \rightarrow 2CuO$

(2) Double displacement reaction –

$$AgNO_3 + NaCl \rightarrow AgCl\downarrow + NaNO_3$$

Q. 8 Classify each of the following reactions as combination, decomposition, displacement or double displacement reactions : *(1 mark each)*

(1) $\underset{\text{Tricalcium aluminate}}{3CaO.Al_2O_{3(s)}} + \underset{\text{Water}}{6H_2O_{(l)}} \rightarrow \underset{\text{Concrete}}{3CaO.Al_2O_3.6H_2O_{(s)}} + \text{Heat}$

(2) $\underset{\text{Sugar}}{C_{12}H_{22}O_{11(s)}} \xrightarrow{\text{heat }\Delta} \underset{\text{Carbon}}{12C_{(s)}} + 11H_2O_{(g)}$

(3) $\underset{\text{Copper sulphate}}{CuSO_{4(aq)}} + Fe_{(s)} \rightarrow \underset{\text{Ferrous sulphate}}{FeSO_{4(aq)}} + Cu_{(s)}$

(4) $\underset{\text{Copper chloride}}{CuCl_{2(aq)}} + \underset{\text{Potassium iodide}}{2KI_{(aq)}} \rightarrow \underset{\text{Copper iodide}}{CuI_2\downarrow} + \underset{\text{Potassium chloride}}{2KCl_{(aq)}}$

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

(6) $\underset{\text{Barium chloride}}{BaCl_{2(aq)}} + \underset{\text{Silver nitrate}}{2AgNO_{3(aq)}} \rightarrow \underset{\text{Barium nitrate}}{Ba(NO_3)_{2(aq)}} + \underset{\text{Silver chloride}}{2AgCl_{(s)}\downarrow}$

Ans.

(1) Combination reactions :

(1) $3CaO.Al_2O_{3(s)} + 6H_2O_{(l)} \rightarrow 3CaO.Al_2O_3.6H_2O_{(s)} + \text{Heat}$

(5) $CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2(aq)}$

(2) Displacement reaction :

(3) $CuSO_{4(aq)} + Fe_{(s)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}$

(3) Decomposition reactions :

(2) $C_{12}H_{22}O_{11(s)} \rightarrow \xrightarrow{\text{heat } \Delta} 12C_{(s)} + 11H_2O_{(g)}$

(4) Double displacement reactions :

(4) $CuCl_{2(aq)} + 2KI_{(aq)} \rightarrow CuI_2 \downarrow + 2KCl_{(aq)}$

(6) $BaCl_{2(aq)} + 2AgNO_{3(aq)} \rightarrow Ba(NO_3)_{2(aq)} + 2AgCl_{(s)} \downarrow$

Q. 9 Name the following : *(1 mark each)*

(1) The product formed in the thermal decomposition of sugar.

Ans. Carbon is formed in the thermal decomposition of sugar.

(2) The gas evolved when sodium metal reacts with ethanol.

Ans. Hydrogen (H_2) gas is evolved when sodium metal reacts with ethanol.

(3) The precipitate formed when barium sulphide reacts with zinc sulphate.

Ans. When barium sulphide reacts with zinc sulphide, a precipitate of barium sulphate is formed.

$$BaS + ZnSO_4 \longrightarrow \underset{\text{precipitate}}{BaSO_4} + ZnS$$

(4) The reducing agent used for the reduction of copper oxide.

Ans. Hydrogen is used for the reduction of copper oxide.

(5) The catalyst used to accelerate the rate of decomposition of hydrogen peroxide.

Ans. Manganese dioxide (MnO_2) is used as a catalyst to accelerate the rate of decomposition of hydrogen peroxide.

(6) Which oxidising agent is used to oxidise ferrous sulphate.

Ans. Potassium permanganate ($KMnO_4$) is used as an oxidising agent to oxidise ferrous sulphate.

(7) The product formed in the oxidation of ethyl alcohol.

Ans. Acetic acid is formed in the oxidation of ethyl alcohol.

(8) How are the blackened silver utensils and patinated (greenish) brass utensils cleaned?

(Find out) (Textbook page 44)

Ans. The blackened silver utensils and patinated (greenish) brass utensils are cleaned using baking soda, vinegar and lemon mix.

Q. 10 Answer the following questions :

(1) What do you understand by a physical change? *OR*

Define physical change.

Ans. The change in which only the physical state of a substance is changed; no new substance is formed. This change is temporary. During this change the composition of the substance does not change.

(2) Explain giving two examples of physical change.

Ans. (1) Conversion of ice into water is a physical change. On heating, ice melts into water. When the water is cooled, it freezes into ice. Thus, we get ice from water by a simple method and no new substance is formed. Hence, conversion of ice into water is a physical change.

(2) Magnetization of iron nail is a physical change. An iron nail magnetized by induction loses its magnetism as soon as it is detached from the magnet which induces magnetism in it. An iron nail magnetized by some other methods can also be demagnetized by simple means such as hammering or heating it. Thus, the magnetization of an iron nail can be easily reversed to get original nail. Hence, it is a physical change.

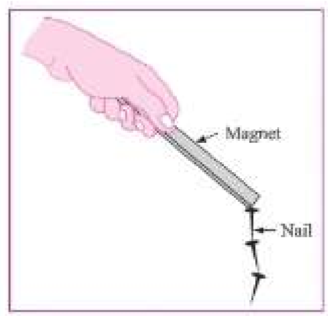


Fig 3.1 : Magnetization of iron nails

(3) What do you understand by a chemical change? *OR*

Define : Chemical change.

Ans. The change in which a substance or substances are converted into a new substance or substances, possessing properties altogether different from the original ones, is called a chemical change. During this change, the original substance cannot be recovered by any simple means. This change is permanent.

(4) Explain giving two examples of chemical change.

Ans. (1) When carbon is burnt, carbon dioxide is formed. In this process carbon combines with oxygen, therefore carbon and oxygen are reactants, while carbon dioxide is a product. This change is permanent.

$$C_{(s)} + O_{2(g)} \xrightarrow{\text{Heat}} CO_{2(g)}$$

(2) When a magnesium wire is burnt in air, a white powder of magnesium oxide is formed. We cannot obtain magnesium from magnesium oxide by simple methods. Properties of magnesium oxide are altogether different from those of magnesium. A new substance MgO is formed in the reaction. Hence, this change is a chemical change.

Fig. 3.2 : Burning of Mg. ribbon

$$\underset{\text{Magnesium}}{2Mg} + O_2 \xrightarrow{\Delta} \underset{\text{Magnesium oxide}}{2MgO}$$

(5) What is meant by a chemical reaction?

Ans. A process in which some substances undergo bond breaking and are transformed into new substances by formation of new bonds is called a chemical reaction.

***(6) Explain the term reactant and product giving examples.**

Ans. (1) The substance which undergoes bond breaking while taking port in a chemical reaction is called reactant.

(2) The substance formed as a result of a chemical reaction by formation of new bonds is called product.

(3) Example : In a chemical reaction, the formation of carbon dioxide gas takes place by combustion of coal in air. In this reaction, coal (carbon) and oxygen (from air) are the reactants while carbon dioxide is the product.

$$\underset{\text{(Reactants)}}{C_{(s)} + O_2} \xrightarrow{\Delta} \underset{\text{(Product)}}{CO_{2(g)}}$$

(7) What is meant by a chemical equation?

Ans. The simple representation of a chemical reaction in a condensed form with the help of chemical formulae is called a chemical equation.

(8) What is meant by a word equation?

Ans. The simple form of representation of a chemical reaction in words is known as word equation.

(9) Write down the physical states of reactants and products in the reaction :

$$SO_2 + 2H_2S \rightarrow 3S + 2H_2O$$

(Use your brain power!) (Textbook page 35)

Ans. Reactants : $SO_{2(g)}$, $2H_2S_{(g)}$

Products : $3S_{(s)}$, $2H_2O_{(l)}$.

(10) Write down the physical states of reactants and products in the reaction :

$$2Ag + 2HCl \rightarrow 2AgCl + H_2$$

(Use your brain power!) (Textbook page 35)

Ans. Reactants : $2Ag_{(s)}$, $2HCl_{(l)}$

Products : $2AgCl\downarrow$, $H_2\uparrow$

(11) Identify the reactants and products of the following equation :

$$\text{Vegetable oil}_{(l)} + H_{2(g)} \xrightarrow[\text{Ni Catalyst}]{60°C} \text{Vanaspathi ghee}$$

(Use your brain power!) (Textbook page 35)

Ans. Reactants : Vegetable oil, $H_{2(g)}$

Product : Vanaspathi ghee

(12) What is the importance of a chemical equation?

Ans. (1) Reactants are converted into products.

(2) Mass is conserved.

(3) Atoms are conserved.

(4) The properties and compositions of the products of a chemical reaction are different from those of its reactants.

(5) Generally, energy is either absorbed or evolved.

(13) What are the conventions used in writing a chemical equation?

Ans. Conventions used in writing a chemical equation :

(1) The reactants are written on the left hand side (LHS), while the products are written on the right hand side (RHS).

(2) Whenever there are two or more reactants, a plus sign (+) is written between each two of them. Similarly, if there are two or more products, a plus sign is written between each two of them.

(3) Reactant side and product side are connected with an arrow ($\rightarrow$) pointing from reactants to products. The arrow represents the direction of the reaction. Heat is to be given from outside to the reaction, it is indicated by the sign $\triangle$ written above the arrow.

(4) The conditions like temperature, pressure, catalyst, etc., are mentioned above the arrow ($\rightarrow$) pointing towards the product side.

(5) The physical states of the reactants and products are also mentioned in a chemical equation. The notations g, l, s, and aq are written in brackets as a subscript along with the symbols /formulae of reactants and products. The symbols g, l, s, and aq stand for gaseous, liquid, solid and aqueous respectively.

If the product is gaseous, instead of (g) it can be indicated by an arrow $\uparrow$ pointing upwards. If the product formed is insoluble solid, then instead of (s) it can be indicated by an arrow $\downarrow$ pointing downwards.

(6) Special information or names of reactants/ products are written below their formulae.

***(14) Explain the term balanced equation with example.**

Ans. In a chemical reaction, the number of atoms of the elements in the reactants is same as the number of atoms of those elements in the product, such an equation is called a balanced equation.

Example : $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$

In the above reaction, the number of atoms of the elements in the reactants is same as the number of atoms of elements in the products.

(15) Write the balanced equations for the following reactions :

***(i)** $H_2S_2O_{7(l)} + H_2O_{(l)} \longrightarrow H_2SO_{4(l)}$

(3 marks) (Board's Model Activity Sheet)

Ans. **Step 1 :** Rewrite the given equation as it is

$H_2S_2O_{7(l)} + H_2O_{(l)} \longrightarrow H_2SO_{4(l)}$

Step 2 : Write the number of atoms of each element in the unbalanced equation on both sides of equations.

Element	Number of atoms in reactant (left side)	Number of atoms in products (right side)
H	4	2
S	2	1
O	8	4

Step 3 : To equalise the number of hydrogen atoms, sulphur atoms and oxygen atoms we use 2 as the coefficient or factor in the product.

Element	Number of atoms in reactant (left side)	Number of atoms in products (right side)
H	4	2×2
S	2	1×2
O	8	4×2
Total	14	14

Now the equation becomes $H_2S_2O_7 + H_2O \rightarrow 2\,H_2SO_4$

Now, count the atoms of each element on both sides of the equation. The number of atoms on both sides are equal. Hence, the balanced equation is $H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

Now indicate the physical states of the reactants and products.

$H_2S_2O_{7(l)} + H_2O_{(l)} \longrightarrow 2H_2SO_{4(l)}$

***(ii) $SO_{2(g)} + H_2S_{(aq)} \longrightarrow S_{(s)} + H_2O_{(l)}$**

Ans. **Step 1 :** Rewrite the given equation as it is

$SO_{2(g)} + H_2S_{(aq)} \longrightarrow S_{(s)} + H_2O_{(l)}$

Step 2 : Write the number of atoms of each element in the unbalanced equation on both sides of equations.

Element	Number of atoms in reactant (left side)	Number of atoms in products (right side)
S	2	1
O	2	1
H	2	2

The number of hydrogen atoms on both sides of the equation are same, therefore, equalise the number of sulphur atoms and oxygen atoms.

Step 3 : To balance the number of sulphur atoms :

Number of atoms of sulphur	In reactants		In products
	SO_2	H_2S	(S)
Initially	1	1	1
To balance	1	1	1×2

To equalise the number of sulphur atoms, we use 2 as the factor in the product, now the equation becomes

$SO_2 + H_2S \longrightarrow 2S + H_2O$

Step 4 : To equalise the number of oxygen atoms in the unbalance equation.

Number of atoms of oxygen	In reactants (SO_2)	In products H_2O
Initially	2	1
To balance	2	1×2

To equalise the number of sulphur atoms, we use 2 as the factor in the product i.e. H_2O, now the unbalanced equation becomes

$SO_2 + H_2S \longrightarrow 2S + 2\ H_2O$

Step 5 : To equalise the number of hydrogen atoms in unbalanced equation :

Number of atoms of hydrogen	In reactants (H_2S)	In products (H_2O)
Initially	2	4
To balance	2×2	4

To equalise the number of hydrogen atoms we use 2 as the factor in the reactant i.e, H_2S, now the unbalanced equation become

$SO_2 + 2\ H_2S \longrightarrow 2S + 2\ H_2O$

Now, count the atoms of each element on both sides of the equation, there are less number of sulphur atoms in the product. Now equalise the sulphur atoms, the balanced equation becomes,

$SO_2 + 2H_2S \longrightarrow 3S + 2H_2O$

Now indicate the physical states of reactants and products.

$SO_{2(g)} + 2H_2S_{(aq)} \longrightarrow 3S_{(s)} + 2H_2O_{(l)}$

***(iii) $Ag_{(s)} + HCl_{(l)} \longrightarrow AgCl\downarrow + H_2\uparrow$**

Ans. **Step 1 :** Rewrite the given equation as it is

$Ag_{(s)} + HCl_{(l)} \longrightarrow AgCl\downarrow + H_2$

Step 2 : Write the number of atoms of each element in the unbalanced equation on both sides of equations.

Element	Number of atoms in reactant (left side)	Number of atoms in products (right side)
Ag	1	1
H	1	2
Cl	1	1

The number of silver and chlorine atoms on both sides of the equation are same, therefore, equalise the number of hydrogen atoms.

Step 3 : To balance the number of hydrogen atoms.

Number of atoms of hydrogen	In reactants HCl	In products H_2
Initially	1	2
To balance	1×2	2

To equalise the number of hydrogen atoms, we use 2 as the factor in the product HCl, now the unbalanced equation become

$Ag + 2HCl \longrightarrow AgCl + H_2$

Step 4 : To balance the number of chlorine atoms :

Number of atoms of chlorine	In reactants (2HCl)	In products (AgCl)
Initially	2	1
To balance	2	2×1

To equalise the number of chlorine atoms, we use 2 as the factor in the product AgCl, now the unbalanced equation becomes

$Ag + 2HCl \longrightarrow 2AgCl + H_2$

Now count the atoms of each element on both sides of the equation, there are less number of silver atoms in the reactant. Now equalise the silver atoms, the balanced equation becomes

$2Ag + 2HCl \longrightarrow 2AgCl + H_2$

Now indicate the physical states of the reactants and products

$2Ag_{(s)} + 2HCl_{(l)} \longrightarrow 2AgCl\downarrow + H_2\uparrow$

* **(iv) $H_2SO_{4(aq)} + NaOH_{(aq)} \longrightarrow Na_2SO_{4(aq)} + H_2O_{(l)}$**

(Nov. '20)

Ans.

Step 1 : Rewrite the given equation as it is

$H_2SO_{4(aq)} + NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + H_2O_{(l)}$

Step 2 : Write the number of atoms of each element in the unbalanced equation on both sides of the equation.

Element	Number of atoms in reactant	Number of atoms in products
Na	1	2
S	1	1
O	5	5
H	3	2

The number of oxygen atoms involved in different compounds on both sides (reactants and products) are equal. Therefore, balance the number of atoms of the second element, sodium.

Step 3 : To balance the number of sodium atoms :

Number of atoms of Sodium	In reactants	In products
To begin with	1 (in NaOH)	2 (in Na_2SO_4)
To balance	1×2	2

To equalise the number of sodium atoms, we use 2 as the factor of NaOH in the reactants. Now, the partly balanced equation becomes as follows :

$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + H_2O$

Step 4 : Now, balance the number of hydrogen atoms :

Number of atoms of hydrogen	In reactants	In products
To begin with	(in H_2SO_4) 2 (in NaOH)	2 (in H_2O)
To balance	4	2×2

To equalise the number of hydrogen atoms, we use 2 as the factor of H_2O in the products. The equation then becomes

$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

Now, count the atoms of each element on both sides of the equation. The number of atoms on both sides are equal. Hence, the balanced equation is

$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

Now indicate the physical states of the reactants and the products.

$H_2SO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Na_2SO_4 + 2H_2O_{(l)}$

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

(Use your brain power!) (Textbook page 35)

Ans. Step 1 : Rewrite the given equation as it is

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

Step 2 : Write the number of atoms of each element in the unbalanced equation on both sides of equations :

Element	Number of atoms in reactants	Number of atoms in products
N	2	1
H	2	3

Step 3 : In the given equation, NH_3 is a compound and it contains hydrogen element. On the left hand side there are two H atoms and on the right side 3 H atoms. Equalise H atoms on both sides.

Hydrogen atoms	In reactants	In products
Initially	2	3
To balance	3×2	2×3

To equalise the number of hydrogen atoms, we use 3 as the factor in the reactant and 2 as the factor in the products. Now the equation becomes

$N_2 + 3H_2 \longrightarrow 2NH_3$

Now, count the atoms of each element on both sides of the equation. The number of atoms on both sides are equal. Hence, the balanced equation is

$N_2 + 3H_2 \longrightarrow 2NH_3$

Now indicate the physical states of the reactants and products

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

(vi) Calcium chloride + Sulphuric acid → Calcium sulphate + Hydrogen chloride.

(Use your brain power!) (Textbook page 35)

Ans. Step 1 : Write the chemical equation from the given word equation.

$CaCl_2 + H_2SO_4 \longrightarrow CaSO_4 + HCl$

Step 2 : Write the number of atoms of each element in the unbalanced on both sides of equation.

Element	Number of atoms in reactants	Number of atoms in products
Ca	1	1
Cl	2	1
H	2	1
S	1	1
O	4	4

Step 3 : In the given equation H_2SO_4 is a compound and it contains hydrogen element. On the left hand side there are two hydrogen atoms and on the right side one hydrogen atom. Equalise H atoms on both sides.

Hydrogen atoms	In reactants (H_2SO_4)	In products (HCl)
Initially	2	1
To balance	2	2×1

To equalise the number of hydrogen atoms we use 2 as the factor in the product so that the number of H atoms on both sides are equal. Therefore, the equation becomes

$CaCl_2 + H_2SO_4 \longrightarrow CaSO_4 + 2\,HCl$

Now, count the atoms of each element on both sides of the equation. The number of atoms on both sides are equal hence, the balanced equation is

$CaCl_2 + H_2SO_4 \longrightarrow CaSO_4 + 2HCl$

Now, indicate the physical state of the reactants and products.

$CaCl_{2(s)} + H_2SO_{4(l)} \longrightarrow CaSO_{4(s)} + 2HCl_{(l)}$

(vii) $Ba(OH)_2 + HBr \longrightarrow BaBr_2 + H_2O$

Ans. Step 1 : Rewrite the given equation as it is

$Ba(OH)_2 + HBr \longrightarrow BaBr_2 + H_2O$

Step 2 : Write the number of atoms of each element in the unbalanced equation on both sides of the equation.

Element	Number of atoms in reactants	Number of atoms in products
Ba	1	1
Br	1	2
O	2	1
H	3	2

Step 3 : To balance the number of oxygen atoms :

Number of atoms of oxygen	In reactants	In products
To begin with	2 [in $Ba(OH)_2$]	1 (in H_2O)
To balance	2	1×2

To equalise the number of oxygen atoms, we use 2 as the coefficient of H_2O in the product.

Now, the partly balanced equation becomes as follows :

$Ba(OH)_2 + HBr \longrightarrow BaBr_2 + 2H_2O$

Step 4 : Now, balance the number of hydrogen atoms :

In the partly balanced equation :

Number of atoms of hydrogen	In reactants	In products
To begin with	2 [in $Ba(OH)_2$] 1 (in HBr)	4 (in $2H_2O$)
To balance	$1 \times 2 + 2$	4

To equalise the number of hydrogen atoms, we use 2 as the coefficient of HBr in the reactants. Now, the equation becomes

$Ba(OH)_2 + 2HBr \longrightarrow BaBr_2 + 2H_2O$

Now, count the atoms of each element on both sides of the equation. The number of atoms on both sides are equal. Hence, the balanced equation is

$Ba(OH)_2 + 2HBr \longrightarrow BaBr_2 + 2H_2O$

Now indicate the physical states of the reactants and products.

$Ba(OH)_{2(aq)} + 2HBr_{(aq)} \longrightarrow BaBr_{2(aq)} + 2H_2O_{(l)}$

(viii) $KCN + H_2SO_4 \longrightarrow K_2SO_4 + HCN$

Step 1 : Rewrite the given equation as it is

$KCN + H_2SO_4 \longrightarrow K_2SO_4 + HCN$

Step 2 : Write the number of atoms of each element or group in the unbalanced equation on both sides of the equation.

Element	Number of atoms in reactants	Number of atoms in products
K	1	2
CN (group)	1	1
O	4	4
H	2	1
S	1	1

The number of oxygen atoms involved in different compounds on both sides (reactants and products) are equal. Therefore, balance the number of atoms of the second element, potassium.

Step 3 : To balance K atoms :

Number of atoms of potassium	In reactants	In products
To begin with	1 (in KCN)	2 (in K_2SO_4)
To balance	1×2	2

To equalise the number of potassium atoms, we use 2 as the coefficient of KCN in the reactants.

Now, the partly balanced equation becomes

$2KCN + H_2SO_4 \longrightarrow K_2SO_4 + 2HCN$

Now, count the atoms of each element on both sides of the equation. The number of atoms on both sides are equal. Hence, the balanced equation is

$2KCN + H_2SO_4 \longrightarrow K_2SO_4 + 2HCN$

Now indicate the physical states of the reactants and the products.

$2KCN_{(aq)} + H_2SO_{4(aq)} \longrightarrow K_2SO_{4(aq)} + 2HCN_{(g)}$

(ix) $CH_4 + O_2 \longrightarrow CO_2 + H_2O$

Step 1 : Rewrite the given equation as it is

$CH_4 + O_2 \longrightarrow CO_2 + H_2O$

Step 2 : Write the number of atoms of each element in the unbalanced equation on both sides of the equation.

Element	Number of atoms in reactants	Number of atoms in products
C	1	1
O	2	3
H	4	2

Step 3 : To balance the number of oxygen atoms :

Number of atoms of oxygen	In reactants	In products
To begin with	2 (in O_2)	1 (in H_2O) 2 (in CO_2)
To balance	2×2	$1 \times 2 + 2$

To equalise the number of oxygen atoms, we use 2 as the coefficient of O_2 in the reactants and 2 as the coefficient of H_2O in the product.

Now, the partly balanced equation becomes

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

Now, count the atoms of each element on both sides of the equation. The number of atoms on both sides are equal. Hence, the balanced equation is,

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

Now, indicate the physical states of the reactants and the products.

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

(16) What are the other uses of silver nitrate in every day life? (Find out) (Textbook page 33)

Ans. Silver nitrate is used in the voters-ink. It is used as reactant in the laboratory. Silver nitrate is used to prevent infection in wounds and skinburns.

(17) What are the different types of chemical reaction?

Ans. Types of chemical reaction :

(1) Combination reaction

(2) Decomposition reaction

(3) Displacement reaction

(4) Double displacement reaction.

(18) What is meant by a combination reaction?

OR

Define : combination reaction.

Ans. When two or more reactants combine in a reaction to form a single product, it is called a combination reaction.

(19) Give two examples of combination reaction.

Ans. Examples of combination reaction :

(1) The ammonia gas reacts with hydrogen chloride gas to form the salt in gaseous state, immediately it condenses at room temperature and gets transformed into the solid state.

$$\underset{\text{Ammonia}}{NH_{3(g)}} + \underset{\substack{\text{Hydrogen}\\\text{chloride}}}{HCl_{(g)}} \longrightarrow \underset{\substack{\text{Ammonium chloride}\\\text{(a single product)}}}{NH_4Cl_{(s)}}$$

(2) Magnesium burns in air to form white powder of magnesium oxide as a single product.

$$\underset{\text{Magnesium}}{2Mg} + O_2 \xrightarrow{\text{heat}} \underset{\substack{\text{Magnesium oxide}\\\text{(a single product)}}}{2MgO}$$

(3) Iron reacts with sulphur to form iron sulphide.

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

(20) Observe the following reaction carefully and answer the sub-questions :

$$NH_3 + HCl \longrightarrow NH_4Cl$$

(a) What are the salt and acid in the above reaction?

(b) Which is the base in the above reaction? Is it weak or strong?

(c) Write a reaction showing dissociation of this base in water. ***(3 marks) (July '19)***

Ans. (a) In the above reaction the salt is NH_4Cl and the acid is HCl.

(b) In the above reaction the base is NH_3 and it is a weak base.

(c) $NH_3 + H_2O \longrightarrow NH_4^{\oplus} + OH^{\ominus}$

***(21) Explain the term combination reaction with examples.**

Ans. *For reference see the answer to Q. 10 (18) and (19).*

(22) What is meant by a decomposition reaction?

Ans. The chemical reaction in which two or more products are formed from a single reactant is called decomposition reaction.

(23) What is meant by a thermal decomposition?

Ans. The reaction in which a compound is decomposed by heating it to a high temperature is called thermal decomposition.

(24) What is meant by a electrolytic decomposition?

Ans. The reaction in which a compound is decomposed by passing an electric current through its solution or molten mass is called an electrolytic decomposition.

(25) Give two examples of thermal decomposition.

Ans. (1) At high temperature, calcium carbonate decomposes into calcium oxide and carbon dioxide.

$$CaCO_{3(s)} \xrightarrow{\text{heat}} CaO_{(s)} + CO_{2(g)}$$

(2) At high temperature sugar decomposes into black mass of carbon and water vapour.

$$\underset{\text{sugar}}{C_{12}H_{22}O_{11(s)}} \xrightarrow{\text{heat } \Delta} 12C_{(s)} + 11H_2O_{(g)}\uparrow$$

(26) Give an example of electrolytic decomposition.

Ans. When an electric current is passed through acidified water, it is electrolysed giving hydrogen and oxygen.

$$2H_2O_{(l)} \xrightarrow{\text{electric current}} 2H_{2(g)}\uparrow + O_{2(g)}\uparrow$$

***(27) How can the rate of chemical reaction, namely, decomposition of hydrogen peroxide be increased?**

Ans. At room temperature, the decomposition of hydrogen peroxide into water and oxygen takes place slowly. However, the same reaction occurs at a faster rate on adding manganese dioxide (MnO_2), powder in it.

(28) Study the following reaction and answer the questions asked.

$$\underset{\text{Acidic water}}{\mathbf{2H_2O_{(l)}}} \xrightarrow{\text{Electrical energy}} \mathbf{2H_2}\uparrow + \mathbf{O_2}\uparrow$$

(a) State the type of reaction.

(b) Define this reaction.

Ans. (a) The type of reaction is electrolytic decomposition reaction.

(b) *For reference see the answer to Q. 10 (24).*

(29) What is meant by a displacement reaction?

Ans. The reaction in which the place of the ion of a less reactive element in a compound is taken by another more reactive element by formation of its own ions, is called displacement reaction.

(30) Give an example of displacement reaction.

Ans. When zinc granules are added to the blue coloured copper sulphate solution, the zinc ions formed from zinc atoms take the place of Cu^{2+} ions in $CuSO_4$, and copper atoms, formed from Cu^{2+} ions comes out i.e. the more reactive zinc displaces the less reactive Cu from copper sulphate.

$$\underset{\text{zinc}}{Zn_{(s)}} + \underset{\text{copper sulphate}}{CuSO_{4(aq)}} \rightarrow \underset{\substack{\text{zinc sulphate} \\ \text{(colourless)}}}{ZnSO_{4(aq)}} + \underset{\text{copper}}{Cu_{(s)}} + \text{Heat}$$

(31) Observe the reaction and answer the following questions.

$$\mathbf{CuSO_{4(aq)} + Fe_{(s)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}}$$

(a) Identify and write the type of chemical reaction.

(b) Write the definition of above reaction.

Ans. (a) When iron powder is added to the blue coloured copper sulphate solution, the iron ions formed from iron atoms take the place of Cu^{2+} ions in $CuSO_4$, and copper atoms, formed from Cu^{2+} ions comes out i.e. the more reactive iron displaces the less reactive Cu from copper sulphate. Therefore this reaction is a displacement reaction.

(b) *For reference see the answer to Q 10 (29).*

(32) Complete the given chemical reaction :

$$\mathbf{CuSO_{4(aq)} + Fe_{(s)}} \rightarrow \text{--------} + \text{--------}$$

Name the type of reaction.

(2 marks) (March '20)

Ans. $CuSO_{4(aq)} + Fe_{(s)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}$

This reaction is a displacement reaction.

***(33) Explain the term displacement reaction with examples.**

Ans. *For reference see the answer to Q. 10 (29) and (30).*

(34) What is meant by a double displacement reaction?

Ans. The reaction in which the ions in the reactants are exchanged to form a precipitate are called double displacement reaction.

(35) Give two examples of double displacement reaction.

Ans. (1) Solutions of sodium chloride and silver nitrate react with each other forming a precipitate of silver chloride and a solution of sodium nitrate.

$$\underset{\substack{\text{Silver} \\ \text{nitrate}}}{AgNO_3} + \underset{\substack{\text{Sodium} \\ \text{chloride}}}{NaCl} \rightarrow \underset{\substack{\text{Silver} \\ \text{chloride} \\ \text{(precipitate)}}}{AgCl_{(s)}} + \underset{\substack{\text{Sodium} \\ \text{nitrate}}}{NaNO_3}$$

White precipitate of AgCl is formed by exchange of ions Ag^{+} and Cl^{-} between the reactants.

(2) Barium sulphide reacts with zinc sulphate to form zinc sulphide and a white precipitate of barium sulphate.

$$\underset{\text{Barium sulphide}}{BaS} + \underset{\text{Zinc sulphate}}{ZnSO_4} \rightarrow \underset{\text{Barium sulphate (precipitate)}}{BaSO_{4(s)}} + \underset{\text{Zinc sulphide}}{ZnS}$$

White precipitate is formed by exchange of ions Ba^{++} and SO_4^{--} between the reactants.

(36) Write down what you understand from the following chemical reaction :

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

Ans. (i) The above reaction is a double displacement reaction.

(ii) $AgNO_3$ and NaCl are the reactants while AgCl and $NaNO_3$ are the products.

(iii) The reactants and the product $NaNO_3$ are in aqueous state. The product AgCl is formed in the form of precipitate.

(37) Study the following chemical reaction and answer the questions given below :

$$AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow \underset{\text{Precipitate}}{AgCl_{(s)}\downarrow} + NaNO_{3(aq)}$$

(i) Identify and write the type of chemical reaction.

(ii) Write the definition of above type of chemical reaction.

(iii) Write the names of reactants and products of above reaction.

(March '19) (3 marks)

Ans. (i) The type of chemical reaction : Double displacement reaction.

(ii) *For reference see the answer to Q. 10 (34).*

(iii) *For reference see the answer to Q. 10 (36) (ii).*

(38) When sodium chromate solution is mixed with barium sulphate solution, a precipitate is formed.

(1) What is the colour of the precipitate formed?

(2) Name the precipitate.

(3) What is the type of chemical reaction?

Ans. (1) The colour of the precipitate is yellow.

(2) The yellow precipitate formed is barium chromate.

(3) The type of chemical reaction is double displacement.

(39) Explain the terms with examples :

***(1) Endothermic reaction**

(2) Exothermic reaction

Ans. (1) **Endothermic reaction :** The reaction in which heat is absorbed is called an endothermic reaction.

When $KNO_{3(s)}$ dissolves in water, there is absorption of heat during the reaction and the temperature of the solution falls.

$$KNO_{3(s)} + H_2O_{(l)} + Heat \longrightarrow KNO_{3(aq)}$$

(2) **Exothermic reaction :** The process in which heat is given out is called an exothermic reaction.

When $NaOH_{(s)}$ dissolves in water, there is evolution of heat leading to a rise in temperature.

$$NaOH_{(s)} + H_2O_{(l)} \longrightarrow NaOH_{(aq)} + Heat$$

(40) State whether the following reactions are exothermic or endothermic :

(1) $\underset{\text{Tricalcium aluminate}}{3CaO.Al_2O_{3(s)}} + 6H_2O_{(l)} \rightarrow \underset{\text{Concrete}}{3CaO.Al_2O_3.6H_2O_{(s)}} + Heat$

(2) $\underset{\text{Plaster of Paris}}{2CaSO_4.H_2O} + 3H_2O \rightarrow \underset{\text{Gypsum}}{2CaSO_4.2H_2O} + Heat$

(3) $KNO_{3(s)} + H_2O_{(l)} + Heat \longrightarrow KNO_{3(aq)}$

(4) $NaOH_{(s)} + H_2O_{(l)} \longrightarrow NaOH_{(aq)} + Heat$

(5) Transformation of ice into water.

(6) Water turns into ice.

(7) Cooking of food.

(8) Burning candle.

*(9) $HCl + NaOH \longrightarrow NaCl + H_2O + Heat$

*(10) $2KClO_{3(s)} \xrightarrow{\Delta} 2KCl_{(s)} + 3O_2\uparrow$ ***(Nov. '20)***

*(11) $CaO + H_2O \longrightarrow Ca(OH)_2 + Heat$

*(12) $CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_2\uparrow$

Ans. The reactions (1), (2), (4), (6), (8), (9), (10), (11) and (12) are exothermic and the reactions (3), (5), (7) are endothermic.

*(41) **Explain the similarity and difference in two events, namely adding NaOH to water and adding CaO to water.** ***(July '19)***

Ans. Similarity : Both NaOH and CaO, when dissolved separately in water, solid NaOH dissolves releasing heat, resulting in rise in temperature. This reaction is exothermic reaction. When solid CaO dissolves in water, $Ca(OH)_2$ is formed, large amount of heat is evolved. This reaction is also exothermic reaction. Both reactions are combination reactions and single product is obtained.

$$NaOH_{(s)} + H_2O \longrightarrow NaOH_{(aq)} + \text{Heat}$$

$$CaO_{(s)} + H_2O \longrightarrow Ca(OH)_{2(aq)} + \text{Heat}$$

Difference : (1) There is no chemical reaction takes place between NaOH and water. Aqueous solution of NaOH is considered as a strong alkali.

(2) Aqueous solution of $Ca(OH)_2$ is considered as a weak alkali. The following reaction takes place

$$CaO + H_2O \longrightarrow Ca(OH)_2 + \text{Heat}$$

• **Can you tell? (Textbook page 39)**

• **Take into account the time required for following processes. Classify them into two groups and give titles to the groups.**

(1) Cooking gas starts burning on ignition.

(2) Iron article undergoes rusting.

(3) Erosion of rocks takes place to form soil.

(4) Alcohol is formed on mixing yeast in glucose solution under proper condition.

(5) Effervescence is formed on adding baking soda into a test tube containing dilute acid.

(6) A white precipitate is formed on adding dilute sulphuric acid to barium chloride solution.

Ans. The above processes are classified into two groups (a) slow speed reactions (b) fast speed reactions.

Slow speed reactions : (2), (3) and (4).

Fast speed reactions : (1), (5) and (6).

(42) What do you mean by slow speed reaction? *OR*

Define : Slow speed reaction.

Ans. The reaction which requires long time for completion i.e. occurs slowly is called slow speed reaction.

(43) What do you mean by fast speed reaction?

OR

Define : Fast speed reaction.

Ans. The reaction which is completed in short time i.e. occurs rapidly is called fast speed reaction.

(44) Give two examples of slow speed reactions.

Ans. (1) On heating potassium chlorate ($KClO_3$) it decomposes slowly into potassium chloride and oxygen gas.

$$\underset{\text{Potassium chlorate}}{2KClO_3} \rightarrow 2KCl + \underset{\text{Oxygen}}{3O_2\uparrow}$$

This reaction requires long time for completion, therefore it is slow speed reaction.

(2) Rusting of iron is a slow speed reaction. In this reaction iron reacts with oxygen from air to form iron oxide.

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

This reaction requires long time for completion.

(45) Give two examples of fast speed reactions.

Ans. (1) The reaction between sodium hydroxide (NaOH) and hydrochloric acid (HCl) is a neutralization reaction and it is fast speed reaction.

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

This neutralization reaction is completed in short time, therefore it is fast speed reaction.

(2) Aqueous solution of sodium chloride reacts with silver nitrate solution to form white precipitate of silver chloride (NaCl) and sodium nitrate.

$$NaCl_{(aq)} + AgNO_{3(aq)} \longrightarrow NaNO_{3(aq)} + \underset{\text{(white)}}{AgCl\downarrow}$$

This reaction is completed in short time, therefore it is fast reaction.

(46) Write a short note on slow speed and fast speed reactions.

Ans. *For reference see the answer to Q. 10 (42 to 45)*

(47) State the factors which affect the speed (or rate) of a reaction.

Ans. The factors which affect the rate of a reaction are :

(1) Nature of the reactants. (2) Size of the particles of the reactants. (3) Concentration of the reactants. (4) Temperature of the reaction. (5) Catalyst.

(48) How does the rate of reaction depend on the nature of the reactants? Illustrate with suitable example.

Ans. (1) When the reactant combines with two or more other reactants then the rate of a chemical reaction depends on the nature of the reactants.

(2) Both Al and Zn reacts with dilute hydrochloric acid, H_2 gas is liberated and water soluble salts of these metals are formed. However, aluminium metal reacts faster with dil. HCl as compared to zinc metal.

(3) Al is more reactive than Zn. Therefore, the rate of reaction of Al with hydrochloric acid is higher than that of Zn. Hence, the nature of the reactant affect the rate of a reaction.

$$2Al + \underset{\text{dil.}}{3HCl} \xrightarrow{\text{fast}} 2AlCl_3 + 3H_2\uparrow$$

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2\uparrow$$

(49) How does the rate of a reaction depend on the size of the particles of reactants?

Ans. (1) In the reaction of dil. HCl and Shahabad tile, CO_2 effervescence is formed slowly. On the other hand, CO_2 effervescence forms at faster speed with the powder of Shahabad tile.

(2) The above observation indicates that the rate of a reaction depends upon the size of the particles of the reactants taking part in the reaction. Smaller the size of the reactant particles taking part in a reaction faster will be the rate of reaction.

(50) How does the rate of a reaction depend upon the concentration of the reactants? Give suitable example.

Ans. (1) A chemical reaction takes place due to collisions of the reactant molecules. Higher the concentrations of the reactants more will be the frequency of collisions and faster will be the rate of the reaction.

(2) In the reaction of dil. HCl and $CaCO_3$, $CaCO_3$ disappears slowly and CO_2 also liberates slowly. On the other hand the reaction with concentrated HCl takes place rapidly and $CaCO_3$ disappears fast.

(3) Concentrated acid reacts faster than dilute acid, that means the rate of a reaction is proportional to the concentration of reactants.

Slow reaction :

$$CaCO_3 + \text{dil. } 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$$

Fast reaction :

$$CaCO_3 + \underset{\text{conc.}}{2HCl} \longrightarrow CaCl_2 + CO_2 + H_2O$$

(51) How does the rate of a reaction depend upon the temperature of reactants? Give suitable example.

Ans. (i) (1) When the temperature of the reactants is increased, the reactant molecules start moving with more velocity and their kinetic energy increases. As a result, the number collisions increases. Hence, the rate of chemical reaction increases.

(2) Lime stone on heating decomposes to give CO_2, which turns lime water milky. On the other hand, the lime water does not turn milky before heating the lime stone; because of the zero rate of reaction. The above observation indicates that the rate of a reaction increases on increasing the temperature.

(ii) Solid $CaCO_3$ does not decompose at room temperature when heated, it decomposes to give CaO and CO_2 that means the rise in temperature increases the rate of reaction.

$$CaCO_3 \xrightarrow{\text{Room temperature}} \text{No chemical reaction.}$$

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$$

(52) How does the rate of a reaction depend upon the catalyst? Give suitable example.

Ans. (1) The substance in whose presence the rate of a chemical reaction changes, without causing any chemical change to it, is called a catalyst.

(2) On heating potassium chlorate ($KClO_3$) decomposes into potassium chloride and oxygen slowly.

$$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$$

The rate of the above reaction neither increases by reducing the particle size nor by increasing the reaction temperature. However in the presence of manganese dioxide, $KClO_3$ decomposes at a comparatively lower temperature and oxygen is produced more briskly. No chemical change takes place in MnO_2 in this reaction. It acts as catalyst.

(53) State the importance of rate in a chemical reaction.

Ans. (1) The use of strong acid and strong base in a chemical reaction increases the rate of reaction.

(2) In a chemical reaction, if the smaller size of the reactant particles, the concentrated solution, high temperature and use of catalyst increases the rate of chemical reaction.

(3) The rate of chemical reaction is important with respect to environment.

(4) If the rate of chemical reaction is fast it is profitable for the chemical factories.

(5) The ozone layer in the earth's atmosphere protects the life of earth from the ultraviolet radiation of the sun. The process of depletion or maintenance of this layer depends upon the rate of production or destruction of ozone molecules.

(54) Define : Oxidation reaction.

Ans. Oxidation : The chemical reaction in which a reactant combines with oxygen or loses hydrogen to form the product is called oxidation reaction.

(55) Give examples of oxidation.

Ans. (1) When carbon burns in air, it forms carbon dioxide. In this reaction carbon accepts oxygen, therefore, this is an oxidation reaction.

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$$

(2) When sodium reacts with ethyl alcohol, sodium ethoxide and hydrogen gas is formed. In this reaction, hydrogen is removed from ethyl alcohol, therefore this is an oxidation reaction.

$$\underset{\text{Ethyl alcohol}}{2C_2H_5OH_{(l)}} + \underset{\text{Sodium}}{2Na} \longrightarrow \underset{\text{Sodium ethoxide}}{2C_2H_5ONa} + \underset{\text{Hydrogen}}{H_2\uparrow}$$

(3) Acidified potassium dichromate ($K_2Cr_2O_7/H_2SO_4$) oxidises ethyl alcohol to acetic acid.

$$CH_3-CH_2-OH \xrightarrow[K_2Cr_2O_7/H_2SO_4]{2(O)} CH_3-COOH + H_2O$$

(56) What do you mean by oxidant? Explain with suitable example.

Ans. The chemical substances which bring about an oxidation reaction by making oxygen available are called oxidants or oxidizing agents.

(1) In the combustion of carbon, oxygen is an oxidant.

(2) In the oxidation of ethyl alcohol, potassium dichromate is used as oxidant.

(57) Name the various oxidants. How nascent oxygen is liberated from these oxidants?

Ans. $K_2Cr_2O_7/H_2SO_4$, $KMnO_4/H_2SO_4$ are the commonly used chemical oxidants. Hydrogen peroxide (H_2O_2) is used as a mild oxidant. Ozone (O_3) is also a chemical oxidant. Nascent oxygen is generated by chemical oxidants and it is used for the oxidation reaction.

$$O_3 \longrightarrow O_2 + [O]$$

$$H_2O_2 \longrightarrow H_2O + [O]$$

$$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

Nascent oxygen is a state prior to the formation of the O_2 molecule. It is the reactive form of oxygen and is represented by writing the symbol as [O]

(58) Why is potassium permanganate used during cleaning water tanks?

(Use your brain power!) (Textbook page 42)

Ans. Potassium permanganate is an oxidising agent. It oxidises dissolved iron, manganese and hydrogen sulphide into solid particles that are filtered out of the water tank. It is used to control bacteria growth in tank.

(59) Which is the oxidant used for purification of drinking water?

(Board Model Activity Sheet)

Ans. The oxidant used for purification of drinking water : $O_3/H_2O_2/K_2Cr_2O_7 - H_2SO_4$ **(Any one)**

(60) Acidified potassium permanganate ($KMnO_4$) is a chemical oxidant and explain, how acidified potassium permanganate oxidise ferrous sulphate ($FeSO_4$). Accordingly write a new definition of oxidation and reduction.

Ans. Acidified $KMnO_4$ oxidises ferrous sulphate ($Fe.SO_4$) to ferric sulphate $Fe_2(SO_4)_3$ and in addition to above K_2SO_4 and $MnSO_4$ by-products are formed.

$$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$$

$$2FeSO_4 \longrightarrow Fe_2(SO_4)_3$$

Ionic reaction :

$$2Fe^{2+} + 2SO_4^{2-} \longrightarrow 2Fe^{3+} + 3SO_4^{2-}$$

Net Ionic equation $Fe^{2+} \longrightarrow Fe^{3+} + e^-$

When ferric ion is formed from ferrous ion the positive change is increased by one unit. While this happens the ferrous ion loses one electron.

When metal or its ion loses electron, it is called an oxidation and gain of electron is called reduction.

$$\underset{\text{Ferrous}}{Fe^{3+}} \rightarrow \underset{\text{Ferric}}{Fe^{3}} + e^- \text{ Oxidation}$$

$$Fe^{3+} + e^- \longrightarrow Fe^{2+} \text{ Reduction.}$$

(61) Define : reduction reaction.

Ans. The chemical reaction in which a reactant gains hydrogen and loses oxygen to form the product is called the reduction reaction.

(62) Give two examples of reduction.

Ans. (1) When hydrogen gas is passed over black copper oxide a reddish coloured layer of copper is formed.

In this reaction an oxygen atom removed from CuO to form copper, hence, this is reduction.

$$\underset{\text{Copper oxide}}{CuO_{(s)}} + H_{2(g)} \rightarrow \underset{\text{Copper}}{Cu_{(s)}} + H_2O_{(l)}$$

(2) When hydrogen gas is passed over red hot coke, methane is obtained.

Here, hydrogen is added to coke (carbon). Hence, this is reduction.

$$\underset{\text{Carbon}}{C_{(s)}} + \underset{\text{Hydrogen gas}}{2H_{2(g)}} \rightarrow \underset{\text{Methane}}{CH_{4(g)}}$$

(63) What do you mean by reductant? Explain with suitable example.

Ans. The chemical substances which bring about reduction by making hydrogen available are called reductant. In the preparation of methane from carbon, hydrogen is a reductant.

***(64) Explain the types of reaction with reference to oxygen and hydrogen. Illustrate with examples.**

Ans. With reference to oxygen and hydrogen there are two types of reaction (1) Oxidation reaction (2) Reduction reaction.

Examples : *For reference see the answer to Q. 10 (55) (62).*

***(65) What is the reaction called when oxidation and reduction takes place simultaneously? Explain with one example.** *OR*

Explain redox reaction with suitable example.

OR

Write a note on redox reaction.

Ans. The reaction which involves simultaneous oxidation and reduction is called an oxidation-reduction or redox reaction.

In a redox reaction, one reactant gets oxidised while the other gets reduced during a reaction.

Redox reaction = Reduction + Oxidation

In redox reaction, the reductant is oxidized by the oxidant and the oxidant is reduced by the reductant.

Example : $CuO_{(s)} + H_{2(g)} \longrightarrow Cu_{(s)} + H_2O$

In this reaction, oxygen is removed from copper oxide therefore it is a reduction of CuO, while hydrogen accepts oxygen to form water that means oxidation of hydrogen takes place. Thus oxidation and reduction reactions occur simultaneously.

Other examples of redox reactions :

$$\underset{\text{Hydrogen sulphide}}{2H_2S} + SO_2 \rightarrow \underset{\text{sulphur}}{3S} + 2H_2O$$

$$\underset{\text{Manganese dioxide}}{MnO_2} + 4HCl \rightarrow \underset{\text{Manganese chloride}}{MnCl_2} + 2H_2O + Cl_2\uparrow$$

(66) What are redox reactions? Identify the substances that are oxidised and the substances that are reduced in the following reactions :

(1) $2H_2S_{(g)} + SO_{2(g)} \rightarrow 3S_{(s)} + 2H_2O_{(l)}$

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

(3) $\underset{\text{Manganese dioxide}}{MnO_2} + 4HCl \rightarrow \underset{\text{Manganese chloride}}{MnCl_2} + 2H_2O + Cl_2\uparrow$

Ans. When oxidation and reduction take place simultaneously in a given chemical reaction, it is known as a redox reaction.

(1) $2H_2S + SO_2 \rightarrow 3S + 2H_2O$

oxidation

reduction

H_2S is oxidised and SO_2 is reduced.

(2) $CuO + H_2 \rightarrow Cu + H_2O$

oxidation

reduction

CuO is reduced and H_2 is oxidised.

(3) oxidation

$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2\uparrow$

reduction

(1) Oxidation : $\longrightarrow$ H_2S, H_2O and HCl.

(2) Reduction $\longrightarrow$ SO_2, CuO and MnO_2

(67) Observe the following reaction and answer the questions given below :

$BaSO_4 + 4C \longrightarrow BaS + 4CO$

(1) What type of reaction is it? Justify.

(2) Give one more example.

Ans.

(1) This is a redox reaction. In this reaction the reduction of $BaSO_4$ and oxidation of carbon take place simultaneously.

$BaSO_4 + 4C \rightarrow BaS + 4CO$

oxidation

reduction

(2) Example :

$CuO + H_2 \rightarrow Cu + H_2O$

$2H_2S + SO_2 \rightarrow 3S + 2H_2O$

***(68) Identify the following reactions the reactants that undergo oxidation and reduction.**

(1) $Fe + S \longrightarrow FeS$

(2) $2Ag_2O \longrightarrow 4Ag + O_2\uparrow$

(3) $2Mg + O_2 \longrightarrow 2MgO$

(4) $NiO + H_2 \longrightarrow Ni + H_2O$

Ans. (1) $Fe + S \longrightarrow FeS$

In this reaction, Iron (Fe) undergoes oxidation and sulphur (S) undergoes reduction.

(2) $2Ag_2O \longrightarrow 4Ag + O_2\uparrow$

In this reaction, reduction of Ag_2O takes place.

(3) $2Mg + O_2 \longrightarrow 2MgO$

In this reaction, oxidation of Mg takes place.

(4) $NiO + H_2 \longrightarrow Ni + H_2O$

In this reaction, reduction of NiO takes place and oxidation of H_2 takes place.

(69) Identify oxidant and reductant from the following reaction :

$CuO + H_2 \longrightarrow Cu + H_2O$ ***(Nov. '20)***

Ans. Oxidant : CuO **Reductant :** H_2

(70) Some more examples of redox reaction are as follows. Identify the reductants and oxidants from them.

(Use your brain power!) (Textbook page 43)

(1) $2H_2S + SO_2 \longrightarrow 3S\downarrow + 2H_2O$

(2) $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2\uparrow$

Ans. Oxidants : SO_2, MnO_2

Reductants : H_2S, HCl

(71) If oxidation means losing electrons, what is meant by reduction.

(Use your brain power!) (Textbook page 43)

Ans. Reduction means gaining one or more electrons.

(72) Write the reaction of formation of Fe^{2+} by reduction Fe^{3+} by making use of the symbol (e^-).

(Use your brain power!) (Textbook page 43)

Ans. $Fe^{3+} + e^- \longrightarrow Fe^{2+}$ (reduction)

• Think about it (Textbook page 43)

The luster of the surface of the aluminium utensils in the house is lost after a few days. Why does this happen?

Ans. The aluminium utensils when kept in the house for a few days, oxidation of aluminium takes place, a thin layer aluminium oxide (Al_2O_3) is deposited on the surface. Hence, aluminium utensils loose their lustre in a few days.

(73) What is corrosion?

Ans. The slow process of decay or oxidation of metals due to various components of atmosphere is known as corrosion.

Iron rusts and a reddish coloured layer is collected on it. This is corrosion of iron.

(74) How does rusting of iron occur?

Ans. Iron when exposed to moist air forms a reddish layer of hydrated ferric oxide.

$$2Fe + 3O_2 + xH_2O \longrightarrow \underset{\text{Ferric oxide (rust)}}{2Fe_2O_3.xH_2O}$$

(75) How can corrosion be prevented?

Ans. (1) Corrosion damages buildings, bridges, automobiles, ships, iron railings and other articles made of iron.

(2) It can be prevented by using an anti-rust solution, coating the surface by a paint, processes like galvanising and electroplating with other metals.

(76) What is corrosion? Do gold ornaments corrode? Justify.

Ans. The slow process of decay or oxidation of metal due to the effect of air, moisture and acids on it is known as corrosion.

(1) Gold is a noble metal. There is no effect of moist air or action of acid on it at any temperature.

(2) Pure gold is a very soft metal, it breaks and gets bent easily. Hence, in gold ornaments, gold is alloyed with other metals like copper or silver in appropriate proportion to make it hard and resistant to corrosion. Hence gold ornaments do not get corroded.

***(77) Observe the following picture and write down the chemical reaction with explanation.**

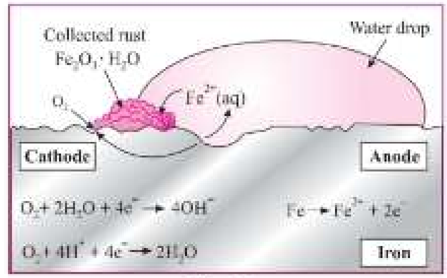


Fig. 3.3

Ans. The rusting of iron is an oxidation process. The rust on iron does not form by a simple reaction between oxygen and iron surface. The rust is formed by an electrochemical reaction. Fe oxidises to $Fe_2O_3.H_2O$ on one part of iron surface while oxygen gets reduced to H_2O on another part of surface. Different regions on the surface of iron become anode and cathode.

(1) Fe is oxidised to Fe^{2+} in the anode region.

$$Fe_{(s)} \longrightarrow Fe^{2+}{}_{(aq)} + 2e^-$$

(2) O_2 is reduced to form water in the cathode region.

$$O_{2(g)} + 4H^+{}_{(aq)} + 4e^- \longrightarrow 2H_2O_{(l)}$$

When Fe^{2+} ions migrate from the anode region they react with water and further get oxidised to form Fe^{3+} ions.

A reddish coloured hydrated oxide is formed from Fe^{3+} ions. It is called rust. It collects on the surface.

$$2Fe^{3+}{}_{(aq)} + 4H_2O_{(l)} \rightarrow Fe_2O_3.\ H_2O_{(s)} + 6H^+{}_{(aq)} \ldots$$

Because of various components in the atmosphere, oxidation of metals takes place, consequently resulting in their damage. This is called 'corrosion'. Iron rusts and a reddish coloured layer is formed on it. This is corrosion of iron.

(78) Complete the process of iron rusting by filling the blanks. Suggest a way to prohibit the process.

The iron rust is formed due to .... reaction. Different regions on iron surface become anode and cathode.

- Reaction on anode region :

$$Fe_{(s)} \longrightarrow Fe^{2+}{}_{(aq)} + 2e^-$$

• Reaction on cathode region :

$O_{2(g)} + 4H^+_{(aq)} + \ldots\ldots\ldots\ldots \longrightarrow 2H_2O_{(l)}$

When Fe^{2+} ions migrate from anode region they react with .... to form Fe^{3+} ions.

A reddish coloured hydrated oxide is formed from .... ions. It is called rust.

$2Fe^{3+}_{(aq)} + 4H_2O_{(l)} \longrightarrow + \ldots\ldots\ldots\ldots + 6H^+_{(aq)}$

A way to prevent rusting ....

Ans. The iron rust is formed due to electrochemical reaction. Different regions on iron surface become anode and cathode.

• Reaction on anode region :

$Fe_{(s)} \longrightarrow Fe^{2+}_{(aq)} + 2e^-$

• Reaction on cathode region :

$O_{2(g)} + 4H^+_{(aq)} + 4e^- \longrightarrow 2H_2O_{(l)}$

When Fe^{2+} ions migrate from anode region they react with water to form Fe^{3+} ions.

A reddish coloured hydrated oxide is formed from Fe^{3+} ions. It is called rust.

$2Fe^{3+}_{(aq)} + 4H_2O_{(l)} \longrightarrow + Fe_2O_3.H_2O_{(s)} + 6H^+_{(aq)}$

A way to prevent rusting by colouring with acrylic paints, Zn plating, galvanizing, anodizing, alloying, etc.

(79) Observe the above picture of question (77) and answer the following questions :

(a) What is a rust?

(b) Write the chemical formula of rust.

(c) Write the reaction of oxidation of iron at anode.

(d) Write the reaction of oxidation of iron at cathode.

(e) What is corrosion? *(5 marks) (March '20)*

Ans. (a) When iron is exposed to moist air, it forms reddish layer of hydrated ferric oxide, this is called rust.

(b) Chemical formula of rust : $Fe_2O_3{\cdot}H_2O$.

(c) Reaction of anode : $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$

(d) Reaction of cathode :

$O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightarrow 2H_2O_{(l)}$

(e) The slow process of decay or damage or oxidation of metals due to various components of atmosphere is known as corrosion.

(80) What are edible oils?

Ans. Edible oils are compounds of alcohols and organic acids (carboxylic acids). The compounds formed are known as esters of carboxylic acids.

(81) State the use of antioxidants in food containing fats and oils.

Ans. Antioxidants are used to prevent oxidation of food containing fats and oils.

(82) Is rancidity a phenomenon of oxidation or reduction?

Ans. Rancidity is a phenomenon of oxidation.

(83) What is the type of this reaction, in which Vanaspathi ghee is formed from vegetable oil?

(Can you tell?) (Textbook page 43)

Ans. Vegetable $oil_{(l)} + H_{2(g)} \xrightarrow[\text{Ni Catalyst}]{60^\circ C}$ Vanaspathi ghee $_{(s)}$.

In the preparation of vanaspathi ghee from vegetable oil hydrogen gas is used. This process is known as hydrogenation. This is reduction reaction.

(84) Define : Rancidity.

Ans. When oil or fat or left over cooking oil for making food stuff undergoes oxidation if stored for a long time and it is found to have foul odour called rancidity.

Q. 11 Give scientific reasons : *(2 marks each)*

(1) It takes time for pieces of Shahabad tile to disappear in HCl, but its powder disappears rapidly.

Ans. (1) The rate of a reaction depends upon the size of the particles of the reactants taking part in the reaction. The smaller the size of the reactants particles, the more is their total surface area and the faster is the rate of reaction.

(2) In the reaction of dil. HCl with pieces of Shahabad tile, CO_2 effervescence is formed and the tile disappears slowly. On the other hand, CO_2 effervescence forms at faster rate with Shahabad tile powder and it disappears rapidly.

(2) Grills of doors and windows are always painted before they are used.

Ans. (1) Grills of doors and windows are made from iron. Iron has a tendency to undergo corrosion.

(2) Paint does not allow air or moisture to come in contact with iron surface.

Therefore, to prevent rusting of iron, grills of doors and windows are always painted before they are used.

(3) Physical states of reactants and products are mentioned while writing a chemical equation.

Ans. (1) While writing a chemical equation, gaseous, liquid and solid states are symbolised as (g), (l) and (s) respectively.

(2) This is done to make it more informative and to emphasise that those reactions occur in that manner only under those conditions. Hence, physical states of reactants and products are mentioned while writing a chemical equation.

***(4) When the gas formed on heating lime stone is passed through freshly prepared lime water, the lime water turns milky.**

Ans. When lime stone is heated, calcium oxide and carbon dioxide are formed. This carbon dioxide gas is passed through freshly prepared lime water, insoluble calcium carbonate and water are formed. In this reaction, lime water turns milky.

$$Ca(OH)_2 + CO_2 \rightarrow \underset{\text{Calcium carbonate}}{CaCO_3} + H_2O$$

***(5) While preparing dilute sulphuric acid from concentrated sulphuric acid in the laboratory, the concentrated sulphuric acid is added slowly to water with constant stirring.**

Ans. (1) The preparation of dilute sulphuric acid falls in the category of extreme exothermic process.

(2) During the preparation of dilute sulphuric acid, large amount of water is taken in a glass container which is surrounded by ice. Cool it for twenty minutes. Now small quantity of conc. H_2SO_4 is added slowly with stirring. Therefore, only a small amount of heat is liberated at a time. In this way dilute sulphuric acid is prepared.

(3) On the other hand, in the process of dilution of conc. sulphuric acid with water, very large amount of heat is liberated. As a result, water gets evaporated instantaneously, if it is poured in to conc. H_2SO_4 which may cause an accident.

***(6) It is recommended to use air tight container for storing oil for long time.**

Ans. (1) If edible oil is allowed to stand for a long time, it undergoes air oxidation, it becomes rancid and its smell and taste changes.

(2) Rancidity in the food stuff cooked in oil or ghee is prevented by using antioxidants. The process of oxidation reaction of food stuff can also be slowed down by storing it in air tight container.

(7) Iron articles rust readily whereas steel which is also mainly made of iron does not undergo corrosion.

Ans. (1) Iron articles rust readily as iron reacts with oxygen and moisture of air to convert into its hydroxide and oxide ($Fe_2O_3 \cdot x\,H_2O$), while steel is an alloy of iron, carbon and chromium.

(2) The properties of an alloy are different from the properties of its constituents. The added metals increase its resistance to corrosion. It is more durable and clean.

(8) Concentrated hydrochloric acid reacts more vigorously with calcium carbonate than dilute hydrochloric acid.

Ans. (1) The rate of a reaction increases with the concentration of the reactant.

(2) As concentrated hydrochloric acid contains more number of HCl molecules than those in an equal volume of dilute HCl, concentrated HCl reacts more vigorously with calcium carbonate.

(9) Zinc powder reacts much faster with dil. H_2SO_4 than does granulated zinc of the same mass.

Ans. (1) In a reaction, the rate of the reaction depends upon the particle size of the solid reactant as the reaction takes place on the surface only. Smaller the particles are, the more will be their total surface area and faster will be the rate of the reaction.

(2) Hence, zinc powder reacts much faster with dil. H_2SO_4 than does granulated zinc.

(10) When copper articles exposed to air for a long time, gets corroded.

Ans. Copper oxidises to form black coloured layer of copper oxide. When copper oxide combines with carbon dioxide from air, copper loses its lustre due to formation of greenish layer of copper carbonate on its surface. Thus, copper articles exposed to air for a long time get corroded.

(11) When silver vessels exposed to air turns blackish after sometime.

Ans. On exposure to air, silver vessels turns blackish after sometime. This is because of the layer of silver sulphide (Ag_2S) formed by the reaction of silver with hydrogen sulphide in air.

Q. 12 Explain the following reactions giving their balanced chemical equations :

(1) Calcium carbonate (Lime stone) is heated.

Ans. When calcium carbonate (Lime stone) is heated at high temperature it decomposes to form quicklime and carbon dioxide gas.

$$\underset{\text{Calcium carbonate}}{CaCO_{3(s)}} \rightarrow \underset{\text{Quick lime}}{CaO_{(s)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}}$$

(2) Copper reacts with dil. nitric acid.

Ans. When copper reacts with dil. nitric acid, nitric oxide gas is formed.

$$Cu_{(s)} + \underset{\text{(dil.)}}{8HNO_{3(aq)}} \rightarrow 3Cu(NO_3)_{2(aq)} + \underset{\text{Nitric oxide}}{2NO_{(g)}} + 2H_2O_{(l)}$$

(3) Copper reacts with conc. nitric acid.

Ans. When copper reacts with conc. nitric acid, reddish coloured poisonous nitrogen dioxide gas is formed.

$$Cu_{(s)} + \underset{\text{(conc.)}}{4HNO_{3(aq)}} \rightarrow Cu(NO_3)_{2(aq)} + \underset{\text{Nitrogen dioxide}}{2NO_2} + 2H_2O_{(l)}$$

(4) Ammonia gas reacts with hydrogen chloride gas.

Ans. When ammonia gas reacts with hydrogen chloride gas, it forms the salt ammonium chloride in gaseous state, but immediately it got transformed into the solid state.

$$\underset{\text{Ammonia}}{NH_{3(g)}} + \underset{\text{hydrogen chloride}}{HCl_{(g)}} \rightarrow \underset{\text{Ammonium chloride}}{NH_4Cl_{(s)}}$$

(5) Magnesium strip is burnt in air.

Ans. When magnesium strip is burnt in air, a white powder of magnesium oxide is formed.

$$\underset{\text{Magnesium}}{2Mg} + O_2 \xrightarrow{\Delta} \underset{\text{Magnesium oxide}}{2MgO}$$

(6) Calcium oxide is mixed with water.

Ans. When calcium oxide (slaked lime) is mixed with water, calcium hydroxide is formed with evolution of large amount of heat.

$$\underset{\text{Calcium oxide}}{CaO} + H_2O \rightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \text{Heat}$$

(7) Sugar is heated.

Ans. When sugar is heated, it decomposes to form carbon (black substance).

$$\underset{\text{Sugar}}{C_{12}H_{22}O_{11}} \xrightarrow{\Delta} \underset{\text{Carbon}}{12C} + 11H_2O_{(g)}$$

(8) Electric current is passed through acidulated water.

Ans. When an electric current is passed through acidulated water, it decomposes into hydrogen and oxygen gas.

$$\underset{\text{Acidulated water}}{2H_2O_{(l)}} \rightarrow \underset{\text{hydrogen}}{2H_2\uparrow} + \underset{\text{oxygen}}{O_2\uparrow}$$

(9) Zinc powder is added to copper sulphate solution.

Ans. When zinc powder is added to copper sulphate solution, more reactive zinc displaces less reactive copper from copper sulphate solution. The colourless zinc sulphate is formed with evolution of heat.

$$\underset{\text{Copper sulphate}}{CuSO_{4(aq)}} + Zn_{(s)} \rightarrow \underset{\text{Zinc sulphate}}{ZnSO_{4(aq)}} + \underset{\text{Copper}}{Cu_{(s)}} + \text{Heat}$$

(10) Iron powder is added to copper sulphate solution.

Ans. When iron powder is added to copper sulphate solution, more reactive iron displaces less reactive copper from copper sulphate. The colourless ferrous sulphate solution is formed with evolution of heat.

$$\underset{\text{Iron}}{Fe_{(s)}} + \underset{\text{copper sulphate}}{CuSO_{4(aq)}} \rightarrow \underset{\text{ferrous sulphate}}{FeSO_{4(aq)}} + \underset{\text{copper}}{Cu_{(s)}} + \text{Heat}$$

(11) Lead is added to copper sulphate solution.

Ans. When lead is added to copper sulphate solution, more reactive lead displaces less reactive copper from copper sulphate. The colourless lead sulphate solution is formed with evolution of heat.

$$CuSO_{4(aq)} + \underset{\text{Lead}}{Pb_{(s)}} \rightarrow \underset{\text{Lead sulphate}}{PbSO_{4(aq)}} + Cu_{(s)} + \text{Heat}$$

(12) Potassium chromate solution is added to barium sulphate solution.

Ans. When potassium chromate solution is added to barium sulphate solution, yellow precipitate of barium chromate is formed.

$$\underset{\substack{\text{Potassium}\\\text{chromate}}}{K_2CrO_{4(aq)}} + \underset{\substack{\text{Barium}\\\text{sulphate}}}{BaSO_{4(aq)}} \rightarrow \underset{\substack{\text{Precipitate}\\\text{(yellow)}}}{BaCrO_4\downarrow} + \underset{\substack{\text{Potassium}\\\text{sulphate}}}{K_2SO_4}$$

(13) Calcium chloride solution is added to sodium carbonate solution.

Ans. When calcium chloride solution is added to sodium carbonate solution, white precipitate of calcium carbonate is formed.

$$\underset{\substack{\text{Calcium}\\\text{chloride}}}{CaCl_{2(aq)}} + \underset{\substack{\text{Sodium}\\\text{carbonate}}}{Na_2CO_{3(aq)}} \rightarrow \underset{\substack{\text{Calcium}\\\text{carbonate}}}{CaCO_3\downarrow} + \underset{\substack{\text{Sodium}\\\text{chloride}}}{2NaCl_{(aq)}}$$

(14) Sodium chloride solution is mixed with silver nitrate solution.

Ans. When sodium chloride solution is mixed with silver nitrate solution, white precipitate of silver chloride is formed.

$$\underset{\substack{\text{Sodium}\\\text{chloride}}}{NaCl_{(aq)}} + \underset{\substack{\text{Silver}\\\text{nitrate}}}{Ag\,(NO_3)_{(aq)}} \rightarrow \underset{\substack{\text{Silver}\\\text{chloride}}}{AgCl\downarrow} + \underset{\substack{\text{Sodium}\\\text{nitrate}}}{NaNO_3}$$

(15) Dilute sulphuric acid is added to barium chloride solution.

Ans. When dilute sulphuric acid is added to barium chloride solution, white precipitate of barium sulphate is formed.

$$\underset{\substack{\text{Barium}\\\text{chloride}}}{BaCl_{2(g)}} + \underset{\text{dil.}}{H_2SO_4} \rightarrow \underset{\substack{\text{Barium}\\\text{sulphate}}}{BaSO_4\downarrow} + 2HCl$$

(16) Calcium carbonate (Lime stone) is treated with dil. hydrochloric acid.

Ans. When calcium carbonate (lime stone) is treated with dil. hydrochloric acid, carbon dioxide gas is formed.

$$\underset{\substack{\text{Calcium}\\\text{carbonate}}}{CaCO_3} + \underset{\text{dil.}}{2HCl} \rightarrow \underset{\substack{\text{Calcium}\\\text{chloride}}}{CaCl_{2(aq)}} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_2\uparrow} + H_2O$$

(17) Aluminium is treated with dil. hydrochloric acid.

Ans. When aluminium is treated with dilute hydrochloric acid, hydrogen gas is liberated.

$$\underset{\text{Aluminium}}{2Al_{(s)}} + 6HCl_{(aq)} \rightarrow \underset{\substack{\text{Aluminium}\\\text{chloride}}}{2AlCl_3} + \underset{\text{Hydrogen}}{3H_2\uparrow}$$

(18) Magnesium is treated with hydrochloric acid.

Ans. When magnesium is treated with hydrochloric acid, hydrogen gas is liberated.

$$\underset{\text{Magnesium}}{Mg_{(s)}} + \underset{\text{(dil.)}}{2HCl} \rightarrow \underset{\substack{\text{Magnesium}\\\text{chloride}}}{MgCl_2} + \underset{\text{Hydrogen}}{H_2\uparrow}$$

(19) Hydrogen peroxide is decomposed in the presence of manganese dioxide (MnO_2).

Ans. When hydrogen peroxide is decomposed in the presence of manganese dioxide (MnO_2), water and oxygen are formed.

$$\underset{\text{Hydrogen peroxide}}{2H_2O_{2(g)}} \xrightarrow[\Delta]{MnO_2} \underset{\text{water}}{2H_2O_{(l)}} + \underset{\text{oxygen}}{O_2}$$

(20) Ethyl alcohol is treated with acidified potassium dichromate.

Ans. When ethyl alcohol is treated with acidified potassium dichromate, acetic acid is formed. This is oxidation reaction.

$$\underset{\substack{\text{Ethyl}\\\text{alcohol}}}{CH_3 - CH_2 - OH} \xrightarrow[K_2Cr_2O_7 + H_2SO_4]{2(O)} \underset{\substack{\text{Acetic}\\\text{acid}}}{CH_3 - COOH} + H_2O$$

(21) Hydrogen gas is passed over black copper oxide.

Ans. When hydrogen gas is passed over black copper oxide, a reddish coloured layer of copper is formed.

$$\underset{\text{copper oxide}}{CuO_{(s)}} + H_{2(g)} \rightarrow \underset{\text{copper}}{Cu_{(s)}} + H_2O_{(l)}$$

Q. 13 Identify A and B from the following table and complete the table. Write the chemical equation : ***(2 marks) (Nov. '20)***

Limestone
↓ Δ heat
A: ....
B: ....

Ans.

Limestone
↓ Δ heat

A	B
Calcium oxide/ CaO or Lime quick	**Carbon dioxide CO_2**

Chemical equation : $CaCO_3 \xrightarrow[\text{heat}]{\Delta} CaO + CO_2 \uparrow$

• Activity 1 (Textbook page 30)

Apparatus : Thermometer, evaporating dish, tripod stand, funnel, Bunsen burner, etc

Chemicals : Lime stone powder, copper sulphate, calcium chloride, potassium chromate, zinc dust, sodium carbonate, phthalic anhydride, etc.

Procedure : Carry out the activities 1 to 5 as given below. Read and record the temperatures in the activities 2 to 4.

Fig. 3.4 : To heat lime stone powder

(1) Take a spoonful of lime stone powder in an evaporating dish. Heat it strongly on a high blue flame.

(2) Add zinc (Zn) dust into the copper sulphate ($CuSO_4$) solution.

(3) Add potassium chromate (K_2CrO_4) solution to barium sulphate ($BaSO_4$) solution.

(4) Add sodium carbonate (Na_2CO_3) solution to the calcium chloride ($CaCl_2$) solution.

(5) Take phthalic anhydride in the evaporating dish.

Close the end of the stem of a funnel with a cotton plug. Keep this funnel inverted on the evaporating dish. Heat the evaporating dish on a tripod stand slowly on a low flame. What did you observe in the funnel during heating?

Observations :

(1) When evaporating dish containing lime stone powder is heated, carbon dioxide gas and calcium oxide are formed.

(2) When zinc powder is added to blue coloured copper sulphate solution, colourless solution of zinc sulphate ($ZnSO_4$) is formed with evolution of heat.

(3) When solution of potassium chromate (K_2CrO_4) is added to barium sulphate ($BaSO_4$) solution, yellow precipitate of ($BaCrO_4$) barium chromate is formed with evolution of heat.

(4) When solution of sodium carbonate (Na_2CO_3) is added to the calcium chloride solution, white precipitate of calcium carbonate ($CaCO_3$) is formed with evolution of heat.

(5) Sublimation takes place, when phthalic anhydride is taken in evaporating dish. When the evaporating dish cools, that time condensation of phthalic anhydride vapours takes place and phthalic anhydride particles are deposited on the inner side of the invested funnel.

Complete the following observation table with reference to the activities 1 to 5.

Activity	Colour change (if present)	Gas released (yes / no)	Temperature change (if present)	Nature of change (chemical / physical)
1.	No colour change	CO_2		chemical
2.	Blue → colourless	–	increases temperature	chemical
3.	Yellow precipitate	–	increases temperature	chemical
4.	White	–	increases temperature	chemical
5.	No colour change	–	–	physical

- **Observe the diagram, state and explain under which category this chemical reaction falls.**

Fig. 3.5 : To heat lime stone powder

(1) The category of the above reaction is decomposition reaction.

(2) When the evaporating dish containing lime stone powder is heated, carbon dioxide gas and calcium oxide are formed.

$$\underset{\text{lime stone}}{CaCO_3} \rightarrow \underset{\text{Calcium oxide}}{CaO} + CO_2\uparrow$$

(3) In the above reaction, no change in colour is observed in the reactants and the products. This reaction falls in the category of chemical change.

• Activity 2 (Textbook page 33)

Apparatus : Test tube, conical flask, balance, etc.

Chemicals : Sodium chloride and silver nitrate.

Procedure :

(1) Take sodium chloride solution in a conical flask and silver nitrate solution in a test tube.

(2) Tie a thread to the test tube and insert it carefully into the conical flask. Make the conical flask air tight by fitting a rubber cork.

(3) Weigh the conical flask with the help of a balance.

(4) Now tilt the conical flask and mix the solution present in the test tube with the solution in the conical flask.

(5) Weigh the conical flask again.

Which changes did you find? Did any insoluble substance form? Was there any change in the weight?

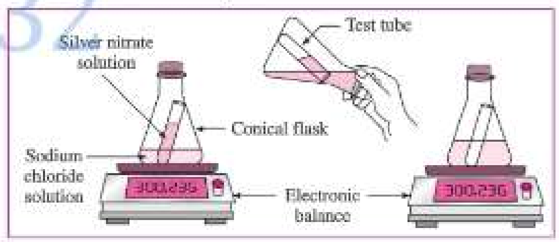


Fig. 3.6 : The reaction of sodium chloride with silver nitrate

Observation :

(1) Sodium chloride (NaCl) reacts with silver nitrate ($AgNO_3$) to form insoluble substance i.e. white precipitate of silver chloride (AgCl) in sodium nitrate solution.

(2) There is no change in the weight.

A word equation is written for the above activity as shown below.

Silver nitrate + Sodium chloride ⟶ Silver chloride + Sodium nitrate.

The above word equation is represented by the following chemical equation.

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

- **Activity 3 (Textbook page 35 and 36)**

Apparatus : Test tube, glass rod, beaker, etc.

Chemicals : Hydrochloric acid, amomonia solution, slaked lime, etc.

Activity 1 : Take a small amount of hydrochloric acid in a test tube. Heat the test tube. Dip a glass rod in the ammonia solution and hold on the top of the test tube. You will observe a white smoke emanating from the tip of the glass rod.

What must have happened?

Due to heating, HCl vapours started coming out from the test tube, and NH_3 gas came out from the solution on the glass rod. The ammonia gas and hydrogen chloride gas reacted to form the salt ammonium chloride in gaseous state first, but immediately due to the condensation process at room temperature it got transformed into the solid state. As a result white smoke was formed.

$$\underset{\text{Ammonia}}{NH_{3(g)}} + \underset{\text{Hydrogen chloride}}{HCl_{(g)}} \rightarrow \underset{\text{Ammonium chloride}}{NH_4Cl_{(s)}} \text{ ......}$$

Activity 2 : Hold a magnesium (Mg) strip in a pair of tongs and ignite. On burning in air a white powder of magnesium oxide is formed.

$$2Mg + O_2 \rightarrow 2MgO \text{ ...}$$

In this reaction magnesium oxide is formed as the single product by combination of magnesium and oxygen.

Activity 3 : Take water in a beaker up to half of its capacity. Add a few pieces of slaked lime (calcium oxide, CaO) to it. Calcium hydroxide ($Ca(OH)_2$) is formed by combination of calcium oxide and water with generation of large amount of heat.

$$\underset{\text{Calcium oxide}}{CaO} + H_2O \rightarrow \underset{\text{calcium hydroxide}}{Ca(OH)_2} + \text{Heat ...}$$

Observation : In all the three reactions above, two reactants combine to give a single product. These are combination reactions.

- **Use your brain power! (Textbook page 36)**

(1) What is the number of reactants in each of the above reactions?

(2) What is the number of molecules of reactants taking part in the above reactions?

(3) How many products are formed in each of the above reactions?

Ans. (1) There are two reactants in each of the above reactions.

(2) The above (1) and (3) reactions, the number of molecules of reactants are two and reaction (2) has three molecules of reactants.

(3) A single product is formed in each of the above reaction.

- **Activity 4 (Textbook page 36)**

Apparatus : Evaporating dish, Bunsen burner, etc.

Chemicals : Sugar, calcium carbonate, sulphuric acid, etc.

Procedure : Take some sugar in an evaporating dish and heat it with the help of a Bunsen burner. After some time you will see the formation of a burnt out black substance. Exactly what must have happened in this activity?

In the above activity a single reactant sugar is divided into two substances (C and H_2O)

$$\underset{\text{Sugar}}{C_{12}H_{22}O_{11}} \longrightarrow \underset{\text{carbon}}{12C} + 11H_2O$$

The reaction in which there is only one reactant giving rise to two or more products is called a decomposition reaction.

(1) The above decomposition reaction takes place, when heat is supplied to the reactants, therefore such reactions are called thermal decomposition reactions.

(2) Water decomposes into hydrogen and oxygen gases on passing electric current through acidulated water. Therefore, this decomposition takes place by means of electrical energy.

$$\underset{\text{(acidified)}}{2H_2O_{(l)}} \xrightarrow{\text{Electric energy}} 2H_2\uparrow + O_2\uparrow$$

Observations : In the above two reactions, from a single reactant, two or more products are formed. These are decomposition reactions.

• **Activity 5 (Textbook page 37)**

Apparatus : Two test tubes, bent tube, rubber cork, burner, etc.

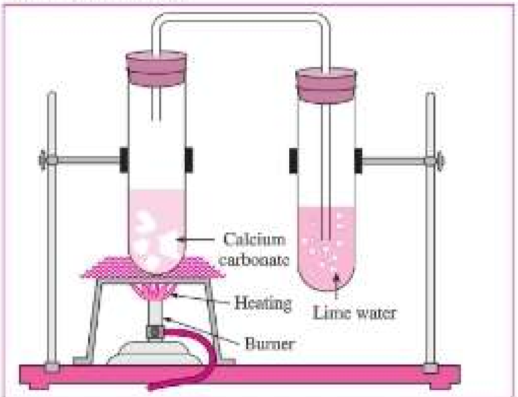


Fig. 3.7 : Decomposition of calcium carbonate

Chemicals : Calcium carbonate, freshly prepared lime water.

Procedure : Take some calcium carbonate in a test tube. Fit a bent tube to this test tube with the help of a rubber cork. Insert the other end of the bent tube in the freshly prepared lime water taken in the other test tube. Heat the powdered calcium carbonate in the first test tube strongly.

In the above activity calcium carbonate undergoes decomposition reaction and the carbon dioxide gas formed turns the lime water milky. The second product of the reaction, the calcium oxide powder, remains behind in the first test tube.

$CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_2\uparrow$ ...;

Similarly, Hydrogen peroxide decomposes gradually to form water and oxygen.

$2H_2O_{2(l)} \longrightarrow 2H_2O_{(l)} + O_2\uparrow$

Both are decomposition reactions.

• **Activity 6 (Textbook page 38)**

Add potassium chromate (K_2CrO_4) into the solution of barium sulphate ($BaSO_4$).

(1) What was the colour of the precipitate formed?

(2) Write the name of the precipitate.

(3) Write down the balanced equation for this reaction.

(4) Will you call this reaction a displacement reaction or a double displacement reaction?

Ans.

(1) The colour of the precipitate formed was yellow.

(2) The name of the precipitate is barium chromate.

(3) Balanced equation :

$$BaSO_{4(aq)} + K_2CrO_4 \rightarrow \underset{\substack{\text{Barium chromate} \\ \text{(yellow precipitate)}}}{BaCrO_4\downarrow} + K_2SO_4$$

(4) This reaction is a double displacement reaction.

• **Activity 7 (Textbook page 39)**

Apparatus : Two plastic bottles, measuring cylinder, thermometer, etc.

Chemicals : Potassium nitrate, sodium hydroxide, water, etc.

(Sodium hydroxide being corrosive, handle it carefully in presence of Teacher.)

Procedure : Take 100 ml water in each of the two plastic bottles. Plastic being insulator of heat, the dissipation of heat can be prevented. Note the temperature of water in the bottles. Put 5 g potassium nitrate (KNO_3) in the bottle and shake well. Note the temperature of the solution formed. Put 5 g sodium hydroxide (NaOH) in the other bottle. Shake the bottle well. Note the temperature.

$KNO_{3(s)} + H_2O_{(l)} + \text{Heat} \longrightarrow KNO_{3(aq)}$

$NaOH_{(s)} + H_2O_{(l)} \longrightarrow NaOH_{(aq)} + \text{Heat}$

Observation : The dissolution of KNO_3 in water, heat from surrounding is absorbed and therefore the temperature of the resulting solution is decreases.

The process in which heat is absorbed from outside, is called endothermic process. When the solid NaOH is dissolved in water heat is given out, and therefore the temperature increases. The process in which heat is given out are called exothermic process.

• **Use your brain power! (Textbook page 39)**

(1) What is the difference in the process of dissolution and a chemical reaction!

Ans. In the process of dissolution, new substance is not necessarily formed. Whereas in a chemical reaction a new substance is definitely formed.

(2) Does a new substance form when a solute dissolves in a solvent?

Ans. It is not necessary that a new substance is always formed.

• Activity 8 (Textbook page 40)

Apparatus : Two test tubes, balance, measuring cylinder, etc.

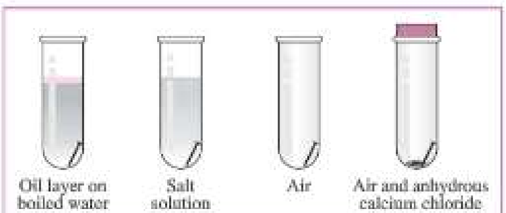
Chemicals : Pieces of Shahabad tile, powder of Shahabad tile, dilute HCl, etc.

Procedure : Take pieces and powder of Shahabad tile in equal weights in two test tubes. Add 10 ml dilute HCl in each of the test tubes. Observe whether effervescence of CO_2 is formed at a faster or slower speed.

Observation : It is found that the CO_2 effervescence is formed slowly with the pieces of Shahabad tile while at a faster speed with the powder.

The above observation indicates that the rate of a reaction depends upon the size of the particles of the reactants taking part in the reaction. Smaller the size of the reactant particles, higher is the rate of the reaction.

• Activity 9 (Textbook page 44)



Apparatus : Four test tubes, four small iron nails, rubber cork, etc.

Chemicals : Anhydrous calcium chloride, oil, boiled water, etc.

Procedure : Place four test tubes on a test tube stand. Take some boiled water in one test tube and put an oil layer on it. Take some salt water in the second test tube. Let there be only air in the third test tube. Take some anhydrous calcium chloride in the fourth test tube. Place a small iron nail in every test tube. Close the fourth test tube with a rubber cork. Let all the four test tubes remain unattended for a few days.

Observation : The rusting process takes place rapidly in presence of salt solution in test tube 2. (A reddish coloured hydrated oxide is formed on their metallic surface.) The slight change was observed in only air containing third test tube and very slight change was observed in test tube 1 containing oil layer on boiled water. No change was observed in the test tube 4 containing air and anhydrous calcium chloride.

In the presence of moisture (water) and air, the process of rusting begins. The rusting occurs rapidly in salt solution, due to the presence of ions.

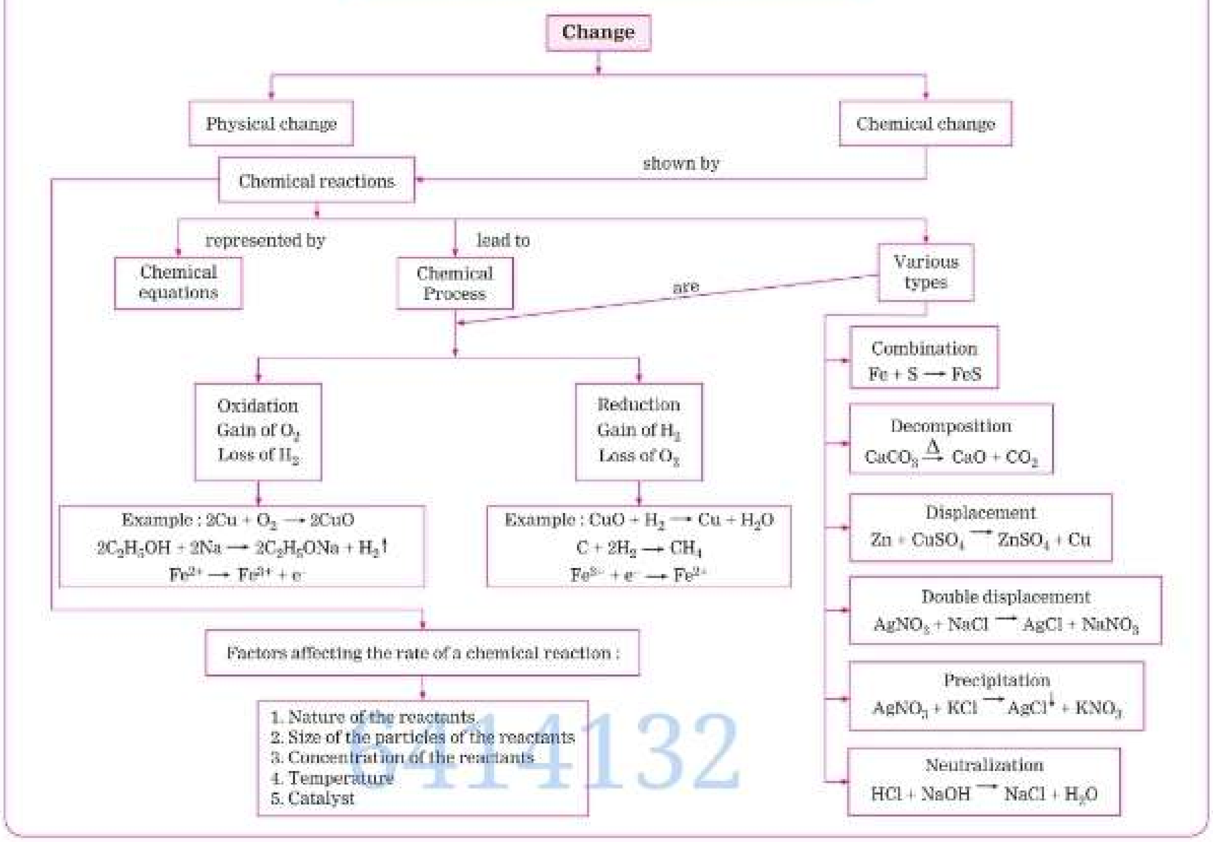
PROJECT

*(1) Prepare aqueous solutions of various solid salts available in the laboratory. Observe what happens when aqueous solution of sodium hydroxide is added to these. Prepare a chart of double displacement reactions based on these observation.

(2) Observe and note the physical and chemical changes experienced in various incidents in your day to day life.

(Find out) (Textbook page 31)

MEMORY MAP / CONCEPT MAP



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4 EFFECTS OF ELECTRIC CURRENT

CHAPTER OUTLINE

IMPORTANT POINTS

• Can you recall? (Textbook page 47)

(1) How do we decide that a given material is a good conductor of electricity or is an insulator?

Ans. A material which has very low electrical resistance is called a good conductor of electricity.

Examples : silver, copper, aluminium.

A material which has extremely high electrical resistance is called an insulator of electricity.

Examples : rubber, wood, glass.

(2) Iron is a conductor of electricity, but when we pick up a piece of iron resting on the ground, why don't we get electric shock?

Ans. When we pick up a piece of iron resting on the ground, we don't get electric shock because that piece does not carry any electric current at that time.

4.1 Energy transfer in electric circuit :

1. **Electric power :** Electric power is the electric work done per unit time or electric energy used per unit time. Its SI unit is the watt (W).

Electric power (P)

$$= \frac{\text{electric work } (W) \text{ or electric energy used}}{\text{time } (t)}$$

$P = VI = I^2R = V^2/R.$

• Think about it (Textbook page 48)

Q. How can we write mechanical power in a manner similar to the electric power?

Ans. Mechanical power (P)

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

$$P = \frac{W}{t} = \frac{Fs\cos\theta}{t}$$

2. **The watt :** If one joule of electric work is done per second, the electric power is 1 watt.

$$1 \text{ watt (W)} = \frac{1 \text{ joule (J)}}{1 \text{ second (s)}}$$

3. **Commercial unit of electric energy :** The commercial unit of electric energy is the kilowatt-hour (kW·h).

$1 \text{ kW·h} = 3.6 \times 10^6 \text{ J}$

It is commonly known as the unit.

• Always remember (Textbook page 49)

The unit of electric power 1 W is a very small unit, hence 1000 W or 1 kW is used as a unit to measure electric power, in practice. If 1 kW power is used for 1 hour, it will mean 1 kW × 1 h of electric energy is used

$1 \text{ kW·h} = 1 \text{ kilowatt-hour} = 1000 \text{ W} \times 3600 \text{ s}$

$= 3.6 \times 10^6 \text{ W·s} = 3.6 \times 10^6 \text{ J}$

4. **Electricity bill :** Electricity bill shows the consumption of units (i.e., kW·h) and the cost of using electric energy.

• Find out (Textbook page 49)

Check monthly electricity bill received from the Electricity Distribution Co. Ltd. Observe various details and get information about them. The electricity bill specifies the usage in 'Units'. What is this unit?

When 1 kW·h electric energy is used, it is termed as 1 unit of energy.

4.2 Heating effect of electric current :

1. **Joule's law about heating effect of electric current :** The quantity of heat produced (H) in a conductor of resistance R, when a current I flows through it for a time t is directly proportional to (1) the square of the current (2) the resistance of the conductor (3) the time for which the current flows.

   $H = I^2Rt = VIt = \frac{V^2}{R}t$, where V is the potential difference ($= RI$) across the conductor. Here, H is expressed in joule, V in volt, I in ampere, R in ohm and t in second. 1 calorie (cal) = 4.18 joules (J). With V in volt, I in ampere, R in ohm and t in second, we have :

   $$H = \frac{I^2Rt}{4.18}\text{ cal} = \frac{VIt}{4.18}\text{ cal} = \frac{V^2t}{4.18R}\text{ cal}$$

2. The working of an electric bulb, electric iron, fuse wire, etc., is based on the heating effect of electric current.

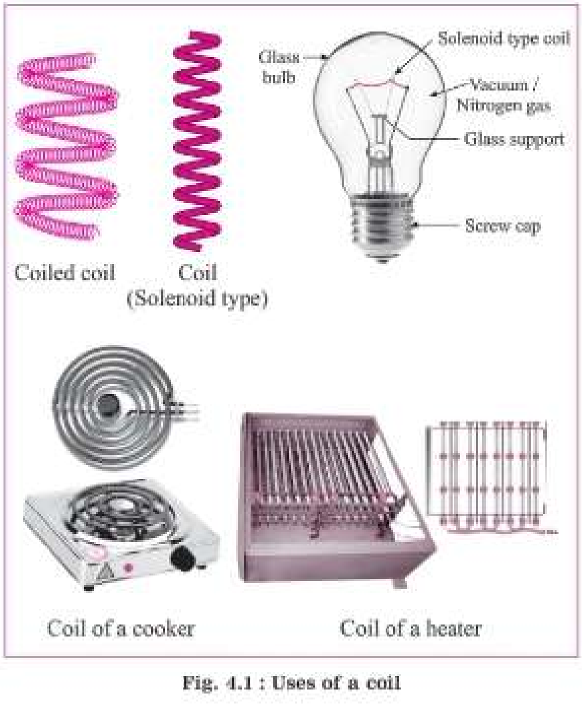


Fig. 4.1 : Uses of a coil

4.3 Magnetic effect of electric current :

1. When an electric current is passed through an electric resistor (electric conductor), heat is produced in it. Passage of electric current through a conductor also produces a magnetic field around it. This effect, called magnetic effect of electric current, was discovered by Hans Christian Oersted. The unit of intensity of magnetic field, the oersted, is named after him.

Oersted's discovery : Hans Christian Oersted (1777 – 1851), Danish physicist, discovered the magnetic effect of electric current in 1820. He observed the deflection of a compass needle when placed near a wire carrying an electric current. The experiment described on page 51 of the textbook refers to his discovery.

2. **Right hand thumb rule :** Imagine that you have held a current-carrying straight conductor in your right hand in such a way that your thumb points in the direction of the current. Then turn your fingers around the conductor. The direction of the fingers is the direction of the magnetic lines of force produced by the current.

3. **Magnetic field due to a current-carrying conductor :**

   (1) The intensity of the magnetic field produced at a given point is directly proportional to the current passing through the conductor.

   (2) The intensity of the magnetic field produced by a given current in the conductor decreases as the distance from the conductor increases.

• Always remember (Textbook page 52)

A magnetic field is produced around a straight current-carrying conductor. If the current is unchanged, this magnetic field reduces as the distance from the wire increases. Therefore, the concentric circles representing the magnetic lines of force are shown bigger and rarefied as the distance from the wire increases. If the current through the wire is increased, the intensity of the magnetic field increases.

4. **Magnetic field due to a current through a circular loop of a conducting wire :** The intensity of the magnetic field due to a current through a circular loop of a conducting wire is maximum at the centre of the loop. In the case of a circular coil, the magnetic field is proportional to the number of turns of the coil, i.e., if there are n turns in the loop, the magnetic field produced will be n times that produced by a single loop.

5. **Solenoid :** When a copper wire with a resistive coating is wound in a chain of loops (like a spring), it is called a solenoid.

6. **Magnetic field due to a current in a solenoid :** The magnetic field lines due to a current in a solenoid are similar to those in the case of a bar magnet. A current-carrying solenoid behaves like a bar magnet and with it we can magnetise iron and some alloys.

7. **Force on a current-carrying conductor in a magnetic field :** A current-carrying conductor is acted upon by a (magnetic) force when placed in a magnetic field. The magnitude of this force depends on the current, the magnetic field, the length of the conductor (assumed to be straight) and the angle between the directions of the current and the field. The direction of the force depends on the directions of the current and the field. The force is maximum when the direction of the current is at right angles to the direction of the magnetic field. The force is zero when the current and the field have the same direction or opposite directions.

8. **Fleming's left hand rule :** The left hand thumb, index finger, and the middle finger are stretched so as to be perpendicular to each other. If the index finger is in the direction of the magnetic field, and the middle finger points in the direction of the current, then the direction of the thumb is the direction of the force on the conductor.

9. **Electric motor :** A device which converts electric energy into mechanical energy is called an electric motor. It works on the principle that a current-carrying conductor placed in a magnetic field experiences a force.

Fig. 4.2 : Electric motor in daily use *(For reference)*

10. **Uses of an electric motor :** An electric motor is used in a mixer, a blender, a refrigerator, a washing machine, an electric fan, a tape recorder, a hair dryer, a record player, a blower, an electric car, a rolling mill, an electric crane, an electric lift, an electric train, a computer, a pump, etc.

11. **Galvanometer :** A galvanometer is a sensitive instrument used to detect the presence of current in a circuit. It can also be used for some electrical measurements. The deflection of its pointer is usually proportional to the current. The deflection is on either side of the zero mark at the centre of the scale depending on the direction of the current.

A galvanometer can be modified suitably to measure (i) current as in an ammeter (ii) potential difference as in a voltmeter.

Fig. 4.3 : Galvanometer *(For reference)*

12. Electromagnetic induction : The process by which a changing magnetic field in a conductor induces a current in another conductor is called electromagnetic induction. A current can be induced in a conductor either by moving it in a magnetic field or by changing the magnetic field around the conductor. Electromagnetic induction was discovered by Michael Faraday (in 1831) and independently by Joseph Henry (in 1830).

• Try this (Textbook page 57)

Collect the material as shown in figure 4.4. Complete the circuit by connecting the galvanometer. Keep the bar magnet erect in such a way that its north or south pole is just below the copper wire. Now if the wire is kept moving from A → B, the pointer of the galvanometer gets deflected. This is called Faraday's electromagnetic induction. Now move the magnet with the wire fixed. The galvanometer pointer still gets deflected.

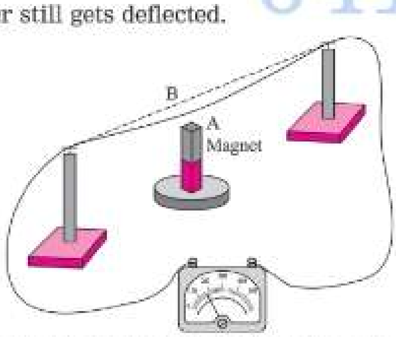


Fig. 4.4 : If a conducting wire is kept moving in a magnetic field, a current is produced in it.

13. Faraday's law of induction : Whenever the number of magnetic lines of force passing through a coil changes, a current is induced in the coil.

14. Fleming's right hand rule : Stretch the thumb, the index finger and the middle finger of the right hand in such a way that they are perpendicular to each other. In this position, the thumb indicates the direction of the motion of the conductor, the index finger the direction of the magnetic field and the middle finger shows the direction of the induced current.

15. Direct current (DC) and Alternating current (AC) : A nonoscillatory current that flows only in one direction is called a direct current (DC). A current that changes in magnitude and direction after equal intervals of time is called an alternating current (AC).

16. Electric generator : An electric device which converts mechanical energy into electric energy is called an electric generator. Its working is based on electromagnetic induction. A generator producing a direct current is called a DC generator and that producing an alternating current is called an AC generator.

IMPORTANT INFORMATION

(Textbook pages 49 and 50)

Several times we hear or read about a building catching fire due to short circuit. Sometimes, if we switch on an equipment in our house, the electrical fuse wire melts and the electric supply shuts down. Let us discuss about the cause briefly. The home electrical connection consists of 'live', 'neutral' and 'earth' wires. The 'live' and the 'neutral' wires have potential difference of 220 V. The 'earth' wire is connected to ground. Due to a fault in the equipment or if the plastic coating on the 'live' and the 'neutral' wires gives way, the two wires come in contact with each other and a large current flows through it producing heat. If any inflammable material (such as wood, cloth, plastic, etc.) exists around that place it can catch fire. Therefore, a fuse wire is used as a precautionary measure. We have learnt about fuse wire in the previous standard. As soon as high current flows in a circuit, the fuse wire melts and breaks the circuit and any mishap is avoided.

Many times particularly in the summer season, huge electrical power is used in the evenings due to home lighting, fans, air conditioners, use of electricity in shops, etc. As a result, excessive current is drawn from the transformer supplying the electricity, and if the capacity of the transformer is insufficient, its fuse wire melts and the supply gets shut down. Such events occur due to overloading.

Fig. 4.5 : Different types of fuses in use

• Do you know? (Textbook page 50)

These days miniature circuit breaker (MCB) switches are used in homes. When the current in the circuit suddenly increases this switch opens and current stops. Different types of MCBs are in use. For the entire house, however the usual fuse wire is used.

Fig. 4.6

• Observe and Discuss (Textbook page 47)

(1) What do you observe in the following pictures?

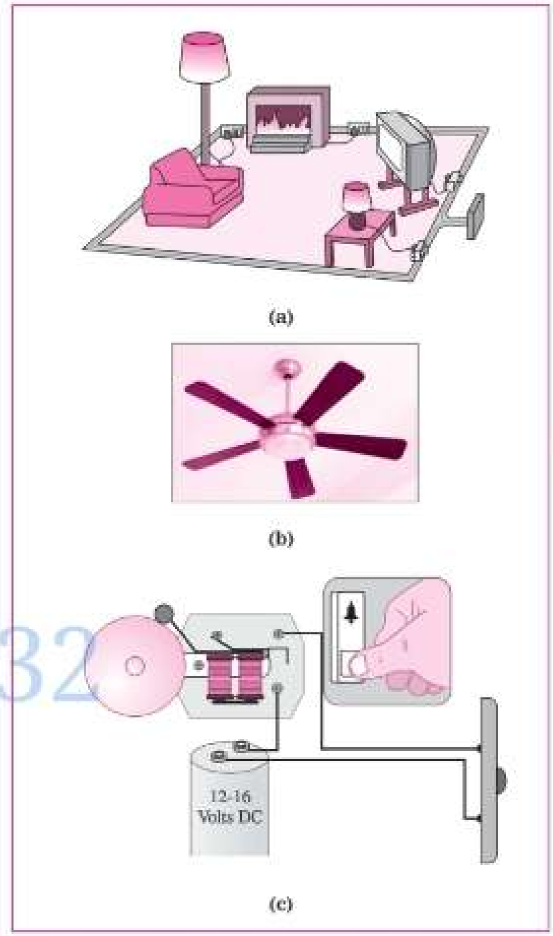


Fig. 4.7 : Effects of electric current

Ans. Lamps, TV, computer, electric fan, electric bell.

(2) Which effects of electric current do you find?

Ans. Heating effect, magnetic effect, production of light, conversion of electric energy into mechanical energy and the conversion of that mechanical energy into sound.

QUESTIONS & ANSWERS

Q. 1 Fill in the blanks and rewrite the completed statements :

(1) Electric power = $\frac{V^2}{\ldots\ldots\ldots}$

(2) .... = 1 joule / 1 second.

(3) 1 kW·h = ... J.

(4) According to Joule's law, quantity of heat (H) produced by an electric current = ...

(5) Magnetic effect of electric current was discovered by ....

(6) .... is expressed in oersted.

(7) Electromagnetic induction was discovered by ....

(8) A galvanometer is used for ....

(9) In India, the frequency of alternating current is ....

(10) Electric motor converts electric energy into .... energy.

(11) Electric generator converts .... energy into electric energy.

Ans.

(1) Electric power = $\frac{V^2}{R}$

(2) 1 watt = 1 joule / 1 second.

(3) 1 kW·h = 3.6×10^6 J.

(4) According to Joule's law, quantity of heat (H) produced by an electric current = I^2Rt or VIt or $\frac{V^2}{R}t$.

(5) Magnetic effect of electric current was discovered by Hans Christian Oersted.

(6) Intensity of magnetic field is expressed in oersted.

(7) Electromagnetic induction was discovered by Michael Faraday and independently by Joseph Henry.

(8) A galvanometer is used for detecting the presence of current in a circuit, as well as for some electrical measurements.

(9) In India, the frequency of alternating current is 50 Hz or 50 cycles per second.

(10) Electric motor converts electric energy into mechanical energy.

(11) Electric generator converts mechanical energy into electric energy.

Q. 2 Choose the correct alternative and write it along with its allotted alphabet : *(1 mark each)*

(1) The device used for producing a current is called ....

(a) a voltmeter *(b) an ammeter*

(c) a galvanometer *(d) a generator*

(2) At the time of short circuit, the current in the circuit ....

(a) increases *(b) decreases*

(c) remains the same *(d) increases in steps*

(3) The direction of the magnetic field around a straight conductor carrying current is given by ....

(a) the right hand thumb rule

(b) Fleming's left hand rule

(c) Fleming's right hand rule

(d) none of these

(4) The resistance of a wire is 100 Ω. If it carries a current of 1 A for 10 seconds, the heat produced will be ....

(a) 1000 J *(b) 10 J* *(c) 0.1 J* *(d) 10000 J*

(5) If 220 V potential difference is applied across an electric bulb, a current of 0.45 A flows in the bulb. What must be the power of the bulb?

(a) 99 W *(b) 70 W* *(c) 45 W* *(d) 22 W*

*(6) Electromagnetic induction means ....

(a) *charging of an electric conductor.*

(b) *production of magnetic field due to a current flowing through a coil.*

(c) *generation of a current in a coil due to relative motion between the coil and the magnet.*

(d) *motion of the coil around the axle in an electric motor.*

(7) Write the correct option by observing the figures.

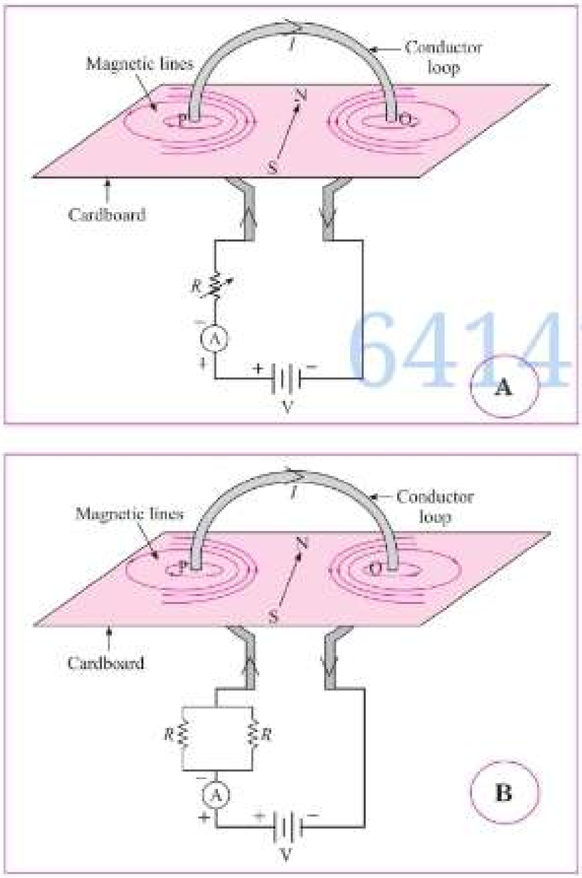


Fig. 4.8 (A)

(a) *Magnetic field in A is stronger.*

(b) *Magnetic field in B is stronger.*

(c) *Magnetic fields in A and B are same.*

(d) *Magnetic fields in A and B are weaker.*

(8) Observe the following diagram and choose the correct alternative : ***(March '19)***

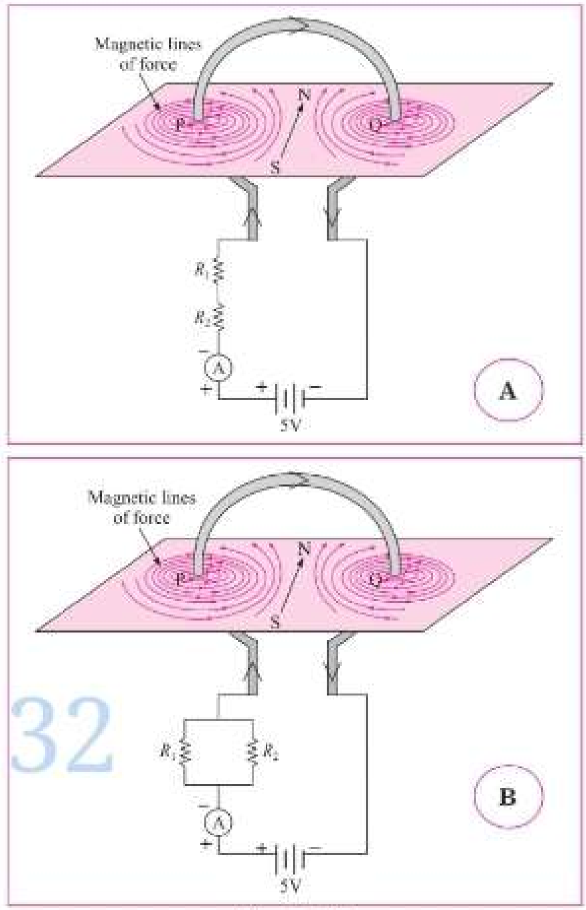


Fig. 4.8 (B)

(a) *The intensity of magnetic field in A is larger than that in B.*

(b) *The intensity of magnetic field in B is less than that in A.*

(c) *The intensity of magnetic field in A and B is same.*

(d) *The intensity of magnetic field in A is less than that in B.*

(9) When an electric current is passed through a solenoid, it shows magnetic lines of force similar to a .... ***(July '19)***

(a) *bar magnet* (b) *horseshoe magnet*

(c) *disc magnet* (d) *spherical magnet.*

Ans.

(1) (d) a generator

(2) (a) increases

(3) (a) the right hand thumb rule
(4) (a) 1000 J
(5) (a) 99W
(6) (c) generation of a current in a coil due to relative motion between the coil and the magnet.
(7) (b) Magnetic field in B is stronger.
[**Explanation :** The resistance in circuit B is less (parallel combination) than that in A. Hence, the current in B is more than that in A. Therefore, the magnetic field in B is stronger than that in A.]
(8) (d) The intensity of magnetic field in A is less than that in B.
(9) (a) bar magnet.

***Q. 3 Which of the statements given below correctly describes the magnetic field near a long, straight current-carrying conductor?**

(1) The magnetic lines of force are in a plane, perpendicular to the conductor in the form of straight lines.
(2) The magnetic lines of force are parallel to the conductor on all the sides of conductor.
(3) The magnetic lines of force are perpendicular to the conductor going radially outward.
(4) The magnetic lines of force are in concentric circles with the wire as the centre, in a plane perpendicular to the conductor.

Ans. The magnetic lines of force are in concentric circles with the wire as the centre, in a plane perpendicular to the conductor.

***Q. 4 Which device is used to produce electricity? Describe with a neat diagram.**

(1) Electric motor
(2) Galvanometer
(3) Electric generator (DC)
(4) Voltmeter

Ans. Electric generator (DC). *For description with a neat diagram, see the answer to Q. 9 (60).*

Q. 5 State whether the following statements are *true* or *false*. (If a statement is false, correct it and rewrite it.) : ***(1 mark each)***

(1) Electric power = I^2R.
(2) Magnetic poles exist in pairs.
(3) Electromagnetism was discovered by Oersted.
(4) Magnetic field increases as we go away from a magnet.
(5) Magnetic lines of force intersect each other.
(6) Electric generator is used to generate current.
(7) An electric motor converts mechanical energy into electric energy.
(8) In India, the frequency of AC is 50 Hz. *OR* The frequency of AC is 50 Hz. ***(March '20)***
(9) The electricity meter in the domestic electric circuit measures electrical energy consumption in kilowatt-hours.
(10) Electric generator converts mechanical energy into electric energy.
(11) Split rings are used in a DC generator and in an electric motor.
(12) Electromagnetic induction was discovered by Coulomb.
(13) Faraday found that electricity could produce rotational motion.
(14) The production of magnetism by an electric current is called electromagnetism.
(15) Magnetic field is a vector quantity.
(16) In India, AC changes direction every $\frac{1}{100}$ s.
(17) In India, the periodic time of AC is 0.02 s.

Ans.
(1) **True.** (2) **True.** (3) **True.**
(4) **False.** (Magnetic field decreases as we go away from a magnet.)
(5) **False.** (Magnetic lines of force do not cross each other.)
(6) **True.**
(7) **False.** (An electric motor converts electric energy into mechanical energy.)
(8) **True.** (9) **True.** (10) **True.** (11) **True.**

(12) **False.** (Electromagnetic induction was discovered by Faraday and independently by Henry.) (13) **True.** (14) **True.** (15) **True.** (16) **True.** (17) **True.**

*Q. 6 Find the odd one out. Give proper explanation :

(1) Fuse wire, bad conductor, rubber gloves, generator.

(2) Voltmeter, ammeter, galvanometer, thermometer.

(Board's Model Activity Sheet; March '20)

(3) Loud speaker, microphone, electric motor, magnet.

(4) Find the odd one out and justify it.
Fuse wire, M.C.B., rubber gloves, generator.

Ans.

(1) **Generator.** It converts mechanical energy into electric energy, the remaining three do not.

(2) **Thermometer.** It measures temperature, the remaining three measure electrical quantities.

(3) **Magnet.** It exerts a force on a magnetic material, the remaining three convert one form of energy into another.

(4) **Generator.** It converts mechanical energy into electric energy. All others are related to safety measures to avoid mishap due to electricity.

Q. 7 Match the columns :

Column I	Column II
(1) The right hand thumb rule	(a) The direction of the force on a current-carrying conductor placed in a magnetic field.
(2) Fleming's right hand rule	(b) The direction of the magnetic field around a straight conductor carrying a current.
	(c) The direction of induced current in a conductor.
	(d) The direction of the force exerted by one current-carrying conductor on another current-carrying conductor.

Ans.

(1) The right hand thumb rule – The direction of the magnetic field around a straight conductor carrying a current.

(2) Fleming's right hand rule – The direction of induced current in a conductor.

Q. 8 Name the following :

(1) The negatively charged particle considered as a free particle moving in a metallic conductor.

(2) The quantity expressed in ampere.

(3) The quantity expressed in ohm.

(4) The quantity expressed in volt.

(5) The quantity expressed in joule.

(6) The quantity expressed in watt.

(7) The quantity expressed in kilowatt-hour.

(8) A component used to control the current.

(9) An instrument used to measure electric current.

(10) An instrument used to measure electric potential difference.

(11) The ratio of the work done to the quantity of charge transferred.

(12) An alloy of Ni, Cr, Mn and Fe.

(13) The SI unit of resistance.

(14) A metal used to make the filament of an electric bulb.

(15) An alloy used to prepare a coil of high resistance for use in electric appliances such as an electric heater.

(16) Constituents of the alloy used to make a fuse wire.

(17) The unit same as the watt·second.

(18) A unit for intensity of magnetic field.

(19) The scientist in whose honour the SI unit of power is named.

(20) A device that converts electric energy into mechanical energy.

(21) A device that converts mechanical energy into electric energy.

Ans. (1) Electron (2) Electric current (3) Electric resistance (4) Electric potential (5) Work (and energy) (6) Power (7) Electric energy (8) Resistor (9) Ammeter (10) Voltmeter (11) Electric potential difference (12) Nichrome (13) The ohm (14) Tungsten (15) Nichrome (16) Lead and tin (17) The joule (18) The oersted (19) James Watt (20) Electric motor (21) Electric generator.

Q. 9 Answer the following questions :

• Try this (Textbook pages 47 and 48)

Materials : Connecting wires, electric cells, electrical resistance, voltmeter, ammeter, plug key.

Procedure : Connect the circuit as shown in the accompanying figure 4.9 after taking the components with proper values. Measure the current (I). Also measure the potential difference $(V)_{AB}$ between the two ends (A and B) of the resistance.

The potential at A is higher than the potential at B as the point A is connected to the positive electrode of the cell and the point B to the negative electrode of the cell.

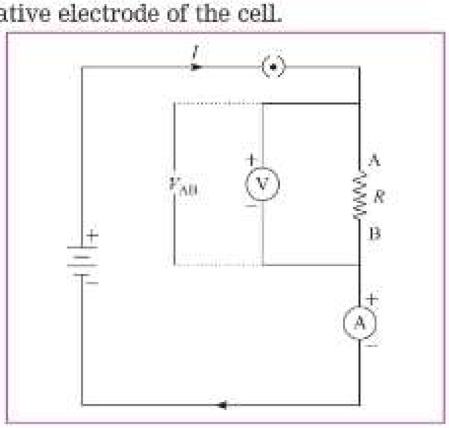


Fig. 4.9 : Electric circuit

If a charge Q flows from A to B, work V_{AB} Q, has been done on Q while going from A to B (Refer to chapter 3 of Std. 9). From where does the energy come to do this work?

Ans. The source of energy is the cell. The cell gives this energy through the charge Q to the resistance where work $V_{AB}Q$ is performed. If the charge Q flows from A to B in time t, i.e. the work is performed in time t, then during that time the energy V_{AB} Q is given to the resistor.

What happens to this energy?

Ans. This energy is received by the resistor and is converted into heat energy, the temperature of the resistor is increased.

• Use your brain power! (Textbook page 48)

• If in the circuit, the resistor is replaced by a motor, in which form will the energy given by the cell get transformed into?

Ans. The energy given by the cell will get transformed into the kinetic energy of the copper coil in the motor.

(1) Define electric power.

Ans. Electric power is the electric work done per unit time. *OR*

Electric power is the time rate at which electric energy is used.

(2) State the formula for electric power. Hence, obtain its SI unit.

Ans. Electric power (P) =

$$\frac{\text{electric work } (W) \text{ done or electric energy used}}{\text{time } (t)}$$

The SI unit of work is the joule and that of time is the second. Hence, the SI unit of power is the joule per second. It is given the special name : the watt (W). One watt equals one joule per second.

$$W = VIt = I^2Rt = \frac{V^2}{R}t$$

$$\therefore\ P = W/t = VI = I^2R = V^2/R.$$

Here, V is the potential difference applied across an electrical appliance, R is the resistance of the appliance and I is the current through the appliance.

[**Note** : The SI unit of power, the watt, is named in honour of James Watt (1736–1819), British instrument maker and engineer.]

(3) What is the commercial unit of electric energy? Obtain the relation between this unit and the SI unit of energy.

Ans. The commercial unit of electric energy is the kilowatt·hour (kW·h) and the SI unit of energy is the joule (J).

$$1\ \text{kW}\cdot\text{h} = 10^3\ \frac{\text{J}}{\text{s}} \times 3600\ \text{s}$$
$$= 3.6 \times 10^6\ \text{J}$$

[**Note** : The kilowatt-hour is often called simply the unit. (See the energy bill, i.e., the electricity bill.)]

(4) What is one kilowatt·hour?

Ans. One kilowatt·hour is the electric energy used in one hour by an electrical appliance of power one kilowatt. It is equal to 3.6×10^6 J.

(5) What is heating effect of electric current? What is its origin?

Ans. The production of heat in a resistor due to the electric current flowing through it when it is connected in an electrical circuit, is called the heating effect of electric current.

When a potential difference is applied across a metallic conductor, free electrons in the conductor move from the end at the lower potential to the end at the higher potential giving rise to electric current. These electrons collide with the atoms and positive ions and transfer some kinetic energy to them. This energy is converted into heat. Hence, the temperature of the conductor begins to rise i.e., the conductor becomes hot. This is the origin of the heating effect of electric current.

(6) Statement 1 : Electric current (flow of electrons) creates heat in a resistor.

Statement 2 : Heat in the resistor is created according to the law of energy conservation.

Explain Statement 1 with the help of Statement 2.

Ans. (1) When electrons flow through a resistor (during flow of electric current) electrons possess kinetic energy.

(2) During the flow of electrons there is a decrease in the kinetic energy of the electrons due to collisions with atoms, ions and molecules.

(3) According to the law of conservation of energy, this decrease in the kinetic energy of the electrons gets converted into heat.

(7) State Joule's law about heating effect of electric current.

Ans. Joule's law about heating effect of electric current : The quantity of heat produced in a conductor when a current flows through it is directly proportional to (1) the square of the current (2) the resistance of the conductor (3) the time for which the current flows.

(8) Obtain the mathematical expression for the heat generated in a metallic conductor by electric current (Joule's law).

Ans. If V is the potential difference applied across a metallic conductor of resistance R, the current through the conductor, given by Ohm's law, is

$I = V/R$. ... (1)

The charge passing through the conductor in time t when the current I flows in the conductor is

$Q = It$. ... (2)

The work done in this process is $W = VQ$ ... (3)

From Eqs. (1), (2) and (3), we have,

$$W = (IR)(It) = I^2Rt = VIt$$
$$= V\left(\frac{V}{R}\right)t = \frac{V^2}{R}t$$

This work is converted into heat.

When I is expressed in ampere, R in ohm, t in second and V in volt, W is expressed in joule. In that case,

$$W = I^2Rt = VIt = \frac{V^2}{R}t \quad \text{(in joule)}$$

Usually heat energy (H) is expressed in calorie. Using the relation 4.18 J = 1 cal, we have

$$H = W = \frac{I^2Rt}{4.18} \quad \text{(in cal)}$$
$$= \frac{VIt}{4.18}\ \text{(in cal)} = \frac{V^2t}{4.18R} \quad \text{(in cal)}$$

This is the required expression.

(9) Two dissimilar bulbs are connected in series. Which bulb will be brighter? (Hint : Consider the resistance of each bulb.)

Ans. The bulb of higher resistance will be brighter, assuming that the filaments of the two bulbs have the same length and the same area of cross section, but are made of metals with different resistivities.

[**Explanation :** Heat produced (H) in time t $= I^2Rt$, where I is the current through a conductor and R is the resistance of the conductor. In a series combination, the current through each conductor is the same. $\therefore$ $H \propto R$ for a given t. Hence, the bulb with higher R will become more hot and hence emit more light energy per second. Here it is assumed that the filaments of the two bulbs have the same length and the same area of cross section, but are made of metals with different resistivities.]

(10) Name any six domestic appliances whose working is based on the heating effect of electric current. *OR*

State applications of heating effect of electric current.

Ans. Domestic appliances whose working is based on the heating effect of electric current :

(1) Electric heater (2) electric iron (3) electric oven (4) electric toaster (5) electric kettle (6) electric geyser (7) fuse.

Some other applications of heating effect of electric current : (1) electric bulb (2) electric furnace (3) in industry for soldering, welding, cutting, drilling (4) in surgery for cutting tissues with a finely heated platinum wire.

(11) Explain the application of heating effect of electric current in an electric bulb.

Ans. In an electric bulb, there is a filament of metal such as tungsten having high melting point. When an electric current is passed through the filament, it becomes hot and emits light. The bulbs are usually filled with chemically inactive gases such as nitrogen and argon to prevent oxidation of the filament and hence prolong their life.

(12) Why is tungsten used to make solenoid type coil in an electric bulb?

Ans. Tungsten is used to make solenoid type coil in an electric bulb for the following reasons :

(1) Tungsten has high resistance and high melting point (nearly 3422 °C).

(2) Using current, it can be heated to high temperature so that it emits more light.

(13) Explain the application of heating effect of electric current in an electric iron. [HOTS]

Ans. In an electric iron, a coil of high resistance is held between mica sheets and placed inside a heavy metal block provided with a handle made of an insulator such as plastic. When an electric current is passed through the coil, it becomes hot. Mica is a good conductor of heat. Hence, heat produced in the coil is transferred to the metal block which can then be used for ironing clothes.

Mica is a bad conductor of electricity. Hence, there is no electrical contact between the coil and the metal block. Therefore, the person using the iron does not get an electric shock even if he or she happens to touch it by chance.

(14) Take any electricity bill of your home. In the bill there is one table which shows the units consumed by you for the last eleven months. Find the average consumption of electricity in your home for each season (i.e., summer, winter and rainy season). Are they the same? Why? [HOTS]

Ans. The units consumed, on an average, in a home are different for each season.

The energy requirement depends very much on the temperature of the surroundings. For example, a refrigerator, electric fans, an air conditioner, etc. are used more in summer than in winter or rainy season. On the contrary, an electric heater, geyser, etc., are used more in winter than in summer. Hence, there is variation in the average consumption of electricity from season to season.

(15) Name the types of wires or cables used in the electric power supply provided by the State Electricity Board for houses and factories.

Ans. The wires or cables used in the electric power supply provided by the State Electricity Board are of three types : (1) phase wire (or live wire, the wire that carries an electric current) (2) neutral wire (3) the earth wire.

(16) In a domestic electric supply in India, what is the potential difference between the live wire and the neutral wire?

Ans. In a domestic electric supply in India, the potential difference between the live wire and the neutral wire is 220 V.

[**Note** : AC is used in domestic electric supply.]

(17) Name the type of wire to which the main fuse is connected.

Ans. The main fuse is connected to the live wire (phase wire).

(18) What does the electricity meter measure?

Ans. The electricity meter measures electric energy consumption. It is expressed in 'units', where 1 unit means 1 kilowatt-hour ($= 3.6 \times 10^6$ joules).

(19) Is the electric potential difference across each appliance (in a domestic electric circuit) the same?

Ans. Yes, the electric potential difference across each appliance (in a domestic electric circuit) is the same.

(20) Name the types of wire across which an electric appliance is connected.

Ans. An electric appliance is connected across the live wire (phase wire) and the neutral wire.

(21) Electrical appliances are connected in parallel. What are the advantages of this arrangement?

Ans. In the parallel arrangement of electric appliances, the applied potential difference is the same in each case. Further, even if one of the appliances does not work or is removed for repairing, the other appliances can still be used.

(22) In a domestic electric supply, if two bulbs are connected in series instead of parallel, what will happen if the filament of one of the bulbs breaks?

Ans. In a domestic electric supply, if two bulbs are connected in series instead of parallel, if the filament of one of the bulbs breaks, there will be no current through the other bulb as well even if the circuit is switched on. Hence the good bulb will also not glow.

(23) Explain the term short circuiting. What does a short circuit lead to? *OR*

***How does a short circuit form? What is its effect?**

Ans. If a bare live wire (phase wire) and a bare neutral wire touch each other (come in direct contact) or come very close to each other, the resistance of the circuit becomes very small and hence huge (very high) electric current flows through it. This condition is called a short circuit or short circuiting.

In this case, a large amount of heat is produced and the temperature of the components involved becomes very high. Hence, the circuit catches fire.

(24) What is overloading? When does it occur? What does it cause? How can overloading be avoided?

Ans. A flow of large amount of current in a circuit, beyond the permissible value of current, is called overloading.

It occurs when many electrical appliances of high power rating, such as a geyser, a heater, an oven, a motor, etc., are switched on simultaneously. This causes fire.

Overloading can be avoided by not connecting many electrical appliances of high power rating in the same circuit.

(25) Explain the application of heating effect of electric current in a fuse.

Ans. A fuse protects electrical circuits and appliances by stopping the flow of electric current when it exceeds a specified value. For this, it is connected in series with the appliance (or circuit) to be protected. A fuse is a piece of wire made of an alloy of low melting point (e.g. an alloy of lead and tin). If a current larger than the specified value flows through the fuse, its temperature increases enough to melt it. Hence, the circuit breaks and the appliance is protected from damage.

[**Note** : The fuse wire is usually enclosed in a cartridge of an insulator such as glass or porcelain provided with metal caps. The current rating (such as 1 A, 2 A) may be printed on the cartridge.]

• Try this (Textbook pages 51 and 52)

Connect the circuit as shown in figure 4.10. Connect a copper wire, thicker and straight as compared to the connecting wires, between A and B. Keep a magnetic needle adjacent to the wire. Keep the plug key open in the circuit and observe the direction of the needle. Close the plug key and observe the direction of the needle. What do you notice? Now interchange the connecting wires connected to the cell and observe the direction of the magnetic needle. Do you notice any relation between the direction of current and position of the needle?

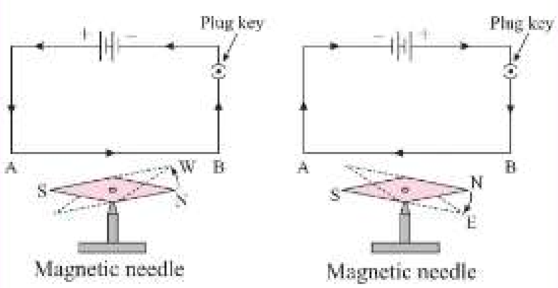


Fig. 4.10 : Magnetic effect of a current

What do you learn from this experiment?

Ans. The magnetic effect is observed because of the current in the wire. This means electricity and magnetism are closely related! Also, if a magnet is moved and kept moving, we will observe electric effect.

(26) State the conclusions that can be drawn from Oersted's experiment. *(For reference, see the experiment described on page 51 of the textbook.)*

Ans. Conclusions that can be drawn from Oersted's experiment :

(1) An electric current produces a magnetic field around it. The moving charge in the conducting wire is a source of magnetic field.

(2) The direction of the magnetic field produced by the current is the direction in which the north pole of the magnetic needle is deflected. Hence, from the experimental observations we can conclude that at any point near the current-carrying conductor, the magnetic field is perpendicular to (i) the length of the conductor and (ii) the line joining the conductor and the given point.

(27) What is the effect on the magnetic needle in Oersted's experiment, when (1) a current is passed through the wire (2) the current through the wire is increased (3) the current through the wire is stopped (4) the current through the wire is reversed (5) the distance between the magnetic needle and the wire is increased, keeping the current through the wire constant?

Ans. In Oersted's experiment, when there is no current in the wire, the magnetic needle is at rest along the north-south direction.

(1) When a current is passed through the wire, the needle is deflected.

(2) When the current through the wire is increased, the deflection of the needle increases.

(3) When the current through the wire is stopped, the needle comes to rest in its original position along the north-south direction.

(4) When the current through the wire is reversed, the needle is deflected in the direction opposite to that in the first case.

(5) When the distance between the magnetic needle and the wire is increased, keeping the current through the wire constant, the deflection of the needle becomes less.

(28) Observe the diagrams and answer the questions : ***(5 marks) (Nov. '20)***

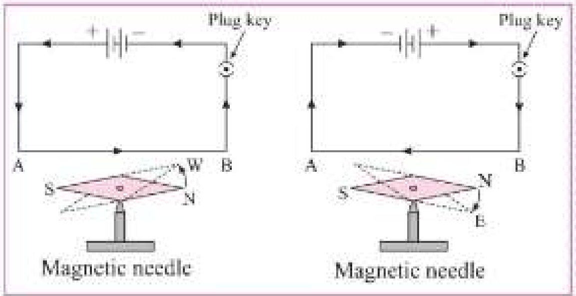


Fig. 4.11

(a) Which effect of electric current is shown in the above figure?

(b) What will happen if the number of electric cells is increased on the magnetic needle?

(c) If the distance between the conductor and magnetic needle is increased, what will be the effect on the intensity of the magnetic field?

(d) If the ends of electric cell are interchanged, what will be the effect on the magnetic needle?

(e) Write the names of any *two* instruments which work on the magnetic effect of electric current.

Ans. (a) Magnetic effect of electric current.

(b) The deflection of the magnetic needle will increase.

(c) The intensity of the magnetic field will decrease, and hence the deflection of the magnetic needle will decrease.

(d) The magnetic needle will be deflected in the opposite sense.

(e) Electric motor, electric bell.

• **Try this (Textbook page 52)**

Connect the circuit as shown in Fig. 4.11. When a large current (approximately 1 A or more) flows through the thick copper wire passing through the cardboard, the magnetic needle kept at different points on the cardboard around the wire stands in different directions. Mark these directions with a pencil.

The direction of the current shown in the circuit is its conventional direction.

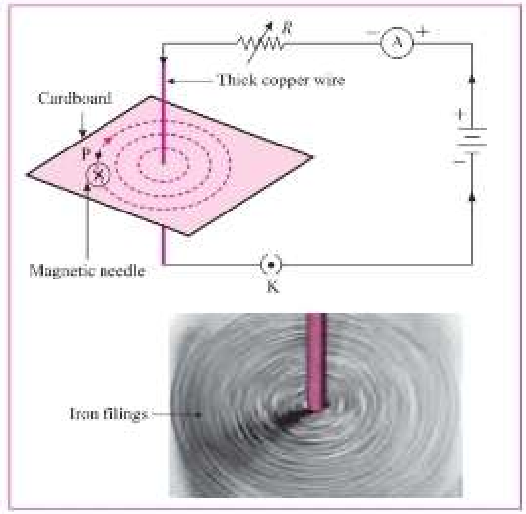


Fig. 4.12 : Magnetic field produced around the conductor

What changes are caused by increasing or decreasing current? What do you see when the magnetic needle is kept a little away from the wire?

Now, instead of the magnetic needle, spread iron filings on the cardboard and observe. The iron filings arrange themselves in a circular manner around the wire. Why does this happen?

Ans. The deflection of the magnetic needle increases when the current is increased. The deflection of the needle decreases when the needle is kept a little away from the wire. The iron filings spread along the magnetic lines of force.

(29) State the factors on which the magnitude of the magnetic field due to a current-carrying conductor depends and how it depends.

Ans. The magnetic field at a point due to a current-carrying conductor depends on the current through the conductor and the distance of the point from the conductor.

(1) The magnitude of the magnetic field produced at a given point is directly proportional to the magnitude of the current passing through the conductor.

(2) The magnitude of the magnetic field produced by a given current in the conductor decreases as the distance from the conductor increases.

[**Note :** If the direction of the current is reversed, the direction of the magnetic field is also reversed.]

(30) State the right hand thumb rule.

Ans. Imagine that you have held a current-carrying straight conductor in your right hand in such a way that your thumb points in the direction of the current. Then turn your fingers around the conductor. The direction of the fingers is the direction of the magnetic lines of force produced by the current.

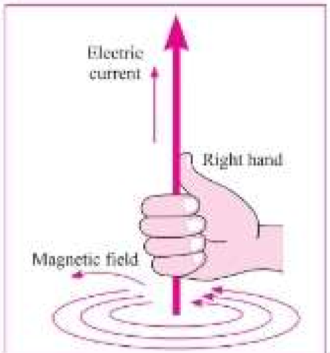


Fig. 4.13 : Right hand thumb rule

• Find out (Textbook page 53)

The right hand thumb rule is called Maxwell's cork-screw rule. What is the cork-screw rule?

Ans. Maxwell's cork screw rule : If a right hand screw is rotated to advance in the direction of the current through a conductor, the direction of rotation of the screw gives the direction of the magnetic field produced by the current.

For reference, see Fig. 4.14.

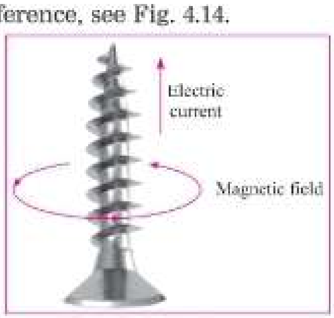


Fig. 4.14

(31) With a neat labelled diagram, describe the pattern of magnetic lines of force due to a current through a circular loop. Also explain how the magnetic field depends on the number of turns (n) in the loop.

Ans. The pattern of magnetic lines of force due to a current through a circular loop is shown in Fig. 4.15.

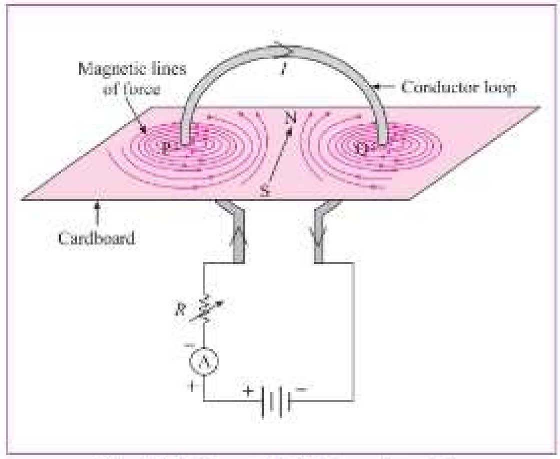


Fig. 4.15 : Magnetic field produced by a current through a loop of conducting wire
(I : Current, R : Resistance, A : Ammeter)

(1) It is seen that every point of the loop forms a centre of a large number of concentric magnetic lines of force forming a series. The circles are small near the wire and become large as we move away from the wire. At the centre of the loop, the arcs of these circles appear as straight lines because of very large radius of the circle.

(2) The magnetic field produced by a current-carrying wire at a given point is directly proportional to the current through the wire. If the loop has n turns, the field produced is n times that produced by a single turn (assuming that all the turns have practically the same radius and are in the same plane). The reason is the current in each turn has the same direction and the field due to each turn contributes equally to the total field.

***(32) What is a solenoid? Compare the magnetic field produced by a solenoid with the magnetic field of a bar magnet. Draw neat figures and name various components.**

Ans. When a copper wire with a resistive coating is wound in a chain of loops (like a spring), it is called a solenoid.

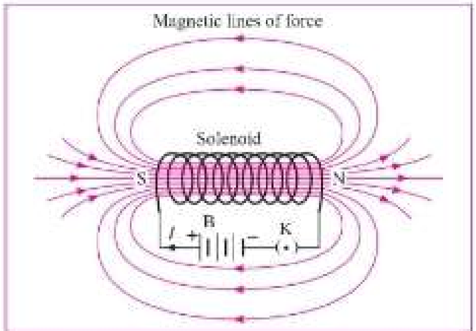


Fig. 4.16 : Magnetic lines of force (magnetic field lines) due to a current-carrying solenoid B : Battery, K : Plug key, *I* : Current, N : North pole, S : South pole

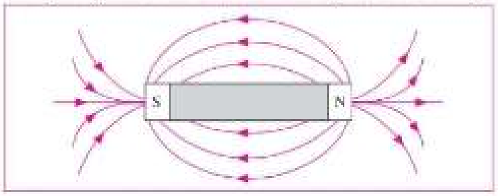


Fig. 4.17 : Magnetic lines of force around a bar magnet

The magnetic field lines (magnetic lines of force) due to a current-carrying solenoid are similar to those of a bar magnet. One face of the coil acts as the south pole and the other face as the north pole (Fig. 4.17).

[**Note :** A current-carrying coil, like a magnet, can be used to magnetise the rod of a given material such as carbon steel or chromium steel. With a strong megnetic field, permanent magnetism can be produced in these materials.]

• Try this (Textbook pages 54 and 55)

Material : Flexible copper wire, stand, electric cell, a horseshoe magnet with a strong magnetic field.

Procedure : Using the stand, fix the copper wire so that it passes through the poles of the horse-shoe magnet as shown in the figure 4.18. Connect the circuit as well. What do you observe?

Whenever a current is not flowing through the wire, it remains straight (position A). When the current flows from top to bottom, the wire bends and comes into position C.

If the current direction is reversed, i.e. it flows from the bottom to the top end, the wire bends but comes in the position B. This means the direction of the force on the wire is perpendicular to both the magnetic field and the direction of the current.

Here, the direction of magnetic field is from N to S, (H). In this experiment it is noted that whenever a current flows through a conductor in the presence of magnetic field, a force is exerted on the conductor. If the direction of the current is reversed, the direction of the force also gets reversed. If the magnet is kept reversed, i.e. its South pole is brought at the position of its North pole and its North pole brought to the position of its South pole, what will happen?

Ans. The direction of the force will be reversed.

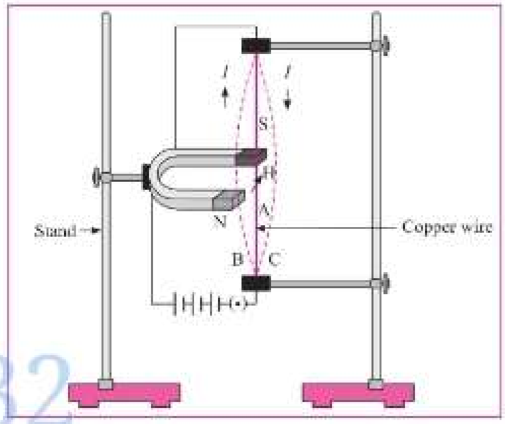


Fig. 4.18 (a) Experimental Setup

The given experiment clearly shows that a force is exerted on the current-carrying conductor. The direction of this force depends on both the direction of the current and the direction of the magnetic field.

Experimentally, it is possible to show that this force is maximum when the direction of the current is perpendicular to the direction of the magnetic field. How will you do this?

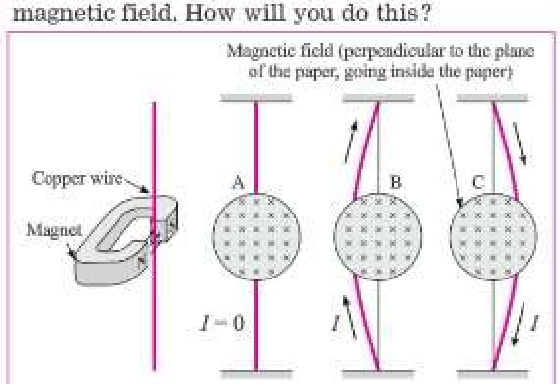


Fig. 4.18 (b) Schematic diagram

Fig. 4.18 : Force acting on a current-carrying conductor in the presence of a magnetic field

Ans. This can be done by measuring the bending of the wire for various angles, ranging from 0° to 90°, between the direction of the current and the direction of the magnetic field.

(33) Write Fleming's left hand rule.

Ans. Fleming's left hand rule : The left hand thumb, index finger, and the middle finger are stretched so as to be perpendicular to each other. If the index finger is in the direction of the magnetic field, and the middle finger points in the direction of the current, then the direction of the thumb is the direction of the force on the conductor.

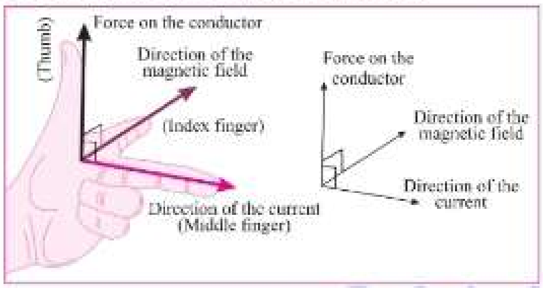


Fig. 4.19 : Fleming's left hand rule

[**Note :** A magnetic field exerts a force on a current-carrying conductor. Electric current is the time rate of flow of electric charge. Thus, a magnetic field exerts a force on a moving charge. This property is used to accelerate charged particles such as protons, deuterons and alpha particles, as well as electrons, to very high energies. A machine used for this purpose is called a charged particle accelerator. It may be linear or circular in design and very big in size. Such high energy particles are used to study the structure of matter.]

(34) What is electric motor?

Ans. A device which converts electric energy into mechanical energy is called an electric motor.

(35) State the principle on which the working of an electric motor is based.

Ans. An electric motor works on the principle that a current-carrying conductor placed in a magnetic field experiences a force. In this case, the forces acting on different parts of the coil of the motor produce the rotational motion of the coil.

***(36) Explain the construction and working of an electric motor. Draw a neat diagram and label it.** *OR*

With a neat labelled diagram, explain the construction and working of an electric motor.

Ans. Figure 4.20 shows the construction of an electric motor. Here, a rectangular loop ABCD of copper wire with resistive coating is placed between the north pole and south pole of a strong magnet, such as a horseshoe magnet, such that the branches AB and CD are perpendicular to the direction of the magnetic field. The ends of the loop are connected

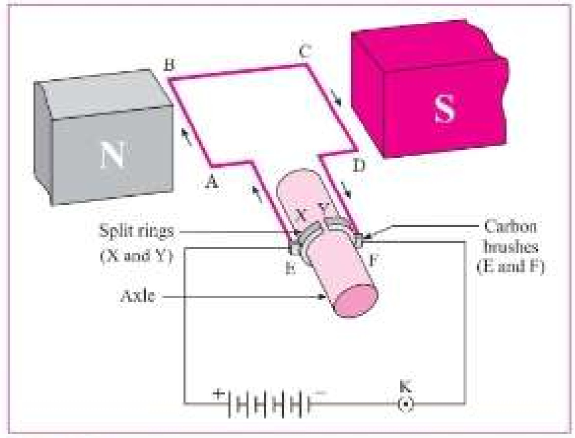


Fig. 4.20 : Electric motor : Principle and working

to the two halves, X and Y, of split rings–X and Y have resistive coating on their inner surfaces and are tightly fitted on the axle. The outer conducting surfaces of X and Y are in contact with two stationary carbon brushes, E and F, respectively.

Working : (1) When the circuit is completed with a plug key or switch, the current flows in the direction E → A → B → C → D → F. As the magnetic field is directed from the north pole to the south pole, the force on AB is downward and that on CD is upward by Fleming's left hand rule. Hence, AB moves downward and CD upward. These forces are equal in magnitude and opposite in direction. Therefore, as observed from the side AD, the loop ABCD and the axle start rotating in anticlockwise direction.

(2) After half a rotation, X and Y come in contact with brushes F and E respectively and the current flows in the direction FDCBAE. Hence the force on CD is downward and that on AB is upward. Therefore, the loop and the axle continue to rotate in the anticlockwise direction.

(3) After every half rotation, the current in the loop is reversed and the loop and the axle continue to rotate in anticlockwise direction.

When the current is switched off, the loop stops rotating after some time.

(37) State the uses/applications of an electric motor.

Ans. Uses / applications of an electric motor : (1) In domestic appliances such as a mixer, a blender, a refrigerator and washing machine. (2) In an electric fan, a hair dryer, a record player, a tape recorder and a blower. (3) In an electric car, a rolling mill, an electric crane, an electric lift, a pump, a computer and an electric train.

(38) (i) Which principle is explained in this figure? *[See Fig. 4.18 (a).]*

(ii) Which rule is used to find out the direction of force in this principle?

(iii) In which machine is this principle used? Draw a diagram showing the working of that machine.

Ans. (i) A force is exerted on a current-carrying conductor in the presence of a magnetic field.

(ii) Fleming's left hand rule is used.

(iii) Electric motor.

Scientifically and technically correct figure. [See Fig. 4.20]

(39) Observe the following diagram and answer the questions.

(a) Construction of which equipment does the following diagram show?

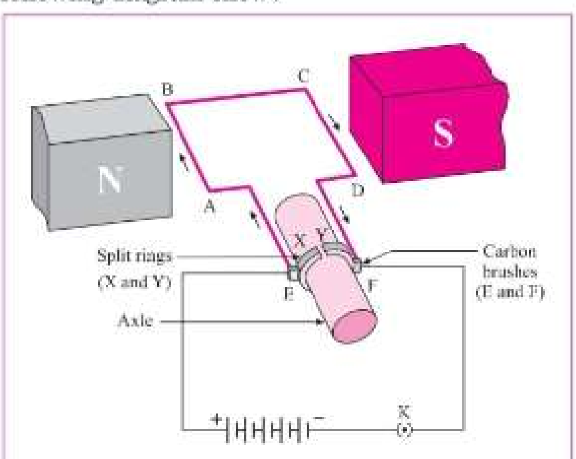


Fig. 4.21

(b) On which principle does this equipment work?

(c) According to which law does the coil ABCD rotate?

(d) Write the law in your own words.

(e) Where is this equipment used?

Ans. (a) Given diagram shows the construction of an electric motor.

(b) *See the answer to Q. 9 (35).*

(c) The rotation of the coil is based on Fleming's left hand rule.

(d) *See the answer to Q. 9 (33).*

(e) *See the answer to Q. 9 (37).*

(40) Study the following principle and answer the questions.

A force is excreted on a current-carrying conductor placed in a magnetic field. The direction of this force depends on both the direction of the current and the direction of the magnetic field. This force is maximum when the direction of the current is perpendicular to the direction of the magnetic field.

(a) By which law can we determine the direction of the force excreted on the current-carrying conductor?

(b) In which electrical equipment is this principle used?

(c) Draw a diagram representing the construction of this equipment.

(d) Write the working of this equipment in brief.

Ans. (a) Fleming's left hand rule.

(b) Electric motor. (c) See Fig 4.20.

(d) *See the answer to Q. 9 (36).*

(41) What is a galvanometer used for? Explain in brief the working of a galvanometer.

Ans. Galvanometer is a sensitive device used to detect the presence of current in a circuit as well as to determine the direction of the current in the circuit.

With suitable modification, it can be used to measure charge, current and voltage. Its working is based on the same principle as that of an electric motor. Here, a coil is pivoted (or suspended) between the pole pieces of a magnet and a pointer is connected to the coil. As the coil rotates when a current is passed through it, the pointer also rotates. The rotation of the coil and hence the deflection of the coil is proportional to the current. The pointer deflects on both sides of the central zero mark depending on the direction of the current.

(42) Take a coil AB having 10–15 turns. Connect the two ends of the coil to the galvanometer as shown in Fig. 4.22. Take a strong bar magnet. (1) Move the north pole of the magnet towards the end B of the coil.

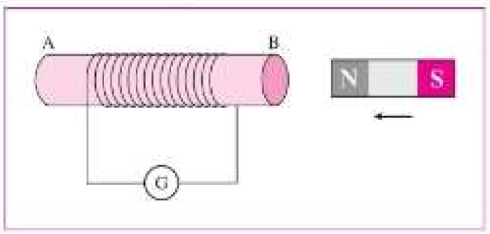


Fig. 4.22

Observe the deflection of the pointer in the galvanometer. Note the direction of the deflection (i.e. right or left). (2) Now repeat this with the south pole of the magnet towards the end B of the coil. Again observe the deflection. Note its direction. (3) What will happen if instead of the magnet, the coil is moved? (4) If both the coil and the magnet are kept stationary, do you observe any deflection? (5) Compare the direction of the deflection when the north pole of the magnet is moved towards the end B of the coil with that when the end B of the coil is moved away from the north pole of the magnet. (6) What conclusions do you draw from the observations?

Ans. Observations : The two deflections, in parts (1) and (2) of the experiment, are in the opposite directions.

(3) If instead of the magnet, the coil is moved towards the stationary magnet, the deflection of the pointer in the galvanometer is observed in one direction, while if the coil is moved away from the magnet, the deflection is observed in the opposite direction. The effect of moving the north pole of the magnet towards the coil and the effect of moving the coil towards the north pole of the magnet are the same.

(4) If both the coil and the magnet are kept stationary, no deflection is observed.

(5) The two deflections are in opposite directions.

(6) Whenever there is relative motion of the coil and the magnet, electric potential difference is induced in the circuit which gives rise to, i.e., induces, an electric current in the circuit causing the deflection of the pointer in the galvanometer. The direction of the current and hence that of the deflection of the pointer in the galvanometer depends on which pole of the magnet faces the coil as well as the direction of relative motion.

[**Note** : If the velocity of the magnet is increased, the induced current increases, and hence the deflection of the pointer in the galvanometer increases.]

• Try this (Textbook pages 57 and 58)

Complete the circuit as shown in figure 4.23 (a). Discuss about and select the components as required. In this experiment, if we open the plug key and make the current zero in the coil, the pointer of the galvanometer deflects to a side and quickly comes back to zero. If the current in the coil is started again, the pointer again deflects to the other side and then returns quickly to zero.

Now when the electrical current is flowing through the solenoid coil and the solenoid coil is displaced with respect to the coil, the current is still produced in the coil.

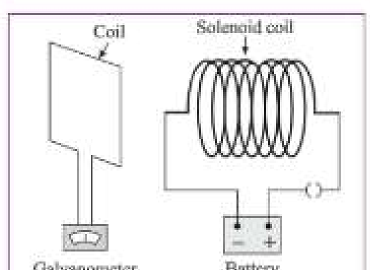


Fig. 4.23 (a) : When the current in the solenoid coil is switched on or off

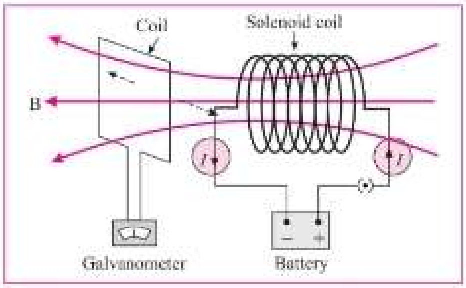


Fig. 4.23 (b) : When a current is passing through the solenoid coil and the coil is displaced laterally with respect to the coil

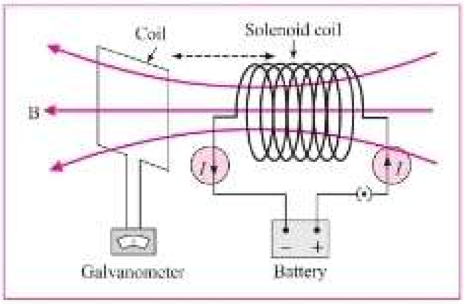


Fig. 4.23 (c) : When a current is passing through the solenoid coil and the solenoid coil is displaced longitudinally with respect to the coil

What can be inferred from these two experiments?

Ans. Even if the solenoid coil is kept stationary, a change in current in the solenoid coil produces a current in the coil. If the solenoid coil is moved towards or away from the coil, we see a deflection in the galvanometer [Fig. 4.23 (c)] Also, the faster is the displacement of the solenoid, larger is the deflection of the galvanometer pointer. If the current in the solenoid coil is changed, a current is produced in the coil or if the solenoid coil is moved towards the coil, then also a current is produced in the coil.

(43) Take two coils of about 50 turns. Insert them over a nonconducting cylindrical roll as shown in Fig. 4.24.

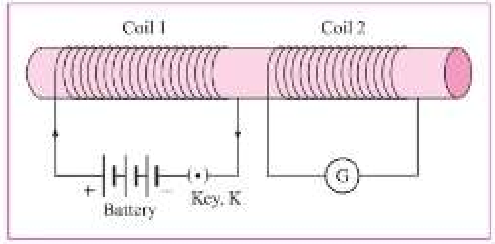


Fig. 4.24

(A thick paper roll can be used.) **Connect coil 1 to a battery with a plug key K. Connect coil 2 to a galvanometer G. (1) Plug the key and observe the deflection in the galvanometer. (2) Unplug the key and again observe the deflection.**

Note your observations. What conclusions do you draw from these observations?

Ans. Observations :

(1) When the key is plugged, the galvanometer shows a momentary deflection. When the current in coil 1 becomes steady, the galvanometer shows zero deflection, i.e., its pointer returns to the zero mark at the centre of the scale.

(2) When the key is unplugged, the galvanometer shows a momentary deflection in the opposite direction relative to that in part (1) of the experiment. When the current in coil 1 becomes zero as the circuit is broken on unplugging the key, the galvanometer shows zero deflection, i.e., its pointer returns to the zero mark at the centre of the scale.

Conclusions : As the current in coil 1 changes, the magnetic field associated with the current changes. This induces an electric potential difference in coil 2 which gives rise to an electric current and hence the deflection of the galvanometer. The direction of the induced current and hence that of the deflection of the pointer in the galvanometer depends on whether the current through coil 1 increases or decreases with time.

When there is a steady current in coil 1, there is no change in the associated magnetic field and hence no production of induced potential difference in coil 2. In that case there is no current in coil 2 and hence the galvanometer shows zero deflection.

[**Note :** Coil 1 is called the primary coil while coil 2 is called the secondary coil. This is because when the current through coil 1 is changed, induced current appears in coil 2.]

(44) What is electromagnetic induction? Who discovered it?

Ans. The process by which a changing magnetic field in a conductor induces a current in another conductor is called electromagnetic induction. A current can be induced in a conductor either by moving it in a magnetic field or by changing the magnetic field around the conductor.

Electromagnetic induction was discovered by Michael Faraday in 1831 and independently by Joseph Henry in 1830.

[**Note :** Michael Faraday (1792-1867), British chemist and physicist, discovered the laws of electrolysis, electromagnetic induction, and a magneto-optical effect now known as the Faraday effect. His discoveries also include benzene and the liquefaction of chlorine. Joseph Henry (1797–1878), US physicist, in addition to the discovery of electromagnetic induction, invented and constructed the first practical electric motor.]

(45) State Faraday's law of induction.

Ans. Whenever the number of magnetic lines of force passing through a coil changes, a current is induced in the coil.

(46) State Fleming's right hand rule.

Ans. Stretch the thumb, the index finger and the middle finger of the right hand in such a way that they are perpendicular to each other. In this position, the thumb indicates the direction of the motion of the conductor, the index finger the direction of the magnetic field, and the middle finger shows the direction of the induced current.

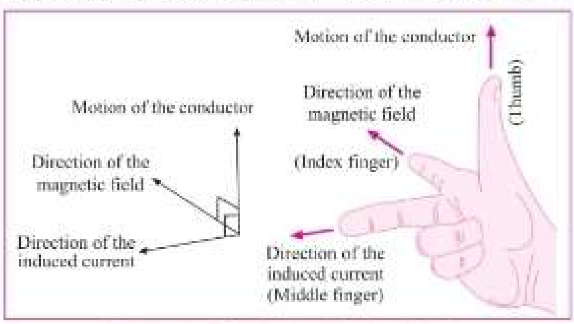


Fig. 4.25 : Fleming's right hand rule

[**Note :** The induced current is maximum when the direction of motion of the conductor is at right angles to the magnetic field.]

(47) Observe the following figure. If the current in the coil A is changed, will some current be induced in the coil B? Explain.

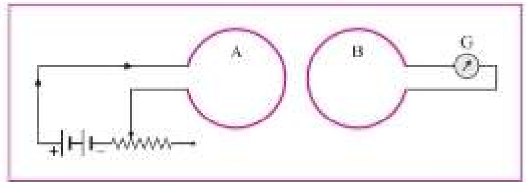


Fig. 4.26

Ans. If the current in the coil A is changed, there will be some current induced in the coil B.

Explanation : When the current in the coil A is changed, the magnetic field associated with the current changes. This induces potential difference in the coil B. This gives rise to (i.e., induces) a current in the coil B. The greater the rate at which the current in the coil A is changed with respect to time, the greater is the current induced in the coil B as can be seen from the deflection of the pointer in the galvanometer. This phenomenon is known as electromagnetic induction.

(48) What is a direct current (DC)?

Ans. A nonoscillatory current that flows only in one direction is called a direct current (DC). It can change in magnitude, but its direction remains the same. [Fig. 4.27 (a) and (b)]

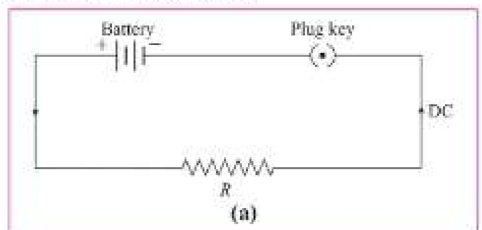


Fig. 4.27 (a) : Circuit

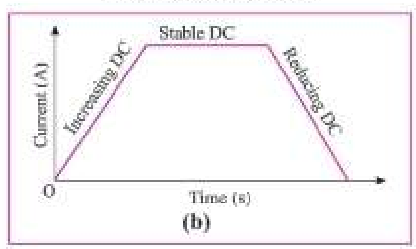


Fig. 4.27 (b) : Direct current (Graphical)

[**Note :** A direct current is obtained with an electric cell or a DC generator.]

(49) What is an alternating current (AC)?

Ans. A current that changes in magnitude and direction after equal intervals of time is called an alternating current (AC) (Fig. 4.28).

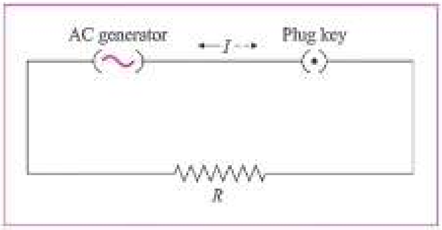


Fig. 4.28 (a) : Circuit

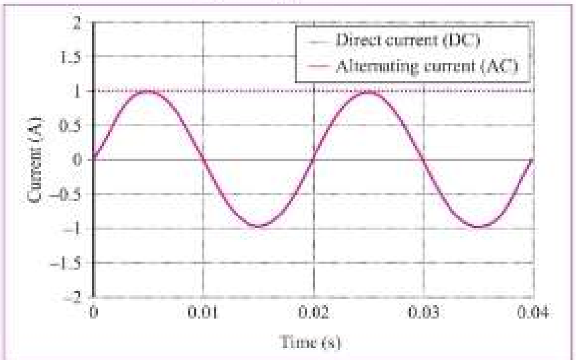


Fig. 4.28 (b) : Graph

Electric current changes sinusoidally with time. Electric current and potential difference are shown by the symbol ~.

[**Note :** An alternating current is obtained with an AC generator.]

(50) What is the value of frequency of AC in India?

Ans. In India, the value of frequency of AC is 50 hertz.

(51) What is the periodic time of AC in India?

Ans. In India, the periodic time of AC is 0.02 s $\left(= \frac{1}{50}\ \text{s}\right)$.

(52) State one advantage of AC over DC.

Ans. One advantage of AC over DC is that electric power can be transmitted over long distances without much loss of energy.

(53) Name two appliances/devices in which a direct current is used.

Ans. A direct current is used in a portable electric torch and radio.

[**Note :** A Direct current is also in an electric bell, a wall clock, to prepare an electromagnet, for electrolysis, etc.]

(54) Name two appliances/devices in which an alternating current is used. *OR*

State any two uses of an AC generator.

Ans. An alternating current is used in an electric heater and a refrigerator.

[**Note :** Alternating current is also used in an electric iron, a washing machine, an electric mixer, a food processor, an air-conditioner, an electric fan, etc.]

(55) What is (1) an electric generator (2) an AC generator (3) a DC generator?

Ans. (1) A device which converts mechanical energy into electric energy is called an electric generator.

(2) A generator which converts mechanical energy into electric energy in the form of an alternating current (AC) is called an AC generator.

(3) A generator which converts mechanical energy into electric energy in the form of a direct current (DC) is called a DC generator.

(56) State the principle on which the working of an electric generator is based.

Ans. The working of an electric generator is based on the principle of electromagnetic induction. When the coil of an electric generator rotates in a magnetic field, a current is induced in the coil. This induced current then flows in the circuit connected to the coil.

[**Note :** An external agency is needed to rotate the coil of an electric generator.]

***(57) Explain the construction and working of an electric generator (AC). Draw a neat diagram and label it.**

Ans. Figure 4.29 shows the construction of an AC electric generator. Here, a coil ABCD of copper wire is kept between the pole pieces (N and S) of a strong magnet. The ends of the coil are connected to the conducting rings R_1 and R_2 via carbon brushes

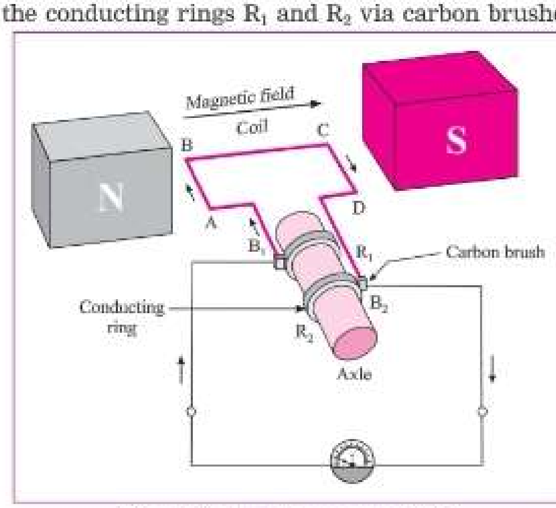


Fig. 4.29 : Electric generator (AC)

B_1 and B_2. The rings are fixed to the axle and there is a resistive coating in between the rings and the axle. The stationary brushes are connected to a galvanometer used to show the direction of the current in the circuit.

Working : When the axle is rotated with a machine from outside, the coil ABCD starts rotating. Suppose the coil rotates in clockwise direction, as observed from the side AD. Then as the branch AB moves upward, the branch CD moves downward. By Fleming's right hand rule, the induced current flows in the direction A → B → C → D and in the external circuit, it flows from B_2 to B_1 through the galvanometer. The induced current is proportional to the number of turns of the copper wire in the coil. After half a rotation, AB and CD interchange their places. Hence, the induced current flows in the direction D → C → B → A. As AB is always in contact with B_1 and CD is in contact with B_2, the current in the external circuit flows from B_1 to B_2 through the galvanometer. Thus, the direction of the current is the external circuit is opposite to that in the previous half rotation. The process goes on repeating and alternating current is generated.

(58) Observe the following diagram. (See Fig. 4.29) and write the answers to the given sub-questions : ***(5 marks) (July '19)***

(a) Which instrument does the above figure show?

(b) Which rule is used to determine the direction of the current produced?

(c) State the rule.

(d) In which direction (B_1 to B_2 or B_2 to B_1) will the current flow in the external circuit in that situation?

(e) What change will have to be made in the coil for increasing the current several times without changing the magnet?

Ans. (a) Electric generator.

(b) Fleming's right hand rule.

(c) See the answer to Q. 9 (46).

(d) B_2 to B_1.

(e) Use a coil of a large number of turns.

(59) Show graphically variation of AC with time. Explain the nature of the graph.

Ans.

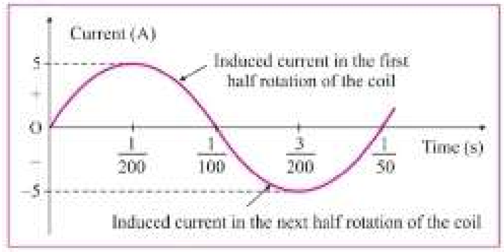


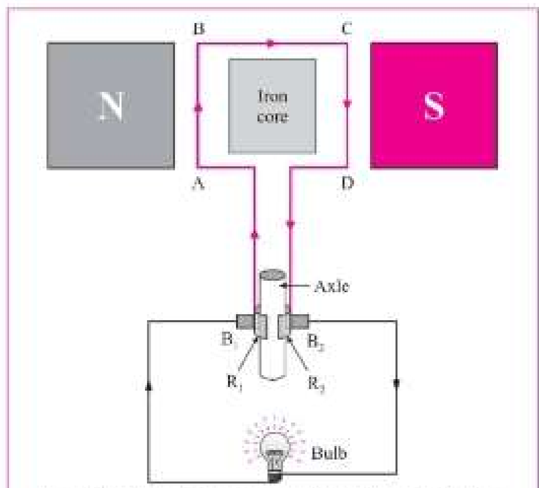
Fig. 4.30 : Alternating current

See Fig. 4.30. In this case, the frequency of the alternating current (AC) produced is 50 Hz. The coil completes 50 rotations every second. The time for one rotation of the coil is $\frac{1}{50}$ second. It is called the periodic time or simply the period of AC. Positive current means the current flows in one direction and negative current means the current flows in the opposite direction in the external circuit. Here, the maximum value of AC is 5 A.

• Use your brain power! **(Textbook page 60)**

(60) Draw the diagram of a DC generator. Then explain as to how the DC current is obtained.

Ans. Figure 4.31 shows the construction of a DC generator.



N and S : Poles of the magnet, R_1 and R_2 : Split rings, B_1 and B_2 : Carbon brushes, ABCD : Armature coil

Fig 4.31 : Electric DC generator

Working : The axle is rotated with a machine from outside. When the armature coil of the generator rotates in the magnetic field, electric potential difference is produced in the coil due to electromagnetic induction. This produces a current as shown by the glowing of the bulb or by a galvanometer. The direction of the current depends on the sense of rotation of the coil.

In a DC generator, one brush is always in contact with the arm of the coil moving up while the other brush is in contact with the arm of the coil moving down in the magnetic field. Hence, the flow of the current in the circuit is always in the same direction and the current flows so long as the coil continues to rotate in the magnetic field.

[**Note :** In the case of a DC generator, the current is in the same direction during both the halves of the rotation of the coil. The magnitude of the current does vary periodically with time. In this respect, it differs from the current supplied by an electric cell.]

***(61) Name the following diagrams and explain the concept behind them.**

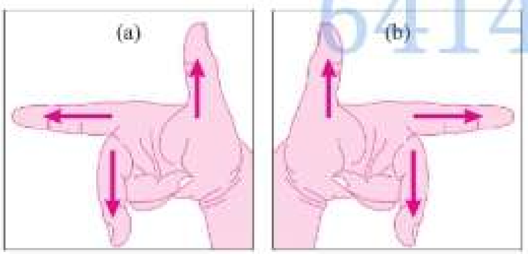


Fig. 4.32

Ans. (a) *See the answer to Q. 9 (46).*

(b) *See the answer to Q. 9 (33).*

(62) Observe the given figure of Fleming's Right Hand Rule and write the labels of A and B correctly. ***(2 marks) (March '20)***

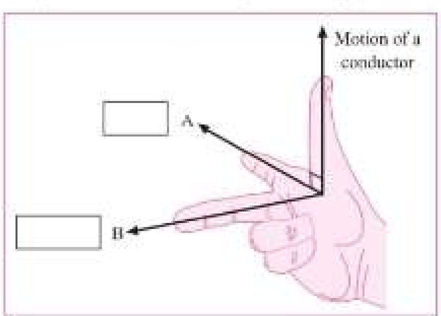


Fig. 4.33

Ans. A : Direction of the magnetic field

B : Direction of the induced current.

***(63) Identify the figures and explain their use.**

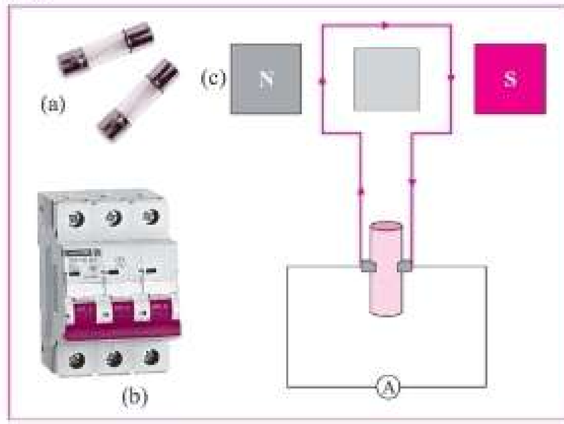


Fig. 4.34

Ans. (a) *See the answer to Q. 9 (25) and Fig. 4.5.*

(b) *See Fig. 4.6 and the accompanying information.*

(c) *See the answer to Q. 9 (60). Here, an ammeter is shown instead of a bulb.*

(64) Observe the figure and answer the following questions. ***(3 marks) (Board's Model Activity Sheet)***

(a) Identify the machine shown in the figure.

(b) Write a use of this machine.

(c) How does transformation of energy take place in this machine?

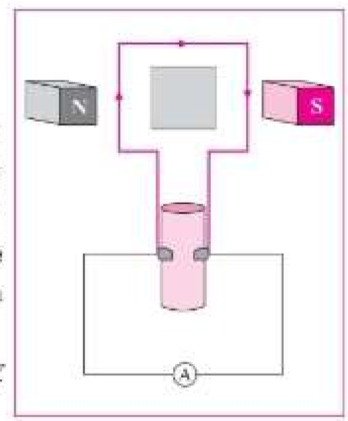


Fig. 4.35

Ans. (a) The instrument shown in the figure is generator.

(b) This machine is used to generate electricity.

(c) The generator generates electricity through following transformation :

Mechanical Energy → Electrical Energy

For a detailed answer, see the answer to Q. 9 (60).

(65) Observe the following figure. Which bulb will fuse?

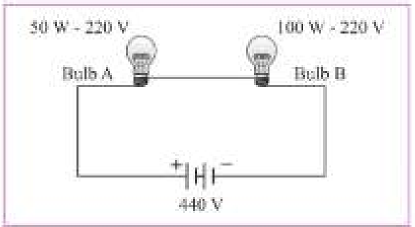


Fig. 4.36

Ans. Bulb A.

Q. 10 Give scientific reasons :

***(1) For electric power transmission, copper or aluminium wire is used.**

Ans. (1) Copper and aluminium are good conductors of electricity.

(2) Copper and aluminium have very low resistivity. Hence, when an electric current flows through a wire of copper or aluminium, heat produced is comparatively low. Therefore, for electric power transmission, copper or aluminium wire is used.

***(2) In practice the unit kW·h, rather than the joule, is used for the measurement of electric energy.**

Ans. (1) If an electric device rated 230 V, 5 A is operated for one hour, electric energy used

$= VIt = 230\ \text{V} \times 5\ \text{A} \times 3600\ \text{s} = 4140000$ joules.

(2) If this energy is expressed in kW·h, it will be $\frac{4140000}{3.6 \times 10^6}$ kW·h $= 1.15$ kW·h (more convenient). Hence, in practice the unit kW·h, rather than the joule, is used for the measurement of electric energy.

***(3) Tungsten is used to make a solenoid type coil in an electric bulb.** *OR*

The filament of an electric bulb is made of tungsten. *OR*

The melting point of the filament of a bulb is very high. *OR*

The filament of a bulb should have a high melting point.

Ans. (1) The intensity of light emitted by the filament of a bulb depends on the temperature of the filament. It increases with the temperature.

(2) The melting point of the material used to make the filament of a bulb should be very high so that the filament can be heated to a high temperature by passing a current through it, without melting it. This enables us to obtain more light. The melting point of tungsten is very high.

Hence, tungsten is used to make a solenoid type coil (filament) in an electric bulb.

(4) In the electric equipment producing heat e.g. iron, electric heater, boiler, toaster, etc. an alloy such as Nichrome is used, not pure metals.** ***(March–July '19; Board's Model Activity Sheet) *OR*

The coils in heating devices such as a toaster and electric iron are made of an alloy such as Nichrome, rather than a pure metal.

Ans. (1) The working of heating devices such as a toaster and an electric iron is based on the heating effect of electric current, i.e., conversion of electric energy into heat by passage of electric current through a metallic conductor.

(2) An alloy, such as Nichrome, has high resistivity and it can be heated to a high temperature without oxidation, in contrast to pure metals. Therefore, the coils in heating devices such as a toaster and an electric iron are made of an alloy, such as Nichrome, rather than a pure metal.

(5) In an electric iron, the coil of high resistance is kept between mica sheets.

Ans. (1) Mica is a bad conductor of electricity and good conductor of heat.

(2) In an electric iron, the coil of high resistance is kept between mica sheets so that there is no electrical contact between the coil and the heavy metal block of the iron though there is heat transfer. This protects the user from getting an electric shock.

(6) The material used for fuse has low melting point. *OR*

A fuse should be made of a material of low melting point.

Ans. (1) A fuse is used to protect a circuit and the appliances connected in the circuit by stopping the flow of an excessive electric current. For this, a fuse is connected in series in the circuit.

(2) When the current in the circuit passes through the fuse, its temperature increases. When the current exceeds the specified value, the fuse must melt to break the circuit. For this, the material used for a fuse has low melting point.

Q. 11 Distinguish between the following :

(1) Electric motor and Electric generator.

Ans.

Electric motor	Electric generator
1. A battery is used in an electric motor to pass a current through the coil.	1. A battery is not used in an electric generator.
2. In this case, a current-carrying coil is set into rotation due to the magnetic field.	2. In this case, a potential difference and hence a current is produced when the coil is set into rotation in the magnetic field by an external agent.
3. Split rings are used in an electric motor.	3. Rings used in an AC generator are not split.
4. In this case, electric energy is converted into mechanical energy.	4. In this case, mechanical energy is converted into electric energy.

***(2) AC generator and DC generator.**

Ans.

AC generator	DC generator
1. In an AC generator, the rings used are not split.	1. In a DC generator, split rings are used.
2. The direction of the current produced reverses after equal intervals of time.	2. The current produced flows in the same direction all the time.

(3) Alternating current and Direct current. ***(2 marks) (Nov. '20)***

Ans.

Alternating current	Direct current
1. Alternating current flows in periodic manner. In one half cycle it flows in one direction, and, in the other half cycle, it flows in the opposite direction.	1. Direct current flows in one direction only.
2. It can be transmitted over a long distance.	2. It cannot be transmitted over a long distance.

Q. 12 Read the given passage and answer the following questions : ***(3 Marks) (March '20)***

The home electrical connection consists of 'live', 'neutral' and 'earth' wires. The 'live' and the 'neutral' wires have potential difference of 220 V. The 'earth' wire is connected to ground. Due to a fault in the equipment or if the plastic coating on the 'live' and the 'neutral' wires gives away the two wires come in contact with each other and a large current flows through it producing heat. If any inflammable material (such as wood, cloth, plastic, etc.) exists around that place it can catch fire. Therefore a fuse wire is used as a precautionary measure.

(a) Name the *two* wires having potential difference of 220 V.

(b) What is short circuit?

(c) Write the function of a fuse.

Ans. (a) The potential difference between the live wire and the neutral wire is 220 V.

(b) If a bare live wire (phase wire) and a bare neutral wire touch each other (come in direct contact) or come very close to each other, the resistance of the circuit becomes very small and hence huge (very high) electric current flows through it. This condition is called a short circuit or short circuiting.

In this case, a large amount of heat is produced and the temperature of the components involved becomes very high. Hence, the circuit catches fire.

(c) A fuse protects electrical circuits and appliances by stopping the flow of electric current when it exceeds a specified value. For this, it is connected in series with the appliance (or circuit) to be protected. A fuse is a piece of wire made of an alloy of low melting point (e.g. an alloy of lead and tin). If a current larger than the specified value flows through the fuse, its temperature increases enough to melt it. Hence, the circuit breaks and the appliance is protected from damage.

Q. 13 Solve the following examples/ numerical problems :

(1) An electric bulb is connected to a source of 250 volts. The current passing through it is 0.27 A. What is the power of the bulb?

Solution : Data : $V = 250$ V, $I = 0.27$ A, $P = ?$

$P = VI$

$= 250 \text{ V} \times 0.27 \text{ A}$

$= 67.5 \text{ W}$

The power of the bulb = 67.5 W.

(2) If a bulb of 60 W is connected across a source of 220 V, find the current drawn by it.

Solution : Data : $P = 60$ W, $V = 220$ V, $I = ?$

$P = VI$

$\therefore I = \frac{P}{V} = \frac{60 \text{ W}}{220 \text{ V}} = \frac{3}{11} \text{ A} = 0.2727 \text{ A}$

The current drawn by the bulb

$= \frac{3}{11}$ **A = 0.2727 A.**

(3) A bulb of 40 W is connected across a source of 220 V. Find the resistance of the bulb.

Solution : Data : $P = 40$ W, $V = 220$ V, $R = ?$

$P = VI = V\left(\frac{V}{R}\right) = \frac{V^2}{R}$

$\therefore R = \frac{V^2}{P} = \frac{(220 \text{ V})^2}{40 \text{ W}} = \frac{220 \times 220}{40} \,\Omega = \frac{220 \times 220}{2 \times 20} \Omega$

$= 11 \times 110 \Omega = 1210 \,\Omega$

The resistance of the bulb = 1210 Ω.

***(4) Heat energy is being produced in a resistance in a circuit at the rate of 100 W. The current of 3 A is flowing in the circuit. What must be the value of the resistance?**

Solution : Data : $P = 100$ W, $I = 3$ A, $R = ?$, $P = I^2R$

$\therefore$ Resistance, $R = \frac{P}{I^2} = \frac{100\text{W}}{(3 \text{ A})^2} = \frac{100}{9} \,\Omega = \mathbf{11.11 \,\Omega}$.

(5) If the current passing through a bulb is 0.2 A and the power of the bulb is 20 W, find the voltage applied across the bulb.

Solution : Data : $I = 0.2$ A, $P = 20$ W, $V = ?$

$P = VI$

$\therefore V = \frac{P}{I} = \frac{20 \text{ W}}{0.2 \text{ A}}$

$= 100 \text{ V}$

The voltage across the bulb = 100 V.

***(6) Two tungsten bulbs of wattage 100 W and 60 W power work on 220 V potential difference. If they are connected in parallel, how much current will flow in the main conductor?**

Solution : Data : $P_1 = 100$ W, $P_2 = 60$ W, $V = 220$ V

$I = ?$ $\quad \therefore I = \frac{P}{V}$

$P = VI \quad \therefore I_1 = \frac{P_1}{V}$ and $I_2 = \frac{P_2}{V}$

Current in the main conductor, $I = I_1 + I_2$ (parallel connection)

$= \frac{P_1}{V} + \frac{P_2}{V} = \frac{P_1 + P_2}{V} = \frac{100 \text{ W} + 60 \text{ W}}{220 \text{ V}} = \frac{160}{220} \text{ A}$

$= 0.727$ A = **nearly 0.73 A.**

(7) Two tungsten bulbs of power 50 W and 60 W work on 220 V potential difference. If they are connected in parallel, how much current will flow in the main conductor?

(2 marks) (March '19)

Solution : Data : $P_1 = 50$ W, $P_2 = 60$ W, $V = 220$ V, $I = ?$

$P = VI \qquad \therefore I = \frac{P}{V} \qquad \therefore I_1 = \frac{P_1}{V}$ and $I_2 = \frac{P_2}{V}$

Current in the main conductor,

$I = I_1 + I_2$ ..... (parallel combination)

$= \frac{P_1}{V} + \frac{P_2}{V} = \frac{P_1 + P_2}{V} = \frac{50\text{ W} + 60\text{ W}}{220\text{ V}}$

$= \frac{110}{220}\text{ A} = \frac{1}{2}\text{ A}$

$=$ **0.5 A.**

(8) An electric iron rated 750 W is operated for 2 hours / day. How much energy is consumed by the electric iron for 30 days?

Solution : Data : $P = 750$ W,

$t = 2\,\frac{\text{hours}}{\text{day}}$ for 30 days

The energy consumed $= P\ t = 750 \times 2 \times 30$

$= 1500 \times 30$

$= 45000$ W·h

$= 45$ kW·h

The energy consumed by the electric iron for 30 days = 45 kW·h.

***(9) Who will spend more electrical energy? 500 W TV set in 30 mins, or 600 W heater in 20 mins?**

Solution : Data : $P_1 = 500$ W,

$t_1 = 30\text{ min} = \frac{30}{60}\text{ h} = \frac{1}{2}\text{ h}$, $P_2 = 600$ W,

$t_2 = 20\text{ min} = \frac{20}{60}\text{ h} = \frac{1}{3}\text{ h}$

Electrical energy used $= Pt$

TV set : $P_1t_1 = 500\text{ W} \times \frac{1}{2}\text{ h} = 250\text{ W·h}$

Heater : $P_2t_2 = 600\text{ W} \times \frac{1}{3}\text{ h} = 200\text{ W·h}$

Thus, the TV set will spend more electrical energy than the heater.

(10) If a TV of rating 100 W operates for 6 hours per day, find the number of units consumed in a leap year.

Solution : Data : $P = 100$ W,

$t = 6\,\frac{\text{hours}}{\text{day}} \times 366\text{ days} = 2196\text{ hours}$

1 unit $\equiv$ 1 kW·h = 1000 W·h

$N = \frac{Pt}{1000\text{ W·h/unit}} = \frac{100\text{ W} \times 2196\text{ hours}}{1000\text{ W·h/unit}}$

$= 219.6$ units

219.6 units are consumed in a leap year.

(11) An electric appliance of rating 300 W is used 5 hours per day in the month of March. Find the number of units consumed.

Solution : Data : $P = 300$ W,

$t = 5\,\frac{\text{hours}}{\text{day}} \times 31\text{ days} = 155\text{ hours}$,

1 unit = 1 kW·h = 1000 W·h

$N = \frac{Pt}{1000\text{ W·h/unit}} = \frac{300\text{ W} \times 155\text{ hours}}{1000\text{ W·h/unit}}$

$= 46.5$ units

46.5 units are consumed in the month of March.

(12) A washing machine rated 300 W operates one hour/day. If the cost of a unit is ₹ 3.00, find the cost of the energy to operate the washing machine for the month of March.

Solution : Data : $P = 300$ W, ₹ 3.00 per unit,

$t = 1\,\frac{\text{hour}}{\text{day}} \times 31\text{ days} = 31\text{ hours}$,

1 unit = 1 kW·h = 1000 W·h, cost of the energy = ?

$N = \frac{Pt}{1\text{ kW·h/unit}} = \frac{300\text{ W} \times 31\text{ hours}}{1000\text{ W·h/unit}} = 9.3\text{ units}$

Cost = 9.3 units × ₹ 3.00 per unit = ₹ 27.9.

The cost of the energy to operate the washing machine for the month of March = ₹ 27.9.

*(13) **An electric iron of 1100 W is operated for 2 hours daily. What will be the electrical consumption expenses for that in the month of April? (The electric company charges ₹ 5 per unit of energy.)**

Solution : Data : $P = 1100$ W, $t = 2 \times 30 = 60$ h,

₹ 5 per unit of energy, expenses = ?

$$N = \frac{Pt}{1000 \text{ W·h/unit}} = \frac{1100 \text{ W} \times 60 \text{ h}}{1000 \text{ W·h/unit}} = 66 \text{ units.}$$

∴ Electrical consumption expenses

= 66 units × ₹ 5 per unit = ₹ **330.**

(14) Find the heat produced in joule if a current of 0.1 A is passed through a coil of resistance 50 Ω for two minutes. Keeping other conditions the same if the length of the wire is reduced to $\frac{1}{4}$th the original length (by cutting the wire), what will be the heat produced?

Solution : Data : $I = 0.1$ A, $R = 50$ Ω,

$t = 2$ minutes $= 2 \times 60$ s $= 120$ s, $H = ?$

$H = I^2Rt = (0.1 \text{ A})^2 \times 50 \ \Omega \times 120 \text{ s}$

$= 0.01 \times 50 \times 120 \text{ J} = 60 \text{ J}$

Heat produced = 60 joules.

In the second case, the resistance of the wire will be $\frac{50 \ \Omega}{4}$. Hence, the heat produced $= \frac{60 \text{ J}}{4}$ = **15 J.**

(15) Calculate the heat produced in calorie when a current of 0.1 A is passed through a wire of resistance 41.8 Ω for 10 minutes.

Solution : Data: $I = 0.1$ A, $R = 41.8$ Ω,

$t = 10$ minutes

$= 10 \times 60$ s $= 600$ s, $H = ?$

$$H = \frac{I^2Rt}{4.18} \text{ cal} = \frac{(0.1)^2 \times 41.8 \times 600}{4.18} \text{ cal} = 60 \text{ cal}$$

Heat produced = 60 calories.

(16) A potential difference of 250 volts is applied across a resistance of 1000 Ω in an electric iron. Find (1) the current (2) the heat produced in joule in 12 seconds. Keeping other conditions the same, if the length of the wire in the iron is reduced to half the original length (by cutting the wire), what will be the current and heat produced?

Solution : Data : $V = 250$ V, $R = 1000$ Ω, $t = 12$ s, $I = ?$, $H = ?$

(1) $V = IR \quad \therefore I = \frac{V}{R} = \frac{250 \text{ V}}{1000 \ \Omega} = 0.25 \text{ A}$

The current through the resistance = 0.25 A.

(2) $H = I^2Rt$

$= (0.25 \text{ A})^2 \times 1000 \ \Omega \times 12 \text{ s}$

$= \left(\frac{1}{4} \times 1000\right) \times \left(\frac{1}{4} \times 12\right) \text{ J}$

$= 250 \times 3 \text{ J} = 750 \text{ J}$ *OR*

$H = VIt = 250 \text{ V} \times 0.25 \text{ A} \times 12 \text{ s}$

$= 250 \times 3 \text{ J} = 750 \text{ J}$

The heat energy produced in the resistance in 12 seconds = 750 joules.

On cutting the wire, the resistance of the wire will become half the initial resistance. Hence, the current will become double the initial current as $I = V/R$ and V is the same in both the cases. Therefore, the current in the wire will be $0.25 \text{ A} \times 2 = 0.5$ A. **(Hence, the heat produced will be $VIt = 250 \text{ V} \times 0.5 \text{ A} \times 12 \text{ s} = 250 \times 6 \text{ J} = 1500 \text{ J}$.)**

(17) A potential difference of 100 V is applied across a resistor of resistance 50 Ω for 6 minutes and 58 seconds. Find the heat produced in (i) joule (ii) calorie.

Solution : Data: $V = 100$ V, $R = 50$ Ω,

$t = 6$ minutes and 58 seconds $= (6 \times 60 + 58)$ s $= (360 + 58)$ s $= 418$ s, $H = ?$

(i) $H = \frac{V^2t}{R} = \frac{(100 \text{ V})^2 \times 418 \text{ s}}{50 \ \Omega}$

$= \frac{100 \times 100 \times 418}{50} \text{ J} = 200 \times 418 \text{ J}$

$= 83600 \text{ J}$

Heat generated = 83600 joules.

(ii) $H = \frac{V^2t}{4.18 \ R} \text{ cal} = \frac{(100)^2 \times 418}{4.18 \times 50} \text{ cal}$

$= \frac{100 \times 100 \times 100}{50} \text{ cal} = 2 \times 10^4 \text{ cal}$

Heat produced = 2×10^4 calories.

NUMERICAL PROBLEMS FOR PRACTICE

1. When the voltage applied across a bulb is 200 V, the current passing through the bulb is 0.1 A. Find the power of the bulb. (**Ans.** 20 W)
2. A bulb of 100 W is connected across a source of 200 V. Find the current drawn by it. (**Ans.** 0.5 A)
3. A bulb of 60 W is connected across a source of 240 V. Find the resistance of the bulb. (**Ans.** 960 Ω)
4. If the current passing through a bulb is 0.15 A and the power of the bulb is 30 W, find the voltage applied across the bulb. (**Ans.** 200 V)
5. An electric appliance of rating 800 W is used 4 hours per day in the month of December. Find the number of units consumed. (**Ans.** 99.2 units)
6. An electric appliance rated 400 W is used 5 hours per day in the month of June. If the cost of a unit is ₹ 3.00, find the energy bill for June. (**Ans.** ₹ 180)
7. An electric bulb rated 60 W is used 10 hours per day for 20 days. If the cost of a unit is ₹ 3.00, find the energy bill. (**Ans.** ₹ 36)
8. Two electric bulbs rated 60 W and 40 W respectively are used 5 hours per day for 20 days. If the cost of a unit is ₹ 4.00, find the cost of the energy used. (**Ans.** ₹ 40)
9. Find the heat produced in joule if a current of 0.1 A is passed through a coil of resistance 25 Ω for one minute. (**Ans.** 15 J)
10. Calculate the heat produced in calorie when a current of 0.1 A is passed through a wire of resistance 41.8 Ω for 5 minutes. (**Ans.** 30 calories)
11. Calculate the heat produced in calorie when a current of 0.2 A is passed through a wire of resistance 41.8 Ω for 10 minutes. (**Ans.** 240 calories)
12. Find the heat produced in calorie when a current of 0.2 A is passed through a wire of resistance 20.9 Ω for 10 minutes. (**Ans.** 120 calories)
13. A potential difference of 100 V is applied across a wire of resistance 50 Ω for one minute. Find the heat produced in joule. (**Ans.** 1.2×10^4 joules)
14. A potential difference of 100 V is applied across a wire for two minutes. If the current through the wire is 0.1 A, find the heat produced in joule. (**Ans.** 1200 joules)
15. A potential difference of 100 V is applied across a wire for 6 minutes and 58 seconds. If the current through the wire is 0.1 A, find the heat produced in calorie. (**Ans.** 1000 calories)

PROJECT

* Under the guidance of your teachers, make a 'free-energy generator'.

MEMORY MAP / CONCEPT MAP

(1)

Heating effect of electric current

- Applications : Electric iron, Electric heater, Electric bulb, Fuse wire
- Joule's law
  - $H = I^2Rt$ joule $= \frac{I^2Rt}{4.18}$ cal
  - $H = \frac{V^2t}{R}$ joule $= \frac{V^2t}{4.18R}$ cal
  - $H = VIt$ joule $= \frac{VIt}{4.18}$ cal

(2)

Electric power

- Time rate of doing electric work
- $P = VI = I^2R = V^2/R$
- SI unit : the watt, 1 watt = 1 joule per second
- Energy : 1 kilowatt-hour $= 3.6 \times 10^6$ J

(3)

Magnetism

- Natural magnets
- Detection by a compass needle
- Produced by electric current (Oersted's discovery)

(4)

Magnetic field

- Possesses magnitude and direction
- Extends to infinity
- Represented by lines of force (field lines)
- Current-carrying solenoid and bar magnet : same pattern
- Near a current-carrying conductor, the direction is given by the right hand thumb rule

(5)

Magnetic effect of electric current and electromagnetic induction

- Magnetic field and electric current together produce force
- Applications/uses in electrical appliances, motor, generator, measuring instruments, medicine, industry, etc.

Did you study the lesson/chapter from the **Navneet Digest**? Now, solve the self-test to ensure solid learning. Scan this **QR Code** for the test and its model answers.

5 HEAT

CHAPTER OUTLINE

IMPORTANT POINTS

• Can you recall? (Textbook page 62)

(1) What is the difference between heat and temperature?

Ans. Heat is a form of energy. Particles of matter (atoms, molecules, etc.) possess potential energy and kinetic energy. Total energy (potential energy + kinetic energy) of all particles of matter in a given sample is called its thermal energy. When two bodies at different temperatures are in thermal contact with each other, there is transfer of thermal energy from a body at higher temperature to a body at lower temperature. This energy in transfer is called heat. It is expressed in joule, calorie and erg.

Temperature is a quantitative measure of degree of hotness or coldness of a body. It is expressed in °C, °F or K (kelvin). Temperature determines the direction of energy transfer.

(2) What are the different ways of heat transfer?

Ans. Ways of heat transfer : conduction, convection and radiation.

[**Note :** heat = heat energy. In the textbook, both the terms are used.]

5.1 Latent heat :

- **Latent heat :** When there is a change of state of a substance, [solid ⟷ liquid, liquid ⟷ gas (vapour), solid ⟷ gas (vapour)] heat energy is absorbed by the substance or heat energy is removed from the substance at constant temperature. This heat energy is called latent heat of transition (or transformation or change of state). Latent heat per unit mass of the substance is called specific latent heat.

  The amount of heat energy absorbed at constant temperature by a unit mass of solid to convert into liquid phase is called the specific latent heat of fusion, and that constant temperature is called the melting point of the substance.

  The amount of heat energy absorbed at constant temperature by a unit mass of liquid to convert into gaseous phase is called the specific latent heat of vaporization and that constant temperature is called the boiling point of the substance.

  Specific latent heat is expressed in J/kg, erg/g, cal/g, kJ/kg and kcal/kg.

At a pressure of one atmosphere						
Substance	Melting Point °C	Boiling Point °C	Specific latent heat of fusion (L)		Specific latent heat of vaporization (L)	
			kJ/kg	cal/g	kJ/kg	cal/g
Water/Ice	0	100	333	80	2256	540
Copper	1083	2562	134	49	5060	1212
Ethyl alcohol	– 117	78	104	26	8540	200
Gold	1063	2700	144	15.3	1580	392
Silver	962	2162	88.2	25	2330	564
Lead	327.5	1749	26.2	5.9	859	207

Heat absorbed or given out in change of state = mL, where m is the mass of the substance.

5.2 Regelation :

- **Regelation :** The phenomenon in which ice converts to liquid due to applied pressure and then re-converts to ice once the pressure is removed is called regelation.

5.3 Anomalous behaviour of water :

- **Anomalous behaviour of water :** If water is heated from 0 °C to 4 °C, it contracts instead of expanding. At 4 °C its volume is minimum. If the water is heated further, it expands, i.e., its volume increases. This abnormal behaviour of water in the temperature range 0 °C to 4 °C is called anomalous behaviour of water. The density of water is maximum at 4 °C.

Hope's apparatus is used to study anomalous behaviour of water.

5.4 Dew point and humidity :

1. **Dew point temperature :** If the temperature of unsaturated air is decreased, a temperature is reached at which the air becomes saturated with water vapour. This temperature is called the dew point temperature.
2. **Absolute humidity :** The mass of water vapour present in a unit volume of air is called absolute humidity. Generally it is expressed in kg/m^3.
3. **Relative humidity :** The ratio of the actual mass of water vapour content in the air for a given volume and temperature to that required to make the same volume of air saturated with water vapour at the same temperature is called the relative humidity. This ratio, multiplied by 100, gives the percentage relative humidity. At the dew point the relative humidity is 100%.

• Try this (Textbook page 67)

(1) Take a bottle of cold water out of a refrigerator and keep it outside for a while. Observe the outer surface of the bottle.

(2) Drops of water can be observed on the outer surface of bottle. In the same way, if we observe the leaves of plants/grass or window-glass of a vehicle in the early morning we see water droplets collected on the surface.

Through these two observations, we sense the presence of water vapour in the atmosphere. When air cools, due to decrease in temperature it becomes saturated with water vapour. As a result, the excess water vapour gets converted into tiny droplets. The dew-point temperature is decided by the amount of vapour in the air.

4. **Unit of heat :** Heat can be expressed in various units, e.g., joule (J), erg, calorie (cal), kilocalorie (kcal).

The amount of heat necessary to raise the temperature of 1 g of water by 1 °C from 14.5 °C to 15.5 °C is called one calorie.

The amount of heat necessary to raise the temperature of 1 kg of water by 1 °C from 14.5 °C to 15.5 °C is called one kilocalorie.

1 kcal = 10^3 cal, 1 cal = 4.18 J,

1 kcal = 4.18×10^3 J.

5.5 Specific heat capacity :

1. **Specific heat capacity (c) :** The amount of heat energy required to raise the temperature of a unit mass of an object by 1 °C is called the specific heat capacity or simply specific heat of the object. It is expressed in various units such as J / kg · °C, erg / g · °C, cal / g · °C, kcal / kg · °C.

Sr. No.	Substance	Specific heat (c) (cal / g·°C)
(1)	Water	1.0
(2)	Paraffin	0.54
(3)	Kerosene	0.52
(4)	Aluminium	0.215
(5)	Iron	0.110
(6)	Copper	0.095
(7)	Silver	0.056
(8)	Mercury	0.033

2. Heat absorbed by an object = $mc\Delta T$, where m is the mass of the object and ΔT is the increase in the temperature of the object.

   Heat lost (given out) by an object = $mc\Delta T$

   Here ΔT is the decrease in the temperature of the object.

3. **Principle of heat exchange :** If a system of two objects is isolated from the environment by keeping it inside a heat resistant box, then no energy can leave the box or enter the box. In this situation, heat energy lost by the hot object = heat energy gained by the cold object.

   In due course, the two objects attain the same temperature.

Additional Important Information

Sublimation : The phenomenon in which a solid directly passes to the gaseous state without passing through the intermediate liquid state is known as sublimation.

Iodine, ammonia and camphor possess the property of sublimation.

Effect of pressure on the melting point of a substance : At a given pressure, a given solid melts at a fixed temperature. A change in pressure changes the melting point of the substance. In the case of the solids which expand on melting, an increase in the pressure raises the melting point of the solid, e.g., lead and wax.

In the case of the solids which contract on melting, an increase in pressure lowers the melting point of the solid, e.g., ice, antimony and bismuth.

Effect of pressure on the boiling point of a liquid : The boiling point of a liquid depends on the pressure on its surface. An increase in pressure raises the boiling point of a liquid while a decrease in pressure lowers its boiling point.

QUESTIONS & ANSWERS

(**Note :** heat ≡ heat energy)

Q. 1 Fill in the blanks and rewrite the sentences :

(1) The amount of water vapour in air is determined in terms of its ....

(2) If objects of equal masses are given equal heat, their final temperature will be different. This is due to difference in their ....

(3) When a liquid is getting converted into solid, the latent heat is ....

Ans.

(1) The amount of water vapour in air is determined in terms of its absolute humidity.

(2) If objects of equal masses are given equal heat, their final temperature will be different. This is due to difference in their specific heat capacities.

(3) When a liquid is getting converted into solid, the latent heat is released.

Q. 2 Choose the correct alternative and write it along with its allotted alphabet : *(1 mark each)*

(1) .... is used to study the anomalous behaviour of water.

(a) Calorimeter *(b) Joule's apparatus*

(c) Hope's apparatus *(d) Thermos flask*

(2) When water boils and is converted into steam, then ....

(a) heat is taken in and temperature remains constant

(b) heat is taken in and temperatures rises

(c) heat is given out and temperature lowers

(d) heat is given out and temperature remains constant

(3) When steam condenses to form water, ...

(a) heat is absorbed and temperature increases

(b) heat is absorbed and temperature remains the same

(c) heat is given out and temperature decreases

(d) heat is given out and temperature remains the same

(4) .... is an example of anomalous behaviour of water. ***(Board's Model Activity Sheet)***

(a) Dew point *(b) Solidification*

(c) Cracking of rocks *(d) Evaporation*

(5) Ice / water is a substance that ....

(a) expands on melting and contracts on freezing

(b) contracts on melting and does not undergo change in volume on freezing

(c) contracts on melting and expands on freezing

(d) does not undergo any change in volume on melting or freezing

(6) Heat absorbed when 1 g of ice melts at 0 °C to form 1 g of water at the same temperature is .... cal.

(a) 80 *(b) 800* *(c) 540* *(d) 54*

(7) The latent heat of vaporization of water is ....

(a) 540 cal / g *(b) 800 cal / g*

(c) 80 cal / g *(d) 54 cal / g*

(8) The latent heat of fusion of ice is ....

(a) 540 cal / g *(b) 80 cal / g*

(c) 800 cal / g *(d) 4 cal / g*

(9) If the temperature of water is decreased from 4 °C to 10 °C, then its ....

(a) volume decreases and density increases

(b) volume increases and density decreases

(c) volume and density, both decrease

(d) volume and density, both increase

(10) At 4 °C, the density of water is ....

(a) $10\ g/cm^3$ *(b)* $4\ g/cm^3$

(c) $4 \times 10^3\ kg/m^3$ *(d)* $1 \times 10^3\ kg/m^3$

(11) The density of water is maximum at ....

(a) 0 °C *(b) − 4 °C* *(c) 100 °C* *(d) 4 °C*

(12) .... heat is needed to raise the temperature of 1 kg of water from 14.5 °C to 15.5 °C.

(a) 4180 J *(b)* 10^3 *J* *(c) 1 cal* *(d) 4180 cal*

(13) .... heat is needed to convert 1 g of water at 0 °C and at a pressure of one atmosphere into 1 g of steam under the same conditions.

(a) 80 cal (b) 540 cal (c) 89 J (d) 540 J

(14) Water expands on reducing its temperature below .... °C. ***(July '19)***

(a) 0 *(b) 4* *(c) 5* *(d) 12*

(15) The vapour content in the air is measured using a physical quantity called ....

(March '20)

(a) absolute humidity *(b) relative humidity*

(d) dew point *(d) humidity*

Ans.

(1) (c) Hope's apparatus

(2) (a) heat is taken in and temperature remains constant

(3) (d) heat is given out and temperature remains the same

(4) (c) Cracking of rocks

(5) (c) contracts on melting and expands on freezing

(6) (a) 80

(7) (a) 540 cal / g

(8) (b) 80 cal / g

(9) (b) volume increases and density decreases

(10) (d) 1×10^3 kg / m^3

(11) (d) 4 °C

(12) (a) 4180 J

(13) (b) 540 cal

(14) (b) 4

(15) (a) absolute humidity

Q. 3 State whether the following statements are *true* or *false*. (If a statement is false, correct it and rewrite it.) : ***(1 mark each)***

(1) Specific latent heat of fusion is expressed in g / cal.

(2) If the temperature of water is raised from 0 °C to 10 °C, its volume goes on increasing.

(3) At dew point relative humidity is 100%.

(4) 1 kcal = 4.18 joules.

(5) Specific heat capacity is expressed in cal / g · °C

(6) Latent heat of fusion, $Q = mL$.

(7) If the relative humidity is more than 60%, we feel that the air is humid.

(8) If the relative humidity is less than 60%, we feel that the air is dry.

(9) Relative humidity has no unit.

(10) Absolute humidity is expressed in kg / m^3.

Ans.

(1) **False.** (Specific latent heat of fusion is expressed in cal / g.)

(2) **False.** (If the temperature of water is raised from 0 °C to 10 °C, its volume goes on decreasing in the range 0 °C to 4 °C and then goes on increasing in the range 4 °C to 10 °C.)

(3) **True.**

(4) **False.** (1 kcal = 4180 joules.)

(5) **True.** (6) **True.** (7) **True.**

(8) **True.** (9) **True.** (10) **True.**

Q. 4 Identify the odd one and give the reason :

(1) Temperature, conduction, convection, radiation.

(2) The joule, The erg, The calorie, The newton.

(3) cal / g, cal / g · °C, kcal / kg · °C, erg / g · °C.

Ans. (1) **Temperature.** It is a physical quantity. Others are modes of transfer of heat. (2) **The newton.** It is a unit of force. Others are units of energy (as well as work.) (3) **cal / g.** It is a unit of specific latent heat. Others are units of specific heat capacity.

Q. 5 Match the columns :

Column A	Column B
(1) Specific latent heat	(a) J/K
(2) Specific heat capacity	(b) J/kg
	(c) kcal
	(d) cal / g · °C

Ans. (1) Specific latent heat – J/kg

(2) Specific heat capacity – cal / g · °C.

Q. 6 Answer the following questions :

• **Try this (Textbook page 62)**

(1) Take a few pieces of ice in a glass beaker as shown in figure 5.1.

(2) Insert the bulb of a thermometer in ice and measure its temperature.

(3) Put the beaker on a stand and heat the ice using a burner.

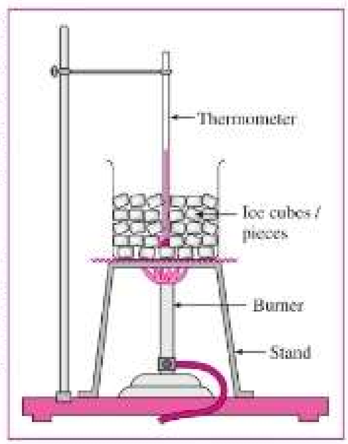


Fig. 5.1 : Latent heat

(4) Record the temperature using the thermometer after every minute.

(5) As the ice is heated, it starts melting. Stir the mixture of ice and water.

(6) Continue the heating even after ice starts melting.

(7) Draw a graph of temperature versus time.

Ans.

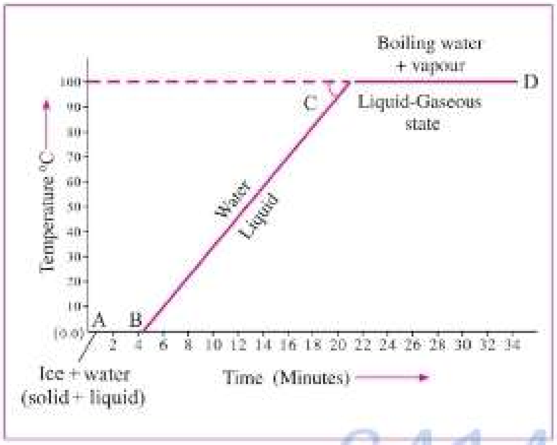


Fig. 5.2 : Temperature vs Time graph

(1) Explain the following temperature vs time graph (shown in Fig. 5.2).** ***(3 marks)

(March–July '19)

Ans. The graph shows what happens when a mixture of ice and water is heated continuously. The temperature of the mixture remains constant (0 °C) till all the ice melts as shown by the line AB. This temperature is the melting point of ice. On further heating, the temperature rises steadily from 0 °C to 100 °C as shown by the line BC, At 100 °C water starts converting into steam. This temperature is the boiling point of water. Further heating does not change the temperature and the conversion water → steam continues as shown by the line CD.

***(2) Explain the role of latent heat in the change of state of a substance.**

Ans. When a solid is heated, initially, its temperature increases. Here, the heat absorbed by the body (substance) is used in increasing the kinetic energy of the particles (atomic, molecules, etc.) of the body as well as for doing work against the forces of attraction between them. As the heating is continued, at a certain temperature (melting point), solid is converted into liquid. In this case, the temperature remains constant and the heat absorbed is used for weakening the bonds and conversion into liquid phase (liquid state). This heat is called the latent heat of fusion.

When a liquid is converted into the gaseous phase (gaseous state), at the boiling point, the heat absorbed is used for breaking the bonds between the atoms or molecules. This heat is called the latent heat of vaporization.

Some solids, under certain conditions, are directly transformed into the gaseous phase. Here the heat is absorbed but the temperature remains constant. The absorbed heat is used for breaking the bonds between atoms or molecules. This heat is called the latent heat of sublimation.

In general, latent heat is the heat absorbed or given out by a substance during a change of state at constant temperature.

In transformations from liquid to solid, gas to liquid and gas to solid, latent heat is given out by the body (substance).

(**Note** : change of state = change of phase)

***(3) What is meant by latent heat? How will the state of matter transform if latent heat is given off?**

Ans. *See the answer of Q. 6 (2).*

(4) Define latent heat of fusion. *OR*

What is latent heat of fusion? State its units.

Ans. When a solid is converted into liquid at constant temperature (melting point of the substance) the amount of heat absorbed by it is called the latent heat of fusion.

Heat is a form of energy. Hence, latent heat is expressed in units joule, erg, calorie or kilocalorie.

(5) Define specific latent heat of fusion. *OR*

What is specific latent heat of fusion? State its units.

Ans. The amount of heat energy absorbed at constant temperature by a unit mass of solid to convert into liquid phase is called the specific latent heat of fusion.

It is expressed in units J / kg, erg / g, cal / g, kJ / kg and kcal / kg.

[**Note** : Specific latent heat $(L) = \dfrac{\text{latent heat } (Q)}{\text{mass of the substance } (m)}$

$\therefore$ SI unit of specific latent heat = SI unit of energy / SI unit of mass = J / kg]

(6) Explain the term latent heat of vaporization.

Ans. When a liquid is heated continuously, initially, its temperature increases. Later, at a certain stage, its temperature does not increase even when heat is supplied to it. At this temperature, heat absorbed by the liquid is used for breaking the bonds between its atoms or molecules, i.e., for doing work against the forces of attraction between the atoms or molecules and conversion into gaseous phase.

This heat is called the latent heat of vaporization and the constant temperature at which this change of state occurs is called the boiling point of the liquid.

(7) Define boiling point of a liquid. *OR*

What is boiling point of a liquid?

Ans. The constant temperature at which a liquid transforms into gaseous state is called the boiling point of the liquid.

[**Note** : On application of pressure, the boiling point of a liquid is raised. On reducting the pressure, the boiling point is lowered.]

(8) Define specific latent heat of vaporization.

OR

What is specific latent heat of vaporization?

Ans. The amount of heat energy absorbed at constant temperature by a unit mass of liquid to convert into gaseous phase is called the specific latent heat of vaporization.

(9) The specific latent heat of fusion of ice is 80 cal / g. Explain this statement.

Ans. When 1 g of ice at a pressure of one atmosphere and at a temperature 0 °C is converted into 1 g of water, heat absorbed by the ice is 80 cal.

(10) The specific latent heat of fusion of silver is 88.2 kJ / kg. Explain this statement.

Ans. When 1 kg of silver at a pressure of one atmosphere and at a temperature of 962 °C (melting point of silver) is converted into 1 kg of silver in liquid phase, heat absorbed by the silver is 88.2 kJ.

(11) The specific latent heat of vaporization of water is 540 cal / g. Explain this statement.

Ans. When 1 g of water at a pressure of one atmosphere and at a temperature of 100 °C is converted into 1 g of steam, heat absorbed by the water is 540 cal.

• Use your brain power! (Textbook page 63)

(1) Is the concept of latent heat applicable during transformation of gaseous phase to liquid phase and from liquid phase to solid phase?

Ans. Yes.

(2) Where does the latent heat go during these transformations?

Ans. During these transformations, the latent heat is given out by the substance to the surroundings.

• Try this (Textbook page 64)

Take a small slab of ice, a thin wire, two identical weights.

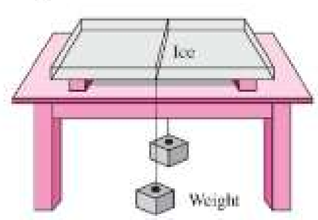


Fig. 5.3 : Regelation

Activity :

(1) Put a slab of ice on a stand as shown in Fig. 5.3.

(2) Hang two equal weights to the two ends of a metal wire and put the wire on the slab as shown in the figure.

What do you observe?

Ans. It is observed that the wire gradually penetrates the ice slab. After some time, the wire comes out of the lower surface of the ice slab. However, the ice slab does not break.

(12) Define regelation. *OR*

What is regelation?

Ans. The phenomenon in which the ice converts to liquid due to applied pressure and then re-converts to ice once the pressure is removed is called regelation.

• Use your brain power! (Textbook page 64)

(1) In the above experiment, the wire moves through the ice slab. However, the ice slab does not break. Why?

Ans. When the thin wire with two equal weights attached to its ends is hung over the block of ice, it exerts pressure on the ice below it. Due to this, the melting point of the ice below the wire is lowered and some ice melts. The wire passes through the water so formed. The water above the wire is no longer under pressure and, therefore, refreezes. Once again the ice below the wire melts, and the wire passes through it, and the process continues. In this way, due to alternate melting of ice and refreezing of water, the wire cuts right through the block of ice leaving the block intact.

(2) Is there any relationship of latent heat with regelation?

Ans. Yes, when ice melts, heat is absorbed, but the temperature does not change. Also, when water refreezes, heat is given out, but the temperature does not change. This heat absorbed or given out is the latent heat.

(3) You know that as we go higher than the sea level, the boiling point of water decreases. What would be the effect on the melting point of a solid?

Ans. As we go higher than the sea level, the melting point of solids (i) that expand on melting is lowered due to a decrease in pressure (ii) that contract on melting is raised due to a decrease in pressure.

[**Note** : The wire used in the experiment is made of a metal (usually copper). Metals are good conductors of heat. Hence, exchange of heat between the portion of the ice above the wire and that below the wire takes place readily.]

• Can you tell? (Textbook page 64)

We feel that some objects are cold, and some are hot. Is this feeling related in some way to our body temperature?

Ans. Yes. If the temperature of the object is lower than our body temperature, e.g., ice, we feel the object is cold. If the temperature of the object is higher than our body temperature, e.g., hot water, we feel the object is hot.

(13) The terms hot and cold are used in relative context. Explain.

Ans. (1) Take three large bowls, P, Q and R. Fill bowl P with cold water, bowl Q with lukewarm water, and bowl R with hot water. (2) Immerse your right hand in bowl P, and left hand in bowl R for about five seconds. (3) Now, immerse both the

Fig. 5.4

hands in bowl Q at the same time. (4) You will find that the water in bowl Q appears warm to your right hand, and cold to your left hand. Thus, the hand immersed in cold water for some time finds the lukewarm water hot while the one immersed in hot water finds the same lukewarm water cold. This experiment shows that the terms hot and cold are relative.

***(14) Observe the following graph. Considering the change in volume of water as its temperature is raised from 0 °C, discuss the difference in the behaviour of water and other substances. What is this behaviour of water called?**

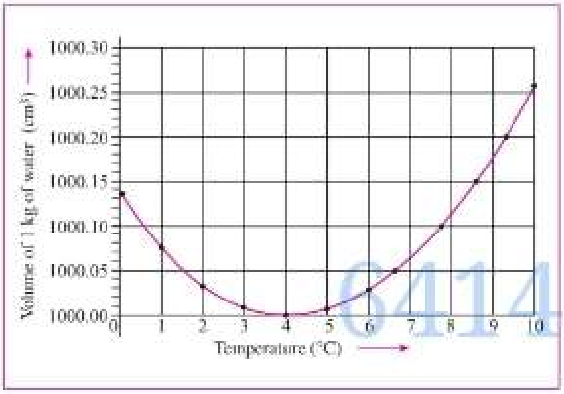


Fig. 5.5

Ans. If the temperature of water is raised from 0 °C to 10 °C, its volume goes on decreasing in the range 0 °C to 4 °C. It is minimum at 4 °C. The volume of water goes on increasing in the range 4 °C to 10 °C.

In general, when a substance is heated, its volume goes on increasing with temperature. Thus, in the range 0 °C to 4 °C, behaviour of water is different from other substances. It is called anomalous behaviour of water.

(15) Observe Fig. 5.5 and answer the following questions : ***(2 marks) (March '20)***

(a) Name the process represented in the figure.

(b) At what temperature does this process take place?

Ans. (a) Anomalous behaviour of water.

(b) This process takes place in the interval 0 °C to 4 °C.

(16) Draw a neat labelled diagram of Hope's apparatus. Explain how this apparatus can be used to demonstrate anomalous behaviour of water. Draw a graph of temperature of water against time.

Ans. Figure 5.6 shows Hope's apparatus. Initially, the cylindrical container in Hope's apparatus is filled with water at about 12 °C and the flat bowl is filled with a freezing mixture of ice and salt.

The temperature of water in the upper part of the container (T_2) is recorded by thermometer T_2 and that of water in the lower part of the container (T_1) is recorded by thermometer T_1. Figure 5.7 shows variation of temperature of water with time.

Initially, both the thermometers show the same temperature (say, 12 °C). In a short time, the temperature shown by the lower thermometer starts decreasing, while the temperature shown by the upper thermometer does not change very much.

This process continues till the temperature shown by the lower thermometer falls to 4 °C and remains constant thereafter. This shows that in the temperature range 12 °C to 4 °C, the density of the water in the central part of the container goes on increasing and hence the water sinks to the bottom. It means that water contracts, i.e., its volume decreases as its temperature falls from 12 °C to 4 °C.

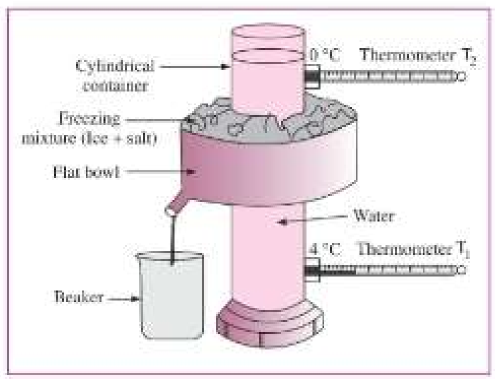


Fig. 5.6. Hope's apparatus

As the temperature of the water in the central part of the container becomes less than 4 °C, the temperature shown by the upper thermometer begins to fall rapidly to 0 °C. But the temperature shown by the lower thermometer remains constant

(4 °C). Later, the reading shown by the lower thermometer decreases to 0 °C.

In the temperature range 4 °C to 0 °C, the water moves upward. This shows that the density of water goes on decreasing in this range. It means that water expands, i.e. its volume increases as its temperature falls from 4 °C to 0 °C.

Thus, the volume of a given mass of water is minimum at 4 °C, i.e., the density of water is maximum at 4 °C.

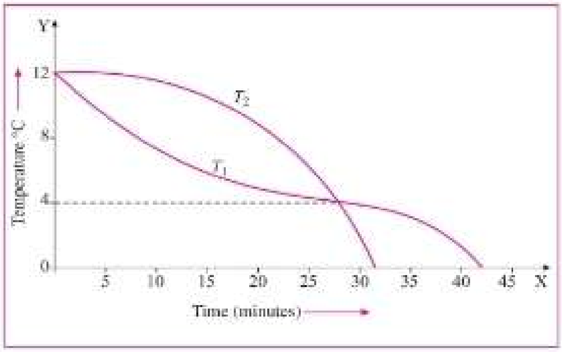


Fig. 5.7 : Graph of temperature of water against time (Schematic diagram)

In Fig. 5.7, the point of intersection of the two curves shows the temperature at which the density of water is maximum. This temperature is 4 °C.

***(17) Explain the role of anomalous behaviour of water in preserving aquatic life in regions of cold climate.**

Ans.

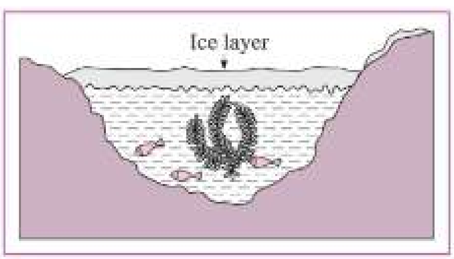


Fig. 5.8 : Aquatic plants and animals in cold regions

In cold regions, during winter, the temperature of the atmosphere falls well below 0 °C. As the temperature decreases, the water at the surfaces of lakes and ponds starts contracting. Hence, its density increases and it sinks to the bottom. This process continues till the temperature of all the water in a lake falls to 4 °C. As the water at the surface cools further, i.e., its temperature falls below 4 °C, it starts expanding instead of contracting. Therefore, its density decreases and it remains at the surface. The temperature of the water at the surface continues to fall to 0 °C. Finally, the water at the surface is converted into ice, but the water below the layer of ice is at 4 °C. Ice is a bad conductor of heat. Hence, the layer of the ice at the surface does not allow transfer of heat from the water to the atmosphere. As the water below the layer of ice remains at 4 °C, fish and other aquatic animals and plants can survive in it. (See Fig. 5.8.)

***(18) Explain the following : In cold regions in winter, the rocks crack due to anomalous expansion of water.**

Ans. Sometimes water enters into crevices of the rocks. When the temperature of the atmosphere falls below 4 °C, water expands. Even when water freezes to form ice, there is increase in its volume. As there is no room for expansion, it exerts a tremendous pressure on the rocks which crack and break up into small pieces.

• Use your brain power! (Textbook page 66)

How will you explain the following statements with the help of the anomalous behaviour of water?

(1) In regions with cold climate, the aquatic plants and animals can survive even when the atmospheric temperature goes below 0 °C.

(2) In cold regions in winter the pipes for water supply break and even rocks crack.

Ans. *See the answers to Q. 6 (17), (18) and Q. 7 (3).*

(19) A mountaineer climbing on the Everest, experienced the following facts. Explain each fact with the scientific reason : (1) He found fishes alive below the ice (2) Time required for cooking was more as he went higher (3) He saw many times cliffs falling suddenly (4) He saw tubes carrying water broken.

Ans. Explanation :

(1) Water expands as its temperature decreases from 4 °C to 0 °C. Water is converted into ice at 0 °C.

The density of water is more than that of ice. Fishes can remain alive in the water (at 4 °C) below the ice.

(2) At high altitudes, atmospheric pressure is low and hence water boils at a temperature lower than its normal boiling point. Therefore, the time required for cooking food is more at higher altitudes.

(3) Water expands while freezing. Hence, the water present in the crevices of the rocks exerts a tremendous pressure on the rocks, while freezing. Therefore, the cliffs fall.

(4) Water expands while freezing. Hence, the water in the tube exerts a large pressure on the tube, while freezing. Therefore, the tube carrying water breaks.

(20) What is humidity?

Ans. The moisture, i.e., the presence of water vapour, in the atmosphere is called humidity.

(21) When is air said to be saturated with water vapour?

Ans. When air contains maximum possible water vapour, it is said to be saturated with water vapour at that temperature.

(22) What does the amount of water vapour needed to saturate air depend on?

Ans. The extent of water vapour needed to saturate air depends on the temperature. The greater the temperature, the greater is the amount of water vapour needed to saturate air.

(23) When is air said to be unsaturated with water vapour?

Ans. When air contains water vapour less than its capacity to hold water vapour at that temperature, it is said to be unsaturated with water vapour.

(24) What is dew point temperature? *OR*

Define dew point temperature.

Ans. If the temperature of unsaturated air is decreased, a temperature is reached at which the air becomes saturated with water vapour. This temperature is called the dew point temperature.

(25) Name the physical quantity used to express the amount of water vapour present in air.

Ans. Absolute humidity.

(26) Define absolute humidity. *OR*

What is absolute humidity?

State its unit.

Ans. The mass of water vapour present in a unit volume of air is called absolute humidity. Generally it is expressed in kg/m^3.

(27) Define relative humidity. *OR*

What is relative humidity?

Write the formula for % relative humidity.

Ans. The ratio of the actual mass of water vapour content in the air for a given volume and temperature to that required to make the same volume of air saturated with water vapour at the same temperature is called the relative humidity.

% Relative humidity = [the actual mass of water vapour content in the air for a given volume and temperature ÷ the mass of water vapour required to make the same volume of air saturated with water vapour at the same temperature] × 100%.

***(28) On what basis and how will you determine whether air is saturated with vapour or not?**

Ans. Whether air is saturated with water vapour or not is determined on the basis of the extent of water vapour present in the air. If the relative humidity is 100%, air is saturated with water vapour. In that case, we can see formation of water droplets on the leaves of plants/grass.

If the relative humidity is less than 100%, air is not saturated with water vapour.

(29) What is the value of relative humidity at the dew point temperature?

Ans. At the dew point temperature, relative humidity is 100%.

(30) The mass of water vapour in air enclosed in a certain space is 60 g and the mass of water

vapour needed to saturate the same air with water vapour under the same conditions is 100 g. What is the corresponding % relative humidity?

Ans. Here, % relative humidity

$$= \left(\frac{60 \text{ g}}{100 \text{ g}}\right) \times 100\% = 60\%.$$

(31) During winter, sometimes we see a white trail at the back of a flying aeroplane in a clear sky. Explain why.

Ans. In winter, air temperature is low. Hence, when an aeroplane flies, the vapour released by its engine condenses and forms white clouds. If the relative humidity of the air surrounding the plane is high, we see this white trail at the back of the plane for a long time before it disappears. If the relative humidity is low, the white trail is short and disappears quickly. If the relative humidity is very low, there is no formation of the white trail.

(32) State two effects of humidity present in atmosphere.

Ans. Effects of humidity present in atmosphere : When the temperature of air falls below the dew point, dew and fog are formed.

(33) Explain how dew and fog are formed. *OR*

Write a short note on formation of dew and fog.

Ans. At a particular temperature, a given volume of air can contain a certain maximum amount of water vapour. Normally, the temperature of air during the day is such that air is not saturated with water vapour present in it.

As the temperature falls, the capacity of air to hold water vapour becomes less. During a cold night, the temperature of air may fall to the dew point, or even below the dew point. If the temperature falls below the dew point, the excess of water vapour in air condenses on the surfaces of cold bodies and dew is formed. If the water vapour condenses on the fine dust particles present in the atmosphere, mist or fog is formed.

***(34) Explain the following : How can you relate the formation of water droplets on the outer surface of a bottle taken out of a refrigerator with formation of dew?**

Ans. At a given temperature, there is a limit on how much water vapour the given volume of air can hold. The lower the temperature, the lower is the capacity of air to hold water vapour.

The temperature of a bottle kept in a refrigerator is lower than room temperature. Hence, when the bottle is taken out of the refrigerator, the temperature of the air surrounding the bottle is lowered. Therefore, the capacity of the air to hold water vapour becomes less. Hence, the excess water vapour condenses to form water droplets (like dew) on the outer surface of the bottle.

(35) State the units of heat.

Ans. Units of heat : joule, erg, calorie, kilocalorie.

(36) Define the kilocalorie.

Ans. The amount of heat necessary to raise the temperature of 1 kg of water by 1 °C from 14.5 °C to 15.5 °C is called one kilocalorie.

(37) Define the calorie.

Ans. The amount of heat necessary to raise the temperature of 1 g of water by 1 °C from 14.5 °C to 15.5 °C is called one calorie.

(38) State the relation between the kilocalorie and the calorie.

Ans. 1 kilocalorie = 10^3 calories.

***(39) While deciding the unit for heat, which temperature interval is chosen? Why?**

Ans. While deciding the unit for heat, the temperature interval chosen is 14.5 °C to 15.5 °C. *For the reason, see the information given in the following box.*

• Always remember (Textbook page 67)

If we heat 1 kg of water by 1 °C in a different temperature range than 14.5 °C to 15.5 °C, the amount of heat required is slightly different. It is, therefore, essential to define a specific temperature range while defining the unit of heat.

*(40) **What is meant by specific heat capacity?**

OR **Define specific heat capacity.**

(1 mark) (Nov. '20)

How will you prove experimentally that different substances have different specific heat capacities?

Ans. The amount of heat energy required to raise the temperature of a unit mass of an object by 1 °C is called the specific heat capacity of that object.

For the experiment see the following box.

• Try this (Textbook page 68)

Material : A tray with thick layer of wax, solid spheres of iron, lead and copper of equal mass, burner or spirit lamp, large beaker.

Procedure :

(1) Take three spheres of iron, copper and lead of equal mass (Fig. 5.9).

(2) Put all the three spheres in boiling water in the beaker for some time.

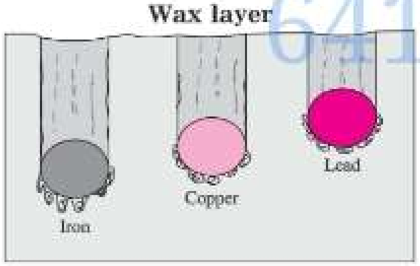


Fig. 5.9 : Specific heat capacity of metals

(3) Take the three spheres out of the water. All the spheres will be at temperature 100 °C. Put them immediately on the thick slab of wax.

(4) Note, the depth that each of the sphere goes into the wax.

The sphere which absorbs more heat from the water will give more heat to wax. More wax will thus melt and the sphere will go deeper in the wax. It can be observed that the iron sphere goes deepest into the wax. Lead sphere goes the least and copper sphere goes to intermediate depth. This shows that for equal rise in temperature, the three spheres have absorbed different amounts of heat. This means that the property which determines the amount of heat absorbed by a sphere is different for the three spheres. This property is called the specific heat capacity.

[**Note :** This experiment shows that the specific heat capacity of iron > that of copper > that of lead]

(41) Study the following procedure and answer the questions below :

1. Take 3 spheres of iron, copper and lead of equal mass.
2. Put all the 3 spheres in boiling water in a beaker for some time.
3. Take 3 spheres out of the water. Put them immediately on a thick slab of wax.
4. Note the depth that each sphere goes into the wax.

(i) Which property of a substance can be studied with this procedure?

(ii) Describe that property in minimum words.

(iii) Explain the rule of heat exchange with this property.

Ans. (i) Specific heat.

(ii) Specific heat : The amount of heat energy required to raise the temperature of a unit mass of an object by 1 °C.

(iii) According to the rule/principle of heat exchange, heat energy lost by the hot object = heat energy gained by the cold object.

In this activity, heat absorbed by the iron sphere is transmitted more in the wax, hence the sphere goes deepest into the wax, while the lead sphere absorbs less heat, resulting in less transmission of heat in the wax, hence the sphere goes the least depth into the wax.

(42) Write the symbol for specific heat capacity. State the units of specific heat capacity.

OR **State the SI unit of specific heat capacity.**

(1 mark) (Nov. '20)

Ans. Symbol for specific heat capacity : *c*.

Units of specific heat capacity : J / kg·K (SI unit), J / kg·°C, erg / g·°C, cal / g·°C, kcal / kg·°C.

[**Notes :** (1) Specific heat capacity

$$= \frac{\text{heat absorbed by an object}}{\text{mass of the object} \times \text{rise in temperature of the object}}$$

∴ Unit of specific heat capacity

$$= \frac{\text{unit of heat}}{\text{unit of mass} \times \text{unit of temperature}}$$

In SI, heat is expressed in joule (J), mass in kg and temperature in kelvin (K).

∴ SI unit of specific heat capacity $= \frac{J}{kg \cdot K}$. (2) The specific heat capacity of a substance depends upon its constituent particles (atoms, molecules, etc.), interaction between them, structure of the substance (atomic / molecular arrangement), temperature of the substance, etc.]

***(43) Which principle is used to measure the specific heat capacity of a substance?**

Ans. The principle of heat exchange is used to measure the specific heat capacity of a substance. This principle is as follows : If a system of two objects is isolated from the environment by keeping it inside a heat resistant box, then no energy can leave the box or enter the box. In this situation, heat energy lost by the hot object = heat energy gained by the cold object.

(44) Explain the principle of heat exchange.

Ans. Suppose two objects A and B at different temperature T_1 and T_2 respectively are enclosed in a box of heat resistant material as shown in Fig. 5.10.

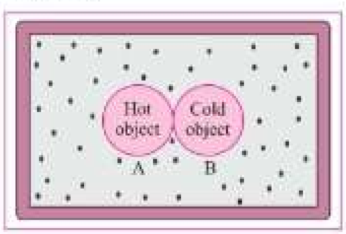


Fig. 5.10 : Box of a heat resistant material

Let m_1 = mass of A, m_2 = mass of B, c_1 = specific heat capacity of A, c_2 = specific heat capacity of B and T = common temperature attained by A and B after the heat exchange between A and B. Here, no heat leaves the box or enters the box from outside. Hence, if $T_1 > T_2$, heat energy lost by A (Q_1) = heat energy gained by B (Q_2).

$$\therefore \; m_1 c_1 (T_1 - T) = m_2 c_2 (T - T_2)$$

[**Note :** If m_1, c_1, T_1, T, m_2 and T_2 are known, c_2 can be determined.]

(45) The specific heat capacity of silver is 0.056 kcal / kg·°C. Explain this statement.

Ans. The amount of heat needed to raise the temperature of 1 kg of silver by 1 °C is 0.056 kcal.

(46) Explain how the specific heat capacity of a solid can be determined (measured) by the method of mixture.

Ans. A hot solid is put in water in a calorimeter. The mixture is stirred continuously and the maximum temperature of the mixture is measured with a thermometer. Heat exchange between the hot solid, water and calorimeter results in all bodies attaining the same temperature after some time. Hence, according to the principle of heat exchange, heat lost by the solid = heat gained by the water in the calorimeter + heat gained by the calorimeter. Now, heat lost by the solid (Q) = mass of the solid × its specific heat capacity × decrease in its temperature, heat gained by the water (Q_1) = mass of the water × its specific heat capacity × increase in its temperature and heat gained by the calorimeter (Q_2) = mass of the calorimeter × its specific heat capacity × increase in its temperature.

Heat lost by the hot object = heat gained by the calorimeter + heat gained by the water. $Q = Q_2 + Q_1$

Using this equation, the specific heat capacity of the solid can be determined (measured) when the other quantities are known.

Q. 7 Give scientific reasons :

(1) Even though heat is supplied to boiling water, there is no increase in its temperature.

Ans. Once water starts boiling, all the heat supplied to it is used in conversion of water into steam at the boiling point of water. Hence, there is no rise in its temperature.

(2) Burns from steam are worse those from boiling water at the same temperature.

Ans. (1) A given quantity of steam contains more heat than the same quantity of boiling water at the same temperature. (2) When steam comes in contact with one's body, it releases extra heat of

540 calories per gram and causes a more serious burn than that caused by boiling water.

(3) In winter, the pipelines carrying water burst in cold countries.

Ans. (1) In cold countries, in winter, the temperature of the atmosphere falls below 0 °C. When the temperature of water falls below 4 °C, it expands. Hence, the water in pipes expands. Even if ice is formed, there is an increase in the volume. (2) As there is no room for expansion, water (or ice) exerts a large pressure on the pipes. Hence, the pipelines carrying water burst.

(4) If crushed ice is pressed and then the pressure is released, a lump of ice is formed.

Ans. (1) When crushed ice is pressed, its melting point is lowered and some ice melts to form water. (2) When pressure is released, the melting point becomes normal and the water freezes to form ice forming a lump.

(5) In cold countries, in winter, even when the water of lakes freezes, aquatic animals and plants can survive.

Ans. (1) In cold countries, in winter, a layer of ice is formed on the surface of lakes when the atmospheric temperature falls below 0 °C. However, below this layer, there is water at 4 °C. (2) Ice, being a bad conductor of heat, does not allow transfer of heat from this water to the atmosphere. Hence, aquatic animals and plants can survive in this water.

(6) Water droplets are seen on the outer surface of a cold drink bottle.

Ans. (1) The temperature of the outer surface of a cold drink bottle is less than that of the atmosphere. (2) Therefore, the excess of water vapour from the air condenses to form droplets on the outer surface of the cold drink bottle.

(7) During cold nights, sometimes dew is formed.

Ans. (1) During a cold night, the temperature of air may fall to the dew point, or even below the dew point. (2) If the temperature falls below the dew point, the excess of water vapour in air condenses on the surfaces of cold bodies and dew is formed.

(8) When you enter a warm room after being outside on a frosty early morning, your spectacles 'steam up'.

Ans. (1) On a frosty early morning, the temperature of air outside a warm room is lower than the dew point. (2) Hence, when you enter the room from outside, some water vapour in the room condenses on the glass of your spectacles, i.e., the spectacles 'steam up'.

(9) A plastic bottle, completely filled with water, when kept in a freezer, is likely to break.

Ans. (1) The temperature of air in the freezer (deepfreeze) compartment of a refrigerator is less than 0 °C. (2) When a plastic bottle, completely filled with water, is kept in this compartment, the temperature of water falls below 4 °C and the water expands. Even when water freezes and ice is formed, there is an increase in the volume. It exerts a large pressure on the sides of the bottle and hence the bottle is likely to break.

(10) The outer surface of a beaker containing ice cubes becomes wet in a short while.

Ans. (1) When ice cubes are placed in a beaker, ice starts melting. The heat required for melting is absorbed from the surrounding air and also from the beaker to some extent. Hence, the temperature of the air and beaker falls. (2) The capacity of air to hold water vapour depends upon the temperature of the air, and this capacity decreases as the temperature decreases. At a certain low temperature, the surrounding air becomes saturated with water vapour present in it. As the temperature falls further, the air is unable to hold all the water vapour. Hence, the extra water vapour starts condensing on the cold outer surface of the beaker in the form of minute drops. Therefore, the outer surface of the beaker containing ice cubes becomes wet in a short while.

*Q. 8 **Read the following paragraph and answer the questions :** ***(5 marks)***
(Board's Model Activity Sheet)

If heat is exchanged between a hot and cold object, the temperature of the cold object goes on increasing due to gain of energy and the temperature of the hot object goes on decreasing due to loss of energy.

The change in temperature continues till the temperatures of both the objects attain the same value. In this process, the cold object gains heat energy and the hot object loses heat energy. If the system of both the objects is isolated from the environment by keeping it inside a heat resistant box (meaning that the energy exchange takes place between the two objects only), then no energy can flow from inside the box or come into the box.

(1) Heat is transferred from where to where?

(2) Which principle do we learn about from this process?

(3) How will you state the principle briefly?

(4) Which property of the substance is measured using this principle?

Ans. (1) Heat is transferred from a hot object to a cold object.

(2) This process shows the principle of heat exchange.

(3) In this process, the cold object gains heat energy and the hot object loses energy. If a system of two objects is isolated from the surroundings, heat energy lost by the hot object = heat energy gained by the cold object.

(4) This principle is used to measure the specific heat capacity of a substance.

Q. 9 **Solve the following examples/ numerical problems :**

[Use the data given in the Tables on pages 129 and 130.]

(1) Calculate the amount of heat required to convert 5 g of ice of 0 °C into water at 0 °C. (Specific latent heat of fusion of ice = 80 cal/g)

Solution : Here, $m = 5$ g, $L = 80$ cal/g; $Q = ?$

Amount of heat required, $Q = mL$

$= 5 \text{ g} \times 80 \text{ cal/g}$

$=$ **400 calories.**

(2) Find the amount of heat required to convert 10 g of water at 100 °C into steam. (Specific latent heat of vaporization of water = 540 cal/g)

Solution : Here, $m = 10$ g, $L = 540$ cal/g; $Q = ?$

Amount of heat required, $Q = mL$

$= 10 \text{ g} \times 540 \text{ cal/g}$

$=$ **5400 calories.**

(3) Calculate the amount of heat required to convert 15 g of water at 100 °C into steam. (Specific latent heat of vaporization of water = 540 cal/g)

Solution : $m = 15$ g, $L = 540$ cal/g; $Q = ?$

Amount of heat required, $Q = mL$

$= 15 \text{ g} \times 540 \text{ cal/g}$

$=$ **8100 calories.**

(4) How many calories of heat will be absorbed when 3 kg of ice at 0 °C melts?

Solution : $m = 3 \text{ kg} = 3000$ g; $L = 80$ cal/g; $Q = ?$

Quantity of heat absorbed, $Q = mL$

$= 3000 \text{ g} \times 80 \text{ cal/g}$

$\therefore Q =$ **240000 calories.**

(5) Calculate the amount of heat required to convert 10 g of water at 30 °C into steam at 100 °C. (Specific latent heat of vaporization of water = 540 cal/g)

Solution : Here, $m = 10$ g; $c = 1$ cal/g·°C

$T_2 - T_1 = 100 \text{ °C} - 30 \text{ °C} = 70 \text{ °C}$;

$L = 540$ cal/g; $Q = ?$

Amount of heat required, $Q = mc\,(T_2 - T_1) + mL$

$= 10 \text{ g} \times 1 \text{ cal/g·°C} \times 70 \text{ °C} + 10 \text{ g} \times 540 \text{ cal/g}$

$= 700 \text{ cal} + 5400 \text{ cal}$

$\therefore Q =$ **6100 calories.**

(6) If water of mass 80 g and temperature 45 °C is mixed with water of mass 20 g and temperature 30 °C, what will be the maximum temperature of the mixture?

Solution : Data : $m_1 = 80$ g, $T_1 = 45$ °C, $m_2 = 20$ g, $T_2 = 30$ °C, $T = ?$

According to the principle of heat exchange, heat lost by hot water = heat gained by cold water

$\therefore\ m_1 c (T_1 - T) = m_2 c (T - T_2)$

$\therefore\ m_1 T_1 - m_1 T = m_2 T - m_2 T_2$

$\therefore\ m_1 T_1 + m_2 T_2 = (m_1 + m_2) T$

$\therefore$ Maximum temperature of the mixture,

$$T = \frac{m_1 T_1 + m_2 T_2}{m_1 + m_2}$$

$$= \frac{80\text{ g} \times 45\text{ °C} + 20\text{ g} \times 30\text{ °C}}{80\text{ g} + 20\text{ g}}$$

$$= \left(\frac{80 \times 45}{100} + \frac{20 \times 30}{100}\right)\text{ °C}$$

$$= (36 + 6)\text{ °C}$$

$$= \mathbf{42\text{°C}}.$$

(7) When water of mass 70 g and temperature 50 °C is added to water of mass 30 g, the maximum temperature of the mixture is found to be 41 °C. Find the temperature of water of mass 30 g before hot water was added to it.

Solution : Data : $m_1 = 70$ g, $T_1 = 50$ °C, $m_2 = 30$ g, $T = 41$ °C, $T_2 = ?$

According to the principle of heat exchange, heat lost by hot water = heat gained by cold water

$\therefore\ m_1 c (T_1 - T) = m_2 c (T - T_2)$

$\therefore\ m_1 T_1 - m_1 T = m_2 T - m_2 T_2$

$\therefore\ m_2 T_2 = (m_1 + m_2)\ T - m_1 T_1$

$$\therefore\ T_2 = \frac{(m_1 + m_2)\ T - m_1 T_1}{m_2}$$

$$= \frac{(70\text{ g} + 30\text{ g})\ 41\text{ °C} - 70\text{ g} \times 50\text{ °C}}{30\text{ g}}$$

$$= \left(\frac{100 \times 41 - 70 \times 50}{30}\right)\text{ °C}$$

$$= \left(\frac{410 - 350}{3}\right)\text{ °C}$$

$$= \frac{60}{3}\text{ °C}$$

$$= \mathbf{20\text{ °C}}$$

This is the required temperature.

(8) Find the heat needed to raise the temperature of a silver container of mass 100 g by 10 °C. ($c = 0.056$ cal/g·°C)

Solution : Data : $m = 100$ g, $\Delta T = 10$ °C, $c = 0.056$ cal/g·°C

Heat needed to raise the temperature of the container $= mc\Delta T$

$= 100\text{ g} \times 0.056\text{ cal/g·°C} \times 10\text{ °C} =$ **56 calories.**

(9) How much heat energy is necessary to raise the temperature of 5 kg of water from 20 °C to 100 °C? ***(2 marks) (March '20)***

Solution : Data : $m = 5$ kg, $\Delta T = 100\text{ °C} - 20\text{ °C} = 80$ °C, $c = 1$ kcal/kg·°C

Heat energy necessary to raise the temperature of water $= mc\Delta T$

$= 5 \times 1 \times 80$

$=$ **400 kcal.**

***(10) Liquid ammonia is used in ice factory for making ice from water. If water at 20 °C is to be converted into 2 kg ice at 0 °C, how many grams of ammonia are to be evaporated?**

(Given : The latent heat of vaporization of ammonia = 341 cal/g)

Solution : Data : $m_1 = 2$ kg, $\Delta T_1 = 20\text{ °C} - 0\text{ °C} = 20$ °C, $c_1 = 1$ kcal/kg·°C, L_1 (ice) $= 80$ kcal/kg, L_2 (vaporization of ammonia) $= 341$ cal/g $= 341$ kcal/kg, $m_2 = ?$

Q_1 (heat lost by water) $= m_1 c_1 \Delta T_1 + m_1 L_1$

$= 2\text{ kg} \times 1\text{ kcal/kg·°C} \times 20\text{ °C} + 2\text{ kg} \times 80\text{ kcal/kg}$

$= 40\text{ kcal} + 160\text{ kcal} = 200\text{ kcal}$

Q_2 (heat absorbed by ammonia) $= m_2 L_2$

$= m_2 \times 341$ kcal/kg

According to the principle of heat exchange, $Q_1 = Q_2$

$\therefore\ 200\text{ kcal} = m_2 \times 341\text{ kcal/kg}$

$\therefore\ m_2 = \frac{200}{341}\text{ kg} = 0.5864\text{ kg} = 586.4\text{ g}$

586.4 g of ammonia are to be evaporated.

***(11) A thermally insulated pot has 150 g ice at temperature 0 °C. How much steam of 100 °C has to be mixed to it, so that water of temperature 50 °C will be obtained?**

(Given : Latent heat of melting of ice = 80 cal / g, latent heat of vaporization of water = 540 cal / g, specific heat of water = 1 cal / g·°C)

Solution : Data : $m_1 = 150$ g,

$\Delta T_1 = 50\ °C - 0\ °C = 50\ °C$, $c_w = 1$ cal/g·°C,

$L_1 = 80$ cal/g, $L_2 = 540$ cal/g,

$\Delta T_2 = 100\ °C - 50\ °C = 50\ °C$, $m_2 = ?$

Q_1 (heat absorbed by ice) $= m_1 L_1$

$= 150 \text{ g} \times 80 \text{ cal/g} = 12000$ cal

Q_2 (heat absorbed by water formed on melting of ice) $= m_1\, c_w\, \Delta T_1$

$= 150 \text{ g} \times 1 \text{ cal/g·°C} \times 50\ °C = 7500$ cal

Q_3 (heat given out by steam) $= m_2 L_2$

$= m_2 \times 540$ cal/g

Q_4 (heat given out by water formed on condensation of steam)

$= m_2\, c_w\, \Delta T_2 = m_2 \times 1 \text{ cal/g·°C} \times 50\ °C$

According to the principle of heat exchange,

$Q_1 + Q_2 = Q_3 + Q_4$

$\therefore 12000 \text{ cal} + 7500 \text{ cal} = m_2 \times 540 \text{ cal/g} + m_2 \times 50$ cal/g

$\therefore 19500 \text{ cal} = m_2 (540 + 50)$ cal/g

$\therefore m_2 = \frac{19500}{590} \text{ g} = 33.05$ g

33.05 g of steam is to be mixed.

***(12) Equal heat is given to two objects A and B of mass 1 g. Temperature of A increases by 3 °C and B by 5°C. Which object has more specific heat? And by what factor?**

Solution : Data : $m = 1$ g, $\Delta T_1 = 3\ °C$, $\Delta T_2 = 5\ °C$, Q same

Here, $Q = mc_1 \Delta T_1 = mc_2 \Delta T_2$

$\therefore \frac{c_1}{c_2} = \frac{\Delta T_2}{\Delta T_1} = \frac{5\ °C}{3\ °C} = \frac{5}{3}$

Thus, $c_1 > c_2$

The specific heat of A is more than that of B and $\frac{\text{specific heat of A}}{\text{specific heat of B}} = \frac{5}{3}$.

***(13) A calorimeter has mass 100 g and specific heat 0.1 kcal / kg·°C. It contains 250 g of liquid at 30 °C having specific heat of 0.4 kcal / kg·°C. If we drop a piece of ice of mass 10 g at 0 °C into the liquid, what will be the temperature of the mixture?**

Solution : Data : $m_1 = 100$ g, $c_1 = 0.1$ kcal/kg·°C, $= 0.1$ cal / g·°C, $T_1 = 30\ °C$, $m_2 = 250$ g,

$c_2 = 0.4$ kcal/kg·°C $= 0.4$ cal / g·°C, $T_2 = 30\ °C$,

$m_3 = 10$ g, $T_3 = 0\ °C$, $L = 80$ cal/g,

c (water) $= 1$ cal / g·°C, $T = ?$

Q_1 (heat lost by calorimeter) $= m_1 c_1 (T - T_1)$,

Q_2 (heat lost by liquid) $= m_2 c_2 (T - T_2)$,

Q_3 (heat absorbed by ice) $= m_3 L$,

Q_4 (heat absorbed by water formed on melting of ice)

$m_3 c\ (T - 0\ °C)$

According to the principle of heat exchange,

$Q_1 + Q_2 = Q_3 + Q_4$

$\therefore m_1\ c_1\ (T_1 - T) + m_2\ c_2\ (T_2 - T) = m_3\ L + m_3 c\ (T - 0\ °C)$

$\therefore m_1\, c_1 T_1 - m_1 c_1 T + m_2\, c_2 T_2 - m_2 c_2 T = m_3\, L + m_3 c\ (T - 0\ °C)$

$\therefore m_1 c_1 T_1 + m_2\, c_2 T_2 = m_3\, L + (\, m_1\, c_1 + m_2\, c_2 + m_3\, c)\ T$

$\therefore 100 \text{ g} \times 0.1 \text{ cal/g·°C} \times 30\ °C + 250 \text{ g} \times 0.4 \text{ cal / g·°C} \times 30\ °C$

$= 10 \text{ g} \times 80 \text{ cal / g} + (100 \text{ g} \times 0.1 \text{ cal / g·°C} + 250 \text{ g} \times 0.4 \text{ cal / g·°C} + 10 \text{ g} \times 1 \text{ cal / g·°C})\ T$

$\therefore (10 + 100 + 10)\ T = (300 + 3000 - 800)°C$

$\therefore 120\ T = 2500\ °C$

$\therefore T = \frac{2500}{120}\ °C = \frac{125}{6}\ °C = \mathbf{20.83\ °C}$

This is the temperature of the mixture.

---

(14) A copper sphere of 100 g mass is heated to raise its temperature to 100 °C and is released in water of mass 195 g and temperature 20 °C in a copper calorimeter. If the mass of the calorimeter is 50 g, what will be the maximum temperature of water? (Specific heat of copper = 0.1 cal / g·°C. ***(3 marks) (Nov. '20)***

Solution : Data : $m_1 = 100$ g, $c_1 = 0.1$ cal / g·°C, $T_1 = 100\ °C$, $m_2 = 195$ g, $c_2 = 1$ cal / g·°C, $T_2 = 20\ °C$, $m_3 = 50$ g, $c_3 = 0.1$ cal / g·°C, $T_3 = 20\ °C$, $T = ?$

Heat lost by the copper sphere,

$Q_1 = m_1\, c_1\, (T_1 - T) = 100 \times 0.1 \times (100 - T)$

Heat absorbed by the water,

$Q_2 = m_2 c_2 (T - T_2) = 195 \times 1 \times (T - 20)$

Heat absorbed by the calorimeter,

$Q_3 = m_3 c_3 (T - T_3) = 50 \times 0.1 \times (T - 20)$

Now, $Q_1 = Q_2 + Q_3$

$\therefore\ 1000 - 10\ T = 195\ T - 195 \times 20 + 5T - 100$

$\therefore\ 210\ T = 1000 + 3900 + 100 = 5000$

$\therefore\ T = \frac{5000}{210} = \frac{500}{21}$

$= \mathbf{23.8\ °C}$

This is the maximum temperature of Water.

(15) If steam of mass 100 g and temperature 100 °C is released on an ice slab of temperature 0 °C, how much ice will melt?

Solution : Data : $m_1 = 100$ g, $L_1 = 540$ cal/g, $T_1 = 100$ °C, mass of ice, $m = ?$, $L_2 = 80$ cal/g, c (water) = 1 cal/g·°C

According to the principle of heat exchange, heat lost by hot body = heat gained by cold body.

Conversion of steam into water :

$Q_1 = m_1 L_1 = 100\ \text{g} \times 540\ \text{cal/g} = 54000\ \text{cal}$

Decrease in the temperature of this water to 0 °C :

$Q_2 = m_1 c \times (T_1 - 0\ °C) = 100\ \text{g} \times 1\ \text{cal/g·°C} \times (100\ °C - 0\ °C) = 10000\ \text{cal}$

Melting of ice : $Q_3 = mL_2$

$= m \times 80$ cal/g

Now, $Q_1 + Q_2 = Q_3$

$\therefore\ (54000 + 10000)\ \text{cal} = m \times 80\ \text{cal/g}$

$\therefore\ m = \frac{64000}{80}\ \text{g} = 800\ \text{g}$

800 g of ice will melt.

NUMERICAL PROBLEMS FOR PRACTICE

1. Calculate the amount of heat required to convert 80 g of ice at 0 °C into water at the same temperature. (Specific latent heat of fusion of ice = 80 cal/g) (**Ans.** 6400 cal)
2. Find the heat required to convert 20 g of ice at 0 °C into water at the same temperature. (Specific latent heat of fusion of ice = 80 cal/g) (**Ans.** 1600 cal)
3. Calculate the quantity of heat released during the conversion of 10 g of ice cold water (temperature 0 °C) into ice at the same temperature. (Specific latent heat of freezing of water = 80 cal/g) (**Ans.** 800 cal)
4. How many calories of heat will be absorbed when 2 kg of ice at 0 °C melts? (Specific latent heat of fusion of ice = 80 cal/g) (**Ans.** 160000 cal)
5. How much heat will be required to convert 20 g of water at 100 °C into steam at 100 °C? (Specific latent heat of vaporization of water = 540 cal/g) (**Ans.** 10800 cal)
6. Find the heat absorbed by 25 g of water at 100 °C to convert into steam at the same temperature. (Specific latent heat of vaporization of water = 540 cal/g.) (**Ans.** 13500 cal)
7. If water of mass 60 g and temperature 50 °C is mixed with water of mass 40 g and temperature 30 °C, what will be the maximum temperature of the mixture? (**Ans.** 42 °C)
8. If water of mass 60 g and temperature 60 °C is mixed with water of mass 60 g and temperature 40 °C, what will be the maximum temperature of the mixture? (**Ans.** 50 °C)
9. Find the heat needed to raise the temperature of a piece of iron of mass 500 g by 20 °C. ($c = 0.110$ cal/g·°C) (**Ans.** 1100 cal)
10. Water of mass 200 g and temperature 30 °C is taken in a copper calorimeter of mass 50 g and temperature 30 °C. A copper sphere of mass 100 g and temperature 100 °C is released into it. What will be the maximum temperature of the mixture? [c (water) = 1 cal/g·°C, c (copper) = 0.1 cal/g·°C] (**Ans.** 33.26 °C)
11. A copper calorimeter of mass 100 g and temperature 30 °C contains water of mass 200 g and temperature 30 °C. If a piece of ice of mass 40 g and temperature 0 °C is added to it, what will be the maximum temperature of the mixture? [c (copper) = 0.1 cal/g·°C, c (water) = 1 cal/g·°C, $L = 80$ cal/g] (**Ans.** 12.4°C)
12. *See the solved Ex. (15).* If the mass of steam is 50 g, how much ice will melt? (**Ans.** 400 g)

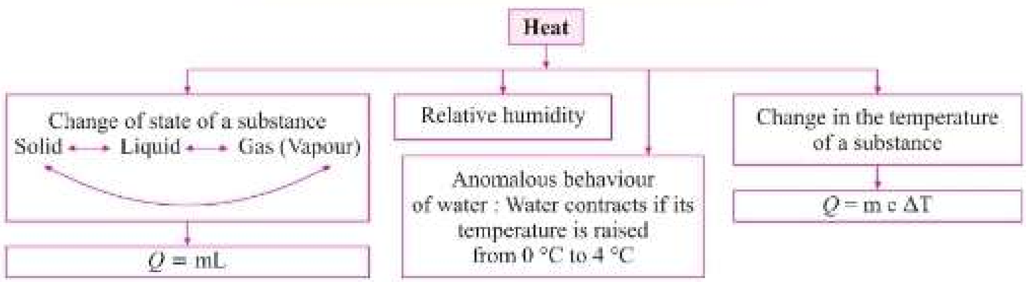
PROJECT

* Take help of your teachers to make a working model of Hope's apparatus and perform the experiment. Verify the results you obtain.

Books are My Friends : Read for more information (Textbook page 71)

1. A Textbook of Heat – J.B. Rajam 2. Heat – V.N. Kelkar 3. A Treatise on Heat – Saha and Srivastava.

MEMORY MAP/CONCEPT MAP



$$\% \text{ Relative humidity} = \frac{\text{actual mass of water vapour content in a given volume of air at a given temperature}}{\text{mass of water vapour needed to make air of the same volume saturated at the same temperature}} \times 100\%$$

Did you study the lesson/chapter from the **Navneet Digest**? Now, solve the self-test to ensure solid learning. Scan this **QR Code** for the test and its model answers.

6 REFRACTION OF LIGHT

CHAPTER OUTLINE

IMPORTANT POINTS

• Can you recall? (Textbook page 73)

(1) What is meant by reflection of light?

Ans. Reflection of light : When light is incident on the surface of an object, in general, it is deflected in different directions. This process is called reflection of light.

(2) What are the laws of reflection?

Ans. Laws of reflection of light : (1) The incident ray and the reflected ray of light are on the opposite sides of the normal to the reflecting surface at the point of incidence and all the three are in the same plane. (2) The angle of incidence and the angle of reflection are equal in measure.

6.1 Refraction of light :

- **Refraction of light :** The change in the direction of propagation of light as it passes obliquely from one transparent medium to another is called refraction of light. Refraction occurs as the velocity of light is different in different media.

• Use your brain power! (Textbook page 74)

(1) Will light travel through a glass slab with the same velocity as it travels in air?

Ans. No.

(2) Will the velocity of light be same in all media?

Ans. No. [This is due to the interaction between light and particles of the medium (atoms, molecules, etc.)]

6.2 Laws of refraction :

- **Laws of refraction of light :**

(1) The incident ray and the refracted ray are on the opposite sides of the normal to the surface at the point of incidence and all the three, i.e., the incident ray, the refracted ray and the normal are in the same plane.

(2) For a given pair of media, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant (Snell's law). This constant is called the refractive index of the second medium with respect to the first medium.

[**Note** : Here, a ray means a ray of light.]

6.3 Refractive index :

1. **Refractive index :** If i is the angle of incidence and r is the angle of refraction, then

$$\frac{\sin i}{\sin r} = \text{constant (Snell's law).}$$

This constant is called the refractive index of the second medium with respect to the first medium, and is denoted by ${}_2n_1$. Thus, ${}_2n_1 = \frac{\sin i}{\sin r}$.

Also, if v_1 is the magnitude of the velocity of light in the first medium and v_2 is the magnitude of the velocity of light in the second medium, then

$${}_2n_1 = \frac{v_1}{v_2}$$

Similarly, the refractive index of the first medium with respect to the second medium is given by

$${}_1n_2 = \frac{v_2}{v_1}$$

If the first medium is vacuum, ${}_2n_1$ is considered with respect to vacuum. It is called the absolute refractive index of the medium 2 and is denoted by n.

The refractive index of a medium depends upon the magnitude of the velocity of light in the medium.

[**Note :** The absolute refractive index of air is 1·003. This shows that for almost all practice purposes, the speed of light in air is very nearly the same as that in vacuum.]

2. **Behaviour of a ray of light in refraction :** When a ray of light passes obliquely from an optically rarer medium (medium of lower refractive index) to an optically denser medium (medium of higher refractive index), it bends towards the normal at the point of incidence. Here, i is greater than r, and ${}_2n_1$ is greater than 1. The greater the value of ${}_2n_1$, the greater is the bending towards the normal.

   When a ray of light passes obliquely from an optically denser medium to an optically rarer medium, it bends away from the normal at the point of incidence. Here, r is greater than i, and ${}_2n_1$ is less than 1. The greater the value of ${}_2n_1$, the less is the bending away from the normal.

   If a ray of light is incident normal to the interface between any two media (whether passing from an optically rarer medium to an optically denser medium or from an optically denser medium to an optically rarer medium), the angle of incidence is zero and so also the angle of refraction. Here, the light goes ahead in the same direction.

(Textbook page 74)

$$\frac{\sin i}{\sin r} = \text{constant} = n$$

n is called the refractive index of the second medium with respect to the first medium. This second law is also called Snell's law. A ray incident along the normal ($i = 0$) goes forward in the same direction ($r = 0$).

Absolute refractive indices of some media (Textbook page 75)

Substance	Refractive index
Air	1.0003
Ice	1.31
Water	1.33
Alcohol	1.36
Kerosene	1.39
Fused quartz	1.46
Turpentine oil	1.47
Benzene	1.50
Crown glass	1.52
Rock salt	1.54
Carbon disulphide	1.63
Dense flint glass	1.66
Ruby	1.76
Sapphire	1.76
Diamond	2.42

3. **Local atmospheric conditions affect refraction of light :** e.g., mirage, objects beyond and above a holi fire appear to be shaking.

4. **Twinkling of a star and atmospheric refraction :** As a star is far away from the earth, it appears as a point source of light. When starlight enters the earth's atmosphere, it undergoes refraction continuously in the medium with gradually varying refractive index. The bending of starlight occurs towards the normal as it passes from the optically rarer part of the medium to the optically denser part. Hence, when a star is observed near the horizon, its apparent position is slightly higher than the actual position. Further, the apparent position varies with time as the medium is not stationary. Also, there is fluctuation in the brightness of a star when observed from the earth. This is called twinkling of a star.

The planets are relatively closer to the earth. Hence they appear as a collection of a large number of point sources of light. The net fluctuation in the brightness of a planet, therefore, turns out to be zero. Also, there is no change in the average position of a planet. Hence, planets do not twinkle.

The advanced sunrise and delayed sunset are also the result of atmospheric refraction.

6.4 Dispersion of light :

1. **Dispersion of light :** The process of separation of light into its component colours while passing through a medium is called dispersion of light. The band of coloured components of a light beam is called its spectrum. The formation of a rainbow is due to refraction, dispersion, internal reflection and again refraction of sunlight by water droplets under appropriate conditions. Our eyes are sensitive to electromagnetic radiation of wavelength in the range 400 nm to 700 nm. [$1 \text{ nm} = 10^{-9}$ m; nm = nanometer] The wavelength of red light is close to 700 nm and that of violet light is close to 400 nm.
2. **Partial and total internal reflection :** When light travels from one medium to another, part of incident light comes back into the first medium. This is called partial reflection. Remaining part is refracted.

When light travels obliquely from a denser medium to a rarer medium, the angle of refraction r is greater than the angle of incidence i. Also, the ratio $\sin i / \sin r$ is constant. For a particular value of i, r becomes 90°. This particular angle of incidence is called critical angle. For $i >$ critical angle, as r cannot be greater than 90°, light is totally reflected in the denser medium. This is called total internal reflection. Here, ${}_2n_1 = \frac{\sin i}{\sin 90°} = \sin i$, where i is the critical angle.

Additional Important Information

In vacuum, the speed of light does not depend on the frequency of light. But in a material medium, it is not so. Hence, the refractive index of glass (n) is different for different colours (different frequencies). It is maximum for violet colour and minimum for red colour. n (violet) > n (indigo) > n (blue) > n (green) > n (yellow) > n (orange) > n (red).

QUESTIONS & ANSWERS

Q. 1 Fill in the blanks and rewrite the statements :

(1) The phenomenon of change in the .... of light when it passes obliquely from one transparent medium to another is called refraction.

(2) The refractive index depends upon the .... of propagation of light in different media.

(3) The process of separation of light into its component colours while passing through a medium is called ....

(4) When a light ray travels obliquely from air to water, it bends .... the normal at the point of incidence.

(5) When a light ray travels obliquely from benzene to air, it bends .... the normal at the point of incidence.

(6) In glass, the speed of red ray is .... violet ray.

(7) The speed of light in glass is .... in water.

(8) The speed of light in water is .... in benzene.

(9) Rainbow occurs due to refraction, dispersion, ... and again refraction of sunlight by water droplets.

(10) In dispersion of sunlight by a glass prism, ... ray is deviated the least.

Ans.

(1) The phenomenon of change in the direction of propagation of light when it passes obliquely from one transparent medium to another is called refraction.

(2) The refractive index depends upon the velocity of propagation of light in different media.

(3) The process of separation of light into its component colours while passing through a medium is called dispersion of light.

(4) When a light ray travels obliquely from air to water, it bends towards the normal at the point of incidence.

(5) When a light ray travels obliquely from benzene to air, it bends away from the normal at the point of incidence.

(6) In glass, the speed of red ray is greater than that of violet ray.

(7) The speed of light in glass is less than that in water.

(8) The speed of light in water is greater than that in benzene.

(9) Rainbow occurs due to refraction, dispersion, internal reflection and again refraction of sunlight by water droplets.

(10) In dispersion of sunlight by a glass prism, red ray is deviated the least.

***Q. 2 Fill in the blanks and explain the completed statements :**

(1) Refractive index depends on the .... of light.

(2) The change in .... of light rays while going from one medium to another is called refraction.

Ans.

(1) Refractive index depends on the velocity of light. It is an experimental fact. (There is no question of explanation.)

(2) The change in the direction of propagation of light rays while going from one medium to another is called refraction. This is definition of refraction. It is assumed that the ray of light passes obliquely from one medium to another. (There is no question of explanation.)

Q. 3 Choose the correct alternative and write it along with its allotted alphabet : *(1 mark each)*

(1) The change in the direction of propagation of light when it passes obliquely from one transparent medium to another is called ....

(a) dispersion *(b) scattering*

(c) refraction *(d) reflection*

(2) When a ray of light travels from air to glass slab and strikes the surface of separation at 90°, then it ....

(a) bends towards the normal

(b) bends away from the normal

(c) passes unbent

(d) passes in zigzag way

(3) If a ray of light passes from a denser medium to a rarer medium in a straight line, the angle of incidence must be ....

(a) 0° *(b) 30°* *(c) 60°* *(d) 90°*

(4) A ray of light strikes a glass slab at an angle of 50° with the normal to the surface of the slab. What is the angle of incidence?

(a) 50° (b) 25° (c) 40° (d) 100°

(5) If a ray of light propagating in air strikes a glass slab at an angle of 60° with the surface of the slab, the angle of refraction is ....

(a) more than 30° *(b) less than 30°*

(c) 60° *(d) 30°*

(6) A ray of light gets deviated when it passes obliquely from one medium to another medium because ....

(a) the colour of light changes

(b) the frequency of light changes

(c) the speed of light changes

(d) the intensity of light changes

(7) The speed of light in turpentine oil is 2×10^8 m/s. The absolute refractive index of turpentine oil is about .... [Speed of light in vacuum $\approx 3 \times 10^8$ m/s]

(a) 1.5 (b) 2 (c) 1.3 (d) 0.67

(8) Out of the following .... has the highest absolute refractive index.

(a) fused quartz (b) diamond

(c) crown glass (d) ruby

(9) The absolute refractive index ....

(a) is expressed in dioptre

(b) is expressed in m/s

(c) of air is about $\frac{4}{3}$

(d) has no unit

(10) The speed of light in a medium of refractive index n is ...., where c is the speed of light in vacuum.

(a) $\frac{c}{n}$ *(b)* nc *(c)* $\frac{n}{c}$ *(d)* $\sqrt{\frac{c}{n}}$

(11) The speed of light in a transparent medium having absolute refractive index 1.25 is .... [Speed of light in vacuum $\approx 3 \times 10^8$ m/s]

(a) 1.25×10^8 *m/s* *(b)* 2.4×10^8 *m/s*

(c) 3.0×10^8 *m/s* *(d)* 1.5×10^8 *m/s*

(12) .... light is deviated the maximum in the spectrum of white light obtained with a glass prism.

(a) Red (b) Yellow (c) Violet (d) Blue

(13) .... light is deviated the least in the spectrum of white light obtained with a glass prism.

(a) Red (b) Yellow (c) Violet (d) Blue

(14) A ray of light makes an angle of 50° with the surface S_1 of the glass slab. Its angle of incidence will be .... ***(March '19)***

(a) 50° (b) 40° (c) 140° (d) 0°

(15) A glass slab is placed in the path of convergent light. The point of convergence of light :

(a) moves away from the slab

(b) moves towards the slab

(c) remains at the same point

(d) undergoes a lateral shift

(16) In refraction of light through a glass slab, the directions of the incident ray and the refracted ray are ....

(a) perpendicular to each other

(b) non-parallel to each other

(c) parallel to each other

(d) intersecting each other

(17) The process of separation of light into its component colours while it is passing through a medium is called .... ***(Nov.' 20)***

(a) reflection (b) refraction

(c) dispersion (d) internal reflection

Ans.

(1) (c) refraction

(2) (c) passes unbent

(3) (a) 0°

(4) (a) 50°

(5) (b) less than 30°

(6) (c) the speed of light changes

(7) (a) 1.5

(8) (b) diamond

(9) (d) has no unit

(10) (a) $\frac{c}{n}$

(11) (b) 2.4×10^8 m/s

(12) (c) Violet

(13) (a) Red

(14) (b) 40°

(15) (a) moves away from the slab

(16) (c) parallel to each other

(17) (c) dispersion.

***Q. 4 Mark the correct answer in the following questions :**

(1) What is the reason for the twinkling of stars?

(a) Explosions occurring in stars from time to time

(b) Absorption of light in the earth's atmosphere

(c) Motion of stars

(d) Changing refractive index of the atmospheric gases

(2) We can see the Sun even when it is little below the horizon because of

(a) reflection of light (b) refraction of light

(c) dispersion of light (d) absorption of light

(3) If the refractive index of glass with respect to air is 3/2, what is the refractive index of air with respect to glass?

(a) $\frac{1}{2}$ (b) 3 (c) $\frac{1}{3}$ (d) $\frac{2}{3}$

Ans. (1) Changing refractive index of the atmospheric gases. (2) refraction of light (3) $\frac{2}{3}$.

Q. 5 State whether the following statements are *True* or *False*. (If a statement is false, correct it and rewrite it.) :

(1 mark each)

(1) The incident ray and the refracted ray of light are on the opposite sides of the normal at the point of incidence.

(2) The refractive index of a medium (such as glass) does not depend on the wavelength of light.

(3) When a light ray travels obliquely from an optically rarer medium to an optically denser medium, it bends away from the normal.

(4) When a light ray travels obliquely from glass to air, it bends towards the normal.

(5) If the angle of incidence is 0°, the angle of refraction is 90°.

(6) In dispersion of white light by a glass prism, yellow colour is deviated the least.

(7) In vacuum, the speed of light does not depend upon the frequency of light.

(8) In glass, the speed of violet ray is less than that of red ray.

(9) In a material medium, the speed of light depends on the frequency of light.

(10) The velocity of light is different in different media.

(11) The wavelength of red light is close to 700 nm.

(12) The wavelength of orange light is greater than that of blue light.

(13) The refractive index depends upon the velocity of light in the medium. ***(Nov. '20)***

Ans.

(1) **True.**

(2) **False.** (The refractive index of a medium depends on the wavelength of light.)

(3) **False.** (When a light ray travels obliquely from an optically rarer medium to an optically denser medium, it bends towards the normal.)

(4) **False.** (When a light ray travels obliquely from glass to air, it bends away from the normal.)

(5) **False.** (If the angle of incidence is 0°, the angle of refraction is also 0°.)

(6) **False.** (In dispersion of white light by a glass prism, red colour is deviated the least.)

(7) **True.** (8) **True.** (9) **True.** (10) **True.**

(11) **True.** (12) **True** (13) **True.**

Q. 6 Find the odd one out and give the reason :

Reflection, Neutralization, Refraction, Dispersion.

Ans. Neutralization. It is associated with a chemical reaction between an acid and an alkali; others are phenomena associated with light.

Q. 7 Match the columns :

Column A	Column B ***(March '20)***
The wavelength of red light	(a) 600 nm (b) 700 nm (c) 500 nm

Ans. The wavelength of red light – 700 nm.

Q. 8 Answer the following questions :

• Try this (Textbook page 73)

Material : Glass, 5 rupee coin, pencil, metallic vessel, etc.

Activity 1 :

1. Take a transparent glass and fill it with water.
2. Dip some portion of a pencil vertically in water and observe the thickness of the portion of the pencil, in water.

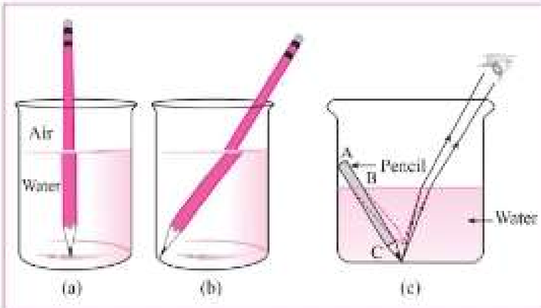


Fig. 6.1

3. Now keep the pencil inclined to water surface and observe its thickness.

In both cases, the portion of the pencil inside water appears to be thicker than the portion above water. In the second case, the pencil appears to be broken near the surface of water. Why does it happen?

Activity 2 :

1. Keep a 5 rupee coin in a metallic vessel.
2. Slowly go away from the vessel.
3. Stop at the place when the coin disappears.

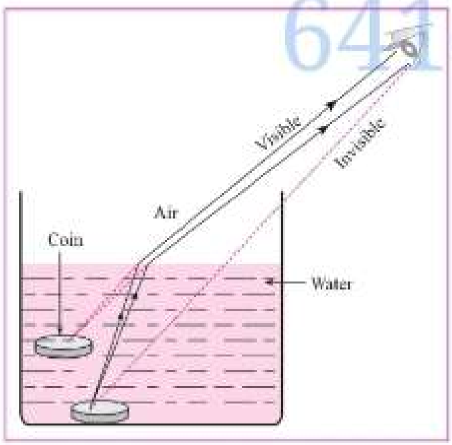


Fig. 6.2

4. Keep looking in the direction of the coin.
5. Ask a friend to slowly fill water in the vessel. You will be able to see the coin once the level of water reaches a certain height. Why does it happen?

In both the above activities the observed effects are created due to the change in the direction of propagation of light while coming out of water. As light rays travel obliquely from water to air, they bend away from the normal.

Light changes its direction of propagation when going obliquely from one transparent medium to another transparent medium. This is called the refraction of light.

(1) What is meant by refraction of light?

Ans. The change in the direction of propagation of light when it passes obliquely from one transparent medium to another is called refraction of light.

(2) Why is there a change in the direction of propagation of light when it passes obliquely from one transparent medium to another?

Ans. The velocity of light is different in different media. Hence, there is a change in the direction of propagation of light when it passes obliquely from one transparent medium to another.

Activity 3 : (Textbook pages 73, 74)

1. Keep a glass slab on a blank paper and draw its outline PQRS as shown in Fig. 6.3.
2. Draw an inclined straight line on the side of PQ so that it intersects PQ at N. Pierce two pins vertically at two points A and B along the line.
3. Look at the pins A and B from the opposite side of the slab and pierce pins C and D vertically so that the images of A and B are in line with C and D.
4. Now remove the chip and the pins and draw a straight line going through points C and D so that it intersects SR at M.
5. Join points M and N. Observe the incident ray AN and emergent ray MD.

The first refraction occurs when light ray enters the glass from air at N on the side PQ. The second refraction occurs when light enters air through the glass at point M on the side SR. For the first refraction the angle of incidence is i while for the second it is i_1. The angle of refraction at N is r.

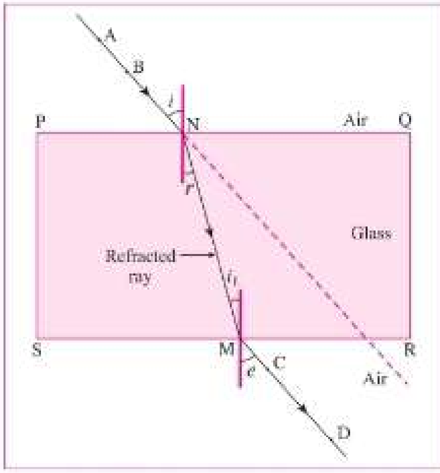


Fig. 6.3 : Refraction of light passing through a glass slab

Note that $i_1 = r$. In the second refraction, the angle of refraction is e which is equal to i. On both parallel sides PQ and RS of the glass slab, the change in direction of light ray is equal but in opposite directions.

Thus, the light ray MD emerging from the glass slab is parallel to the incident ray AN on the side PQ of the slab. But the emergent ray is displaced with respect to the incident ray.

(3) In the case of refraction of light through a glass slab, the emergent ray is parallel to the incident ray, but it is displaced sideways. Why does this happen?

Ans. The first refraction takes place as light passes obliquely from air to glass (see Fig. 6.3). In this case, the ray of light bends towards the normal at point N. The second refraction takes place as light passes obliquely from glass to air. In this case, the ray of light bends away from the normal at point M. The faces PQ and SR of the glass slab are parallel. Hence, the extent of bending of light at SR is equal in magnitude but opposite in sense relative to the bending of light at PQ. Hence, the emergent ray of light (MD) is parallel to the incident ray of light (AN), but it is displaced sideways as shown in Fig. 6.3.

(4) Define angle of incidence and angle of refraction.

Ans. (1) The angle made by the incident ray of light with the normal to the surface at the point of incidence is called the angle of incidence.

(2) The angle made by the refracted ray of light with the normal to the surface at the point of incidence is called the angle of refraction.

[**Note** : The angle e in Fig. 6.3 is also called the angle of emergence as it is the angle made by the emergent ray with the normal to the surface at the point of emergence.]

(5) Repeat the activity "Refraction of light passing through a glass slab" by replacing the glass slab by a transparent plastic slab. [HOTS]

(i) What similarity do you observe?

Ans. Similarity : The emergent ray is parallel to the incident ray, but it is displaced sideways.

(ii) What difference do you notice?

Ans. Difference : For a given angle of incidence, the extent of refraction (bending) is different (in general, less) for a transparent plastic slab relative to the glass slab.

(6) State the laws of refraction of light.

Ans. Laws of refraction of light :

(1) The incident ray and the refracted ray are on the opposite sides of the normal to the surface at the point of incidence and all the three, i.e., the incident ray, the refracted ray and the normal are in the same plane.

(2) For a given pair of media, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant (Snell's law). This constant is called the refractive index of the second medium with respect to the first medium.

[**Note** : Here, a ray means a ray of light.]

(7) Observe the given figure and answer the following questions.

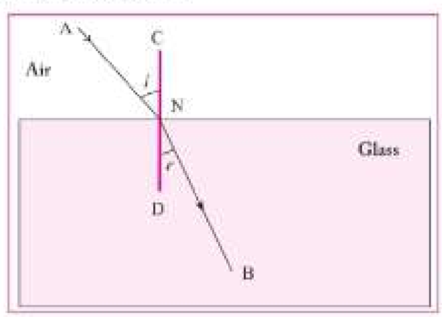


Fig. 6.4

(a) Name the process represented by the figure.

(b) State the *two* laws related to the process.
(3 marks) (March '20)

Ans. (a) Refraction of light.

(b) See the answer to Q. 8 (6) above.

(8) How is refraction of light related to refractive index?

Ans. When a ray of light travels obliquely from an optically rarer medium (lower refractive index) to an optically denser medium (higher refractive index), the ray bends towards the normal. When a ray of light travels obliquely from an optically denser medium to an optically rarer medium, the ray bends away from the normal. For a given angle of incidence ($i \neq 0$), the extent of refraction (bending) of light is different in different media. If the refractive index of the second medium with respect to the first medium is greater than 1, the greater the refractive index, the greater is the bending of the ray of light towards the normal. If the refractive index of the second medium with respect to the first medium is less than 1, the greater the refractive index, the lesser is the bending of the ray of light away from the normal.

(9) Define the refractive index of the second medium with respect to the first medium. *OR*

What is meant by refractive index?

Ans. The refractive index of the second medium with respect to the first medium is defined as the ratio of the sine of the angle of incidence to the sine of the angle of refraction when the ray of light is obliquely incident at the boundary separating the two media and travels from the first medium to the second medium. (See Fig. 6.5.)

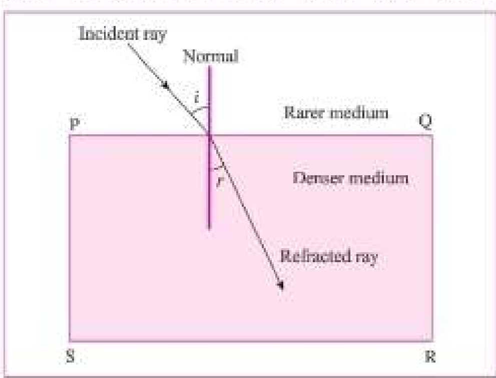


Fig. 6.5 : A ray of light travelling from medium 1 to medium 2

OR

The refractive index of the second medium with respect to the first medium is defined as the ratio of the magnitude of the velocity of light in the first medium to the magnitude of the velocity of light in the second medium.

[**Note :** Velocity is a vector, i.e., it has magnitude and direction. In definition of refractive index, we consider only the magnitude of velocity of light (speed of light). Velocity of light in a medium depends on the physical condition of the medium as well as the frequency of light. Velocity of light is different in different media. For a given medium, the refractive index depends on the colour of light (frequency of light.)]

(10) State the formulae for the refractive index of the second medium with respect to the first medium.

Ans. The refractive index of the second medium with respect to the first medium,

$${}_2n_1 = \frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

where i is the angle of incidence, r is the angle of refraction (as the ray of light passes obliquely from the first medium to the second medium), v_1 is the magnitude of the velocity (speed) of light in the first medium and v_2 is the magnitude of the velocity of light in the second medium.

(11) Define absolute refractive index.

Ans. The absolute refractive index of a medium is defined as the ratio of the magnitude of the velocity of light in vacuum to the magnitude of the velocity of light in the medium.

[**Note :** The speed of light is maximum in vacuum, about 3×10^8 m/s. When light travels from one medium to another, there occurs a change in its speed and wavelength (λ). But its frequency (v) remain the same.]

(12) Obtain the relation between the refractive index of the second medium with respect to the first medium and the refractive index of the first medium with respect to the second medium.

Ans. Let v_1 = speed of light in the first medium, v_2 = speed of light in the second medium, ${}_2n_1$ = refractive index of the second medium with respect to the first medium and ${}_1n_2$ = refractive index of the first medium with respect to the second medium.

By definition, ${}_2n_1 = \frac{v_1}{v_2}$ and ${}_1n_2 = \frac{v_2}{v_1}$.

Hence, ${}_1n_2 = \frac{1}{{}_2n_1}$ *OR*

${}_1n_2 \times {}_2n_1 = 1$.

(13) If the refractive index of a certain material with respect to air is 1.5, what is the refractive index of air with respect to that material?

Ans. As the refractive index of the given material with respect to air is 1.5, the refractive index of air with respect to the material is

$\frac{1}{1.5} = \frac{1}{3/2} = \frac{2}{3} = 0.6667$ (approximately)

• **Can you recall? (Textbook page 75)**

If the refractive index of the second medium with respect to the first medium is ${}_2n_1$ and that of the third medium with respect to the second medium is ${}_3n_2$, what and how much is ${}_3n_1$?

Ans. ${}_3n_1$ is the refractive index of the third medium with respect to the first medium.

${}_2n_1 = \frac{v_1}{v_2}$, ${}_3n_2 = \frac{v_2}{v_3}$, ${}_3n_1 = \frac{v_1}{v_3} = \frac{v_1}{v_2} \times \frac{v_2}{v_3}$

$\therefore\ {}_3n_1 = {}_2n_1 \times {}_3n_2$.

[Suppose medium 1 ≡ air, medium 2 ≡ ice and medium 3 ≡ diamond. Then, ${}_2n_1 = 1.31$, ${}_3n_2 = 1.847$

$\therefore\ {}_3n_1 = {}_2n_1 \times {}_3n_2 = 1.31 \times 1.847 = 2.42$ which is the refractive index of diamond with respect to air.]

***(14) If the angle of incidence and angle of emergence of a light ray falling on a glass slab are i and e respectively, prove that $i = e$.**

Ans. In the following figure, SR ∥ PQ and NM is the refracted ray. Hence, $r = i_1$.

Now ${}_gn_a = \sin i/\sin r$ and ${}_an_g = \sin i_1/\sin e$.

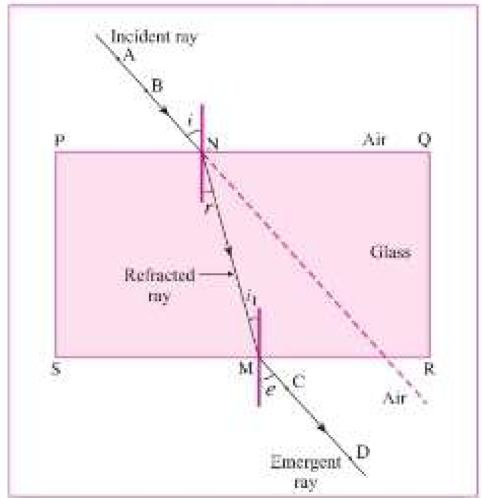


Fig. 6.6 : Refraction of light

Also ${}_gn_a = \frac{1}{{}_an_g}$

$\therefore\ \frac{\sin i}{\sin r} = \frac{\sin e}{\sin i_1}$

As $r = i_1$, it follows that $\sin i = \sin e$

$\therefore\ i = e$.

(15) Explain the terms optically rarer medium and optically denser medium with examples.

Ans. When we consider two media (such as air and glass), the medium with lower refractive index is called the optically rarer medium (in the present case, air) and the medium with higher refractive index is called the optically denser medium (glass, in the present case).

The higher density does not necessarily mean higher refractive index. For example, the density of water is greater than that of kerosine, but the absolute refractive index of water is less than that of kerosine. Thus, when we consider water and kerosine, water is an optically rarer medium while kerosine is an optically denser medium.

If we consider kerosine and benzene, kerosine is an optically rarer medium while benzene is an optically denser medium.

(16) A ray of light is incident obliquely at a boundary separating two media. What is its behaviour if (1) the refractive index of the second medium is greater than that of the first medium (2) the refractive index of the first

medium is greater than that of the second medium? Draw the corresponding neat and labelled diagrams.

Ans. Consider a ray of light incident obliquely at a boundary separating two media.

(1) If the refractive index of the second medium is greater than that of the first medium, the ray bends towards the normal at the point of incidence as it travels from the first medium (optically rarer medium) to the second medium (optically denser medium). The angle of refraction (r) is less than the angle of incidence (i). (Fig. 6.7)

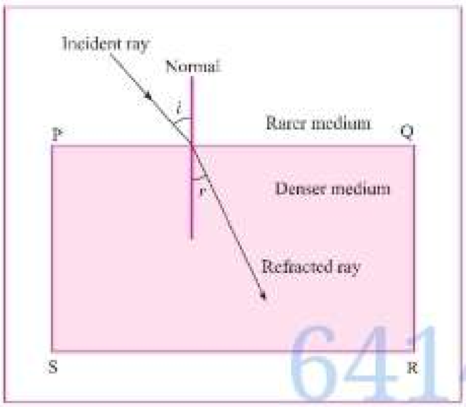


Fig. 6.7 : A ray of light travelling from a rarer medium to a denser medium (Schematic diagram)

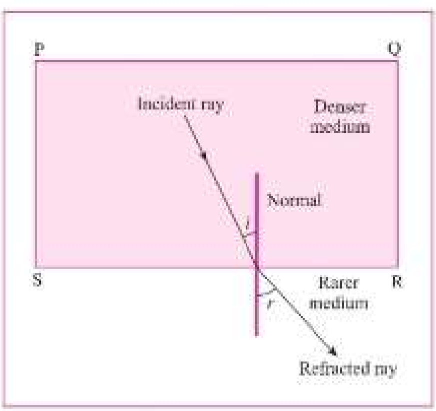


Fig. 6.8 : A ray of light travelling from a denser medium to a rarer medium (Schematic diagram)

(2) If the refractive index of the first medium is greater than that of the second medium, the ray bends away from the normal at the point of incidence as it travels from the first medium (optically denser medium), to the second medium (optically rarer medium). The angle of refraction (r) is greater than the angle of incidence (i). (Fig. 6.8)

[**Note** : In this chapter, a rarer medium means an optically rarer medium and a denser medium means optically denser medium unless stated otherwise.]

(17) Observe the following figure and write accurate conclusion regarding refraction of light.

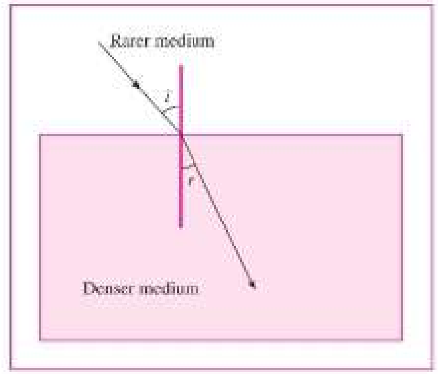


Fig. 6.9

Ans. When a light ray passes obliquely from a rarer medium to a denser medium, it bends towards the normal.

(18) What happens when a ray of light is incident normal to the interface between two media? Draw the corresponding neat and labelled diagram.

Ans. When a ray of light is incident normal to the interface between two media, the ray propagates undeviated as it travels from the first medium to the second medium irrespective of the refractive indices of the two media. In this case, the angle of incidence (i) is zero and so also the angle of refraction (r). (Fig. 6.10)

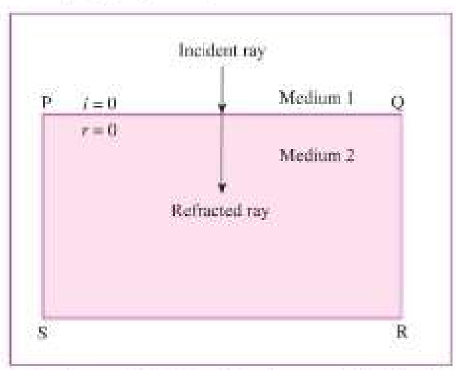


Fig. 6.10 : A ray of light incident normal to the interface between two media propagates without any change in its direction of propagation

(19) Draw a neat and labelled diagram to show the path of a ray of light in air and glass when the ray is incident obliquely on a glass slab. Show the (i) incident ray (ii) refracted ray (iii) emergent ray (iv) angle of incidence (v) angle of refraction (vi) angle of emergence in the diagram. *OR*

Draw a neat and labelled diagram to show refraction of light through a glass slab.

Ans.

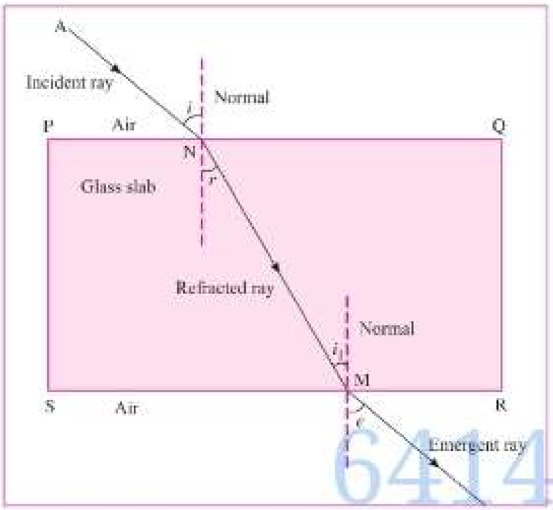


Fig. 6.11 : The path of a ray of light in air and glass when the ray is incident obliquely on a glass slab

In Fig. 6.11, i = angle of incidence, r = angle of refraction and e = angle of emergence.

(20) Observe the given figure and name the following rays :

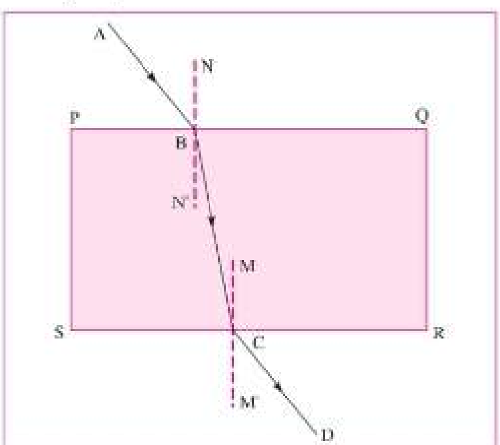


Fig. 6.12

(i) ray AB (ii) ray BC (iii) ray CD

Ans. (i) The ray AB is the **incident ray.**

(ii) The ray BC is the **refracted ray.**

(iii) The ray CD is the **emergent ray.**

(21) A plane mirror is kept at the bottom of a trough with water in it as shown in the following figure (Fig. 6.13). The ray of light emerging from a source at the point S outside the trough, reaches the point A on the surface of water. Draw a neat ray diagram to show the subsequent path of light and complete the ray diagram. **[HOTS]**

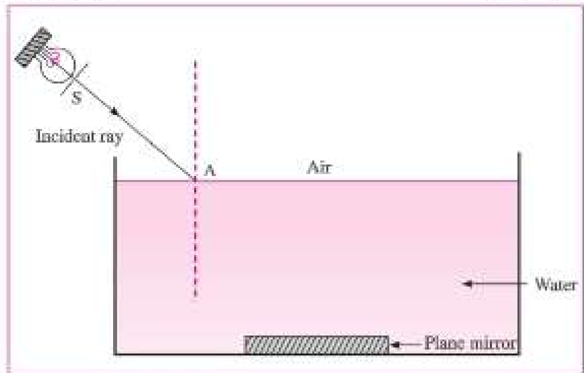


Fig. 6.13

Ans.

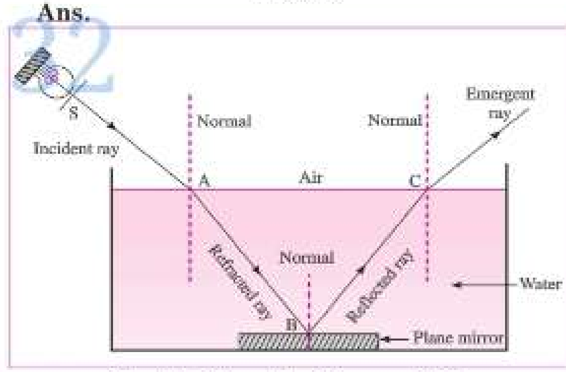


Fig. 6.14 : The path of the ray of light

• Can you tell? (Textbook page 76)

(1) Have you seen a mirage which is an illusion of the appearance of water on a hot road or in a desert?

Ans. *See the answer to Q. 8 (23).*

(2) Have you seen that objects beyond and above a holi fire appear to be shaking? Why does this happen?

Ans. The temperature of air beyond and above a holi fire changes all the time. Hence, the density of air also changes constantly. Hence, the direction of propagation of the rays of light approaching us from the objects beyond and above the holi fire changes constantly. Therefore, those objects appear to be shaking.

(22) Give two examples of the effect of atmospheric refraction on a small scale in local environment.

Ans. (1) The occurrence of a mirage and (2) flickering of an object seen through a turbulent stream of hot air rising above the Holi fire are examples of the effect of atmospheric refraction on a small scale in local environment.

(23) What is a mirage? With a neat labelled diagram, explain the conditions under which it is seen.

Ans. Due to the changes in refraction of light, the light rays coming from a distant object appear to be coming from the image of the object inside the ground. This is called a mirage. When the earth's surface is heated by the sun, the temperature of air increases. This produces a layer of hot air of lower density (mass per unit volume) and lower refractive

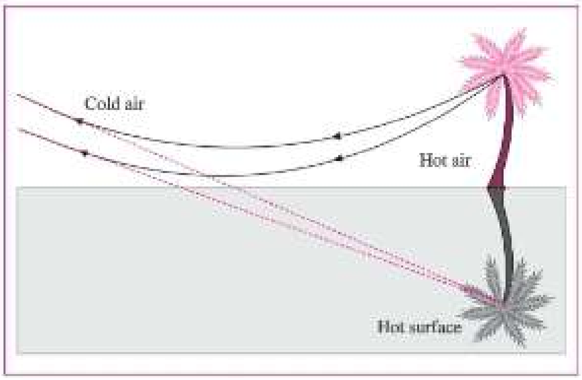


Fig. 6.15 : Mirage

index at the surface. Hot air works as an optically rarer medium relative to cool air. When the temperature changes rapidly in the vertical direction, as refraction of light takes place, the angle of refraction changes continuously. The rays of light from the top of an object such as a car or tree cross the rays from the bottom of the object on their way to the observer's eye. Hence, an inverted image is formed below the object's true position and downward towards the surface in the direction of air at higher temperature. In this case, some rays of light bend back up into the denser air above (Fig. 6.15). Mirage produces an impression of water near the hot ground.

(24) Explain in brief the flickering of an object seen through a turbulent stream of hot air rising above the Holi fire.

Ans. During the Holi fire, the temperature of the air just above the fire becomes much greater than that of the air further up. The hot air has lower density (mass per unit volume) and lower refractive index. It becomes an optically rarer medium. The cool air has higher density and higher refractive index. It is an optically denser medium relative to hot air. Hence, in refraction of light, the angle of refraction changes continuously due to a continuous variation in refractive index. As the physical conditions of air change rapidly, the apparent position of an object fluctuates rapidly. This gives rise to the flickering of an object seen through a turbulent stream of hot air rising above the Holi fire.

(25) With a neat labelled diagram, explain twinkling of a star. Also explain why a planet does not twinkle.

Ans. (1) As a star is far away from the earth, it appears as a point source of light. The density of air decreases with height above the earth's surface. Hence, the refractive index of air also decreases with height. When starlight enters the earth's atmosphere, it undergoes refraction continuously in the medium with gradually changing refractive index. The bending of starlight occurs towards the normal as it passes from the optically rarer part of the medium to the optically denser part.

(2) Hence, when a star is observed near the horizon, its apparent position is slightly higher than the actual position (Fig. 6.16).

(3) Further, the apparent position varies with time as the medium is not stationary due to mobility

of air and change in temperature. When more light is refracted towards the observer the star appears bright. When less light is refracted towards the observer, the star appears dim.

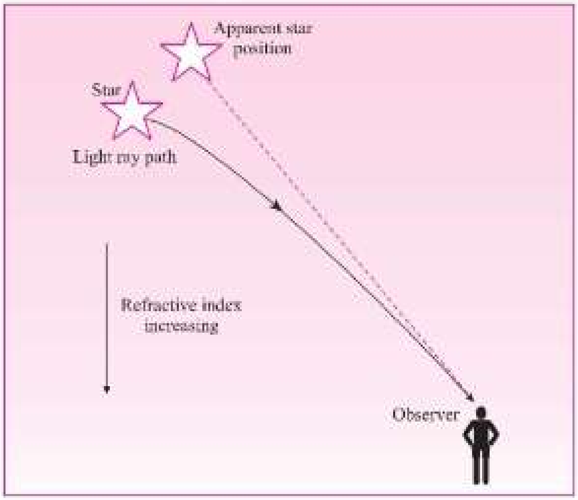


Fig. 6.16 : Actual position and apparent position of a star (Schematic diagram)

(4) Thus there is fluctuation in the brightness of a star when observed from the earth. This is called twinkling of a star.

(5) Compared to stars, planets are relatively closer to the earth. Hence, a planet appears as a collection of a large number of point sources. Due to the changes in the refractive index of air, there is a change in the position and brightness of these point sources. There is an increase in intensity of light coming from some point sources while there is a decrease in intensity of light coming from equal number of other point sources, on an average. The average brightness of a planet remain the same. Also, there is no change in the average position of a star. Hence, a planet does not twinkle.

(26) What is the correct reason for blinking / flickering of stars? Explain it.

(a) The blasts in the stars.

(b) Absorption of star light by the atmosphere.

(c) Motion of the stars.

(d) Changing refractive index of gases in the atmosphere.

Ans. (d) Changing refractive index of the gases in the atmosphere results in blinking/flickering of stars.

See the answer to Q. 8 (25) for explanation.

(27) With a neat labelled diagram, explain advanced sunrise and delayed sunset.

Ans. (1) The sunrise (the appearance of the sun above the horizon) is advanced due to atmospheric refraction of sunlight. An observer on the earth sees the sun two minutes before the sun reaches the horizon. A ray of sunlight entering the earth's atmosphere follows a curved path due to atmospheric refraction before reaching the earth. This happens due to a gradual variation in the refractive index of the atmosphere. For the observer on the earth, the apparent position of the sun is slightly higher than the actual position. Hence, the sun is seen before the sun reaches the horizon.

(2) Increased atmospheric refraction of sunlight occurs also at the sunset (the sun disappearing below the horizon). In this case, the observer on the earth continues to see the setting sun for two minutes after the sun has dipped below the horizon, thus delaying the sunset.

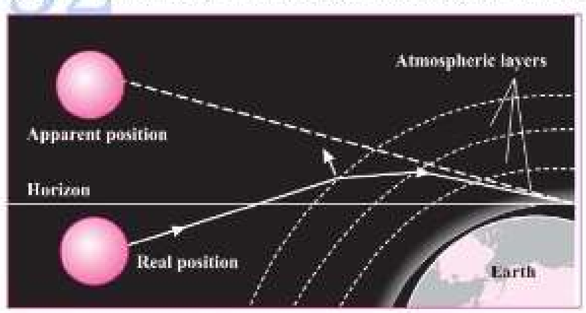


Fig. 6.17 : Effect of atmospheric refraction

The advanced sunrise and delayed sunset increases the duration of day by four minutes (Fig. 6.17).

(28) Water in a swimming pool or water tank appears shallower than its depth. Why?

Ans. When light rays travel obliquely from an optically denser medium (water, in this case) to an optically rarer medium (air, in this case), they bend away from the normal at the point of incidence. As a result, the bottom of a swimming pool or water tank appears raised to an observer standing near the edge of the pool or the tank. Therefore, the swimming pool or water tank appears shallower than its depth.

(29) Place a coin at the bottom of a glass jar containing water. Now tilt the jar suitably. When viewed at a suitable angle, the coin appears to be floating. Why?

Ans. When light rays travel obliquely from an optically denser medium (water, in this case) to an optically rarer medium (air, in this case), they bend away from the normal at the point of incidence. As a result, the coin appears raised. Therefore, when the jar is tilted suitably and observed at a suitable angle, the coin appears to be floating.

(30) State the wavelength range of electromagnetic radiation to which our eyes are sensitive.

Ans. Our eyes are sensitive to light (electromagnetic radiation). Its wavelength range is 400 nm to 700 nm.

[**Note** : Wavelength (λ) goes on decreasing and frequency (ν) goes on increasing from red ($\lambda \simeq 700$ nm) $\rightarrow$ orange $\rightarrow$ yellow $\rightarrow$ green $\rightarrow$ blue $\rightarrow$ indigo $\rightarrow$ violet ($\lambda \simeq 400$ nm). $c = \nu\lambda$, where c is the speed of light in vacuum.]

(31) What do you mean by dispersion of light? What is a spectrum of light? Name the different colours of light in the proper sequence in the spectrum of white light. *OR*

What do you mean by dispersion? Name the different colours of light in the proper sequence in the spectrum of white light.

Ans. The process of separation of light into its component colours while passing through a medium is called dispersion of light.

The band of coloured components of a light beam is called spectrum.

The different colours of light in the spectrum of white light are violet, indigo, blue, green, yellow, orange and red.

(32) What is a prism?

Ans. A prism is a transparent medium bound by two plane surfaces inclined at an angle. Normally it is made of glass and has triangular cross section.

(33) With a neat labelled diagram, describe the experiment to demonstrate dispersion of sunlight (white light) by a prism.

Ans. Experiment :

(1) Procedure : Keep a glass prism on a table in a dark room. Hold a plane mirror outside the room so that it reflects a beam of sunlight into the room. Allow this beam to pass through a narrow slit made in a cardboard and then fall on the prism. Place a white screen on the other side of the prism as shown in the following figure. [Fig. 6.18]

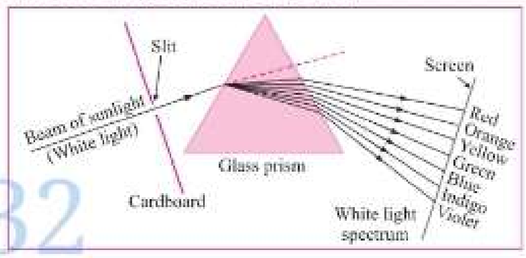


Fig. 6.18 : Dispersion of sunlight (white light) by a glass prism

(2) Observations :

(1) A pattern of various colours is observed on the screen. This pattern is called the spectrum.

(2) It is found that in dispersion, the ray corresponding to violet colour deviates the most.

(3) The ray corresponding to red colour deviates the least.

(4) The deviation of rays corresponding to other colours is intermediate.

(3) Conclusion : When sunlight (white light) is incident on a prism, dispersion of light takes place, forming a spectrum.

[**Notes :** (1) This experiment is due to Sir Isaac Newton (1642 – 1727), English physicist and mathematician. (2) If in a Board examination, incomplete diagram (as shown in Fig. 6.19) is given, students should complete it and label its parts as shown in Fig. 6.18.]

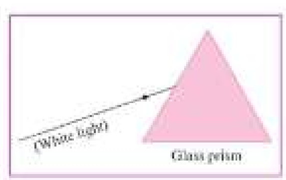


Fig. 6.19

(34) (a) Draw a neat labelled diagram of 'dispersion of white light through a glass prism'.

(b) Which coloured ray is the least deviated?

(c) Which coloured ray is the most deviated?
(3 marks) (Nov. '20)

Ans. (a) See Fig. 6.18.

(b) Red ray is the least deviated.

(c) Violet ray is the most deviated.

(35) How does the dispersion of white light take place when it passes through a glass prism? [HOTS]

Ans. When rays of light are incident on a prism, they are refracted twice, while travelling from air to glass and then from glass to air. Even when the incident rays are directed away from the base of the prism, the emergent rays bend towards the base of the prism, as the prism is triangular. Thus, the rays are deviated as they pass through the prism.

The refractive index of glass is different for different colours. Therefore, the rays corresponding to different colours are deviated to different extents. White light is a mixture of seven colours : violet, indigo, blue, green, yellow, orange and red. Hence, when white light is incident on a prism, a spectrum of seven colours is obtained.

The refractive index of glass is maximum for violet light and minimum for red light. Hence, violet light is deviated the most and red light is deviated the least. The deviation of rays corresponding to other colours is intermediate. In this manner, the dispersion of light takes place when it passes through a glass prism. *[For reference, see Fig. 6.18.]*

(36) What is a spectrum? Why do we get a spectrum of seven colours when while light is dispersed by a prism? *OR*

Explain how a spectrum is formed.

Ans. A band of coloured components of a light beam is called a spectrum.

When white light is incident on a prism, the rays corresponding to different colours bend through different angles on refraction.

Of the various colours in the visible region, red light bends the least and violet light bends the most. Each colour emerges through the prism along a different path and becomes distinct. Hence, we get a spectrum of seven colours.

• **Use your brain power! (Textbook page 77)**

(1) From incident white light how will you obtain white emergent light by making use of two prisms?

Ans.

- Take a prism. Allow white light to fall on it.
- Obtain a spectrum.
- Take a second identical prism. Place it parallel to the first prism in an upside down position with the first prism [as shown in Fig. 6.20].
- Allow the colours of the spectrum to pass through the second prism.
- Obtain the beam of light emerging from the other side of the second prism.

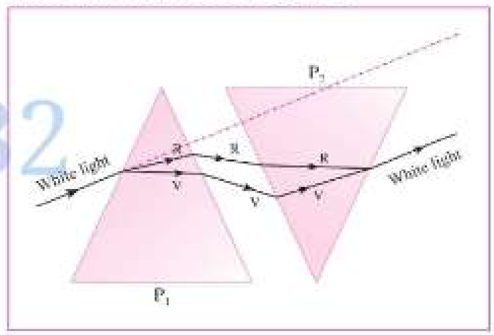


Fig. 6.20 : (Schematic diagram)

The beam of light emerging from the other side of the second prism is a beam of white light.

Explanation : White light is made up of seven colours. The first prism produces dispersion of white light while the second prism combines light of different colours to produce white light again. The net deviation of a ray of light is zero.

[**Note :** This experiment is due to sir Isaac Newton. It proved that it was not the prism which added colours to the white light but a property of the white light itself.]

(2) You must have seen chandeliers having glass prisms. The light from a tungsten bulb gets dispersed while passing through these prisms and we see coloured spectrum. If we use an LED light instead of a tungsten bulb, will we be able to see the same effect?

Ans. Light emitted by LED (light-emitting-diode) does not have all wavelengths in the region 400 nm to 700 nm. Hence, its spectrum is not the same as that of light from a tungsten bulb or as that of sunlight.

(37) What is partial reflection of light?

Ans. When light travels from a denser medium to a rarer medium, it is partially reflected, i.e., part of light comes back into the denser medium as per the laws of reflection. This is called partial reflection of light.

[**Note** : Partial reflection of light occurs even when light travels from a rarer medium to a denser medium. The rest of light is refracted.]

(38) Explain the terms total internal reflection and critical angle.

Ans. Figure 6.21 shows passage of light from water (denser medium) to air (rarer medium).

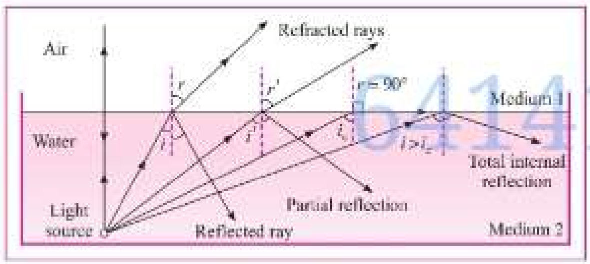


Fig. 6.21 : Partial and total internal reflection, $i_c \equiv$ critical angle

The ray of light incident at the boundary separating the two media bends away from the normal on refraction. Here, the angle of refraction r, is greater than the angle of incidence i. Now $_a n_w = \dfrac{\sin i}{\sin r} < 1$. Here, $_a n_w$ is the refractive index of air with respect to water. As $_a n_w$ is constant, r increases as i increases. For $r = 90°$, the ray travels along the boundary. If i is increased further, as r cannot be greater than 90°, light does not enter air. There is no refraction of light and all the light enters water on reflection. This is called total internal reflection.

For $r = 90°$, $_a n_w = \dfrac{\sin i}{\sin 90°} = \sin i$. This angle i is called the critical angle.

(39) The observation made by Swarali while doing the experiment are given below. Based on these write answers to the following questions :

Swarali found that the light ray travelling from the denser medium to a rarer medium goes away from the normal. If the angle of incidence (i) is raised by Swarali, the angle of refraction (r) went on increasing. However, after certain value of the angle of incidence, the light ray is seen to return back into the denser medium.

So, Swarali has some questions. Answer them.

(a) Name this certain value of i. What is the value of r at that time?

(b) Name this process of returning of light in the denser medium. Explain the process.

(3 marks) (Board' Model Activity Sheet)

Ans. (a) Critical angle

$r = 90°$

(b) Total internal reflection.

As light goes from a denser to rarer medium, if the value of the angle of incidence increases, then the value of the angle of refraction also increases. But after a specific angle of incidence called the critical angle, the light gets reflected back into the denser medium.

[**Note** : See the answer to Q. 7 (38) for a detailed explanation.]

(40) The observations made by Swarali while doing the experiment are given below. Based on these write answers to the questions :

Swarali found that the light ray travelling from the denser medium to a rarer medium goes away from the normal. If the angle of incidence (i) is raised by Swarali, the angle of refraction (r) went on increasing. However, after certain value of the angle of incidence, the light ray is seen to return back into the denser medium. ***(March '19)***

(i) What is the specific value of $\angle i$ called?

(ii) What is the process of reflection of incident ray into a denser medium called?

(iii) Draw the diagrams of three observations made by Swarali.

Ans. (i) Critical angle

(ii) Total internal reflection

(iii)

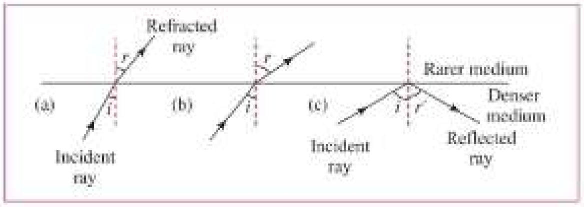


Fig. 6.22

(41) Define total internal reflection of light.

Ans. When light travels from a denser medium to a rarer medium, if the angle of incidence is greater than the critical angle, there is no refraction of light and all the light is reflected in the denser medium. This is called total internal reflection of light.

(42) Define critical angle.

Ans. When light travels from a denser medium to a rarer medium, the angle of incidence for which the angle of refraction becomes 90°, is called the critical angle.

(43) If the refractive index of a rarer medium with respect to a denser medium is 0.5, what is the critical angle?

Ans. ${}_2n_1 = 0.5 = \sin i$

$\therefore$ Critical angle $i = 30°$.

(44) Name the devices in which total internal reflection of light is used. **[HOTS]**

Ans. (1) Total internal reflecting prisms are used in a camera, binoculars, periscope.

(2) Total internal reflection of light is used in optical fibres.

[**Note :** Total internal reflection of light plays an important role in sparkling brilliance of a diamond.]

(45) Explain why an empty test tube held obliquely in water appears shiny to an observer looking down.

Ans. When an empty test tube is held obliquely in water in a beaker, some light rays passing from water to air are incident at an angle greater than the critical angle. They are, thus, totally internally reflected as shown, and the surface of the test tube has a silvery shine.

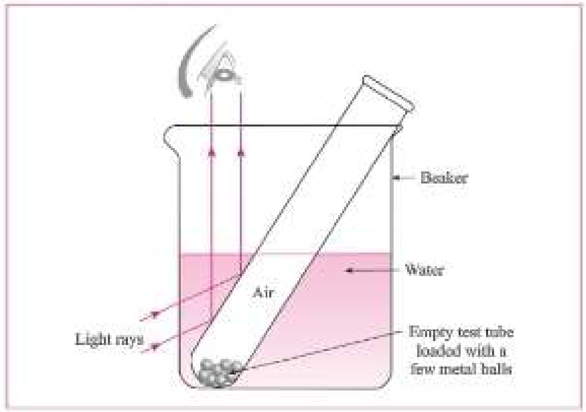


Fig. 6.23 : An empty test tube held immersed in water appears shiny

***(46) Prove the following statement : A rainbow is the combined effect (an exhibition) of the refraction, dispersion, and total internal reflection of light (taken together).** *OR*

With a neat labelled diagram, explain how the formation of rainbow occurs.

Ans. (1) The formation of a rainbow in the sky is a combined result of refraction, dispersion, internal reflection and again refraction of sunlight by water droplets present in the atmosphere after it has rained.

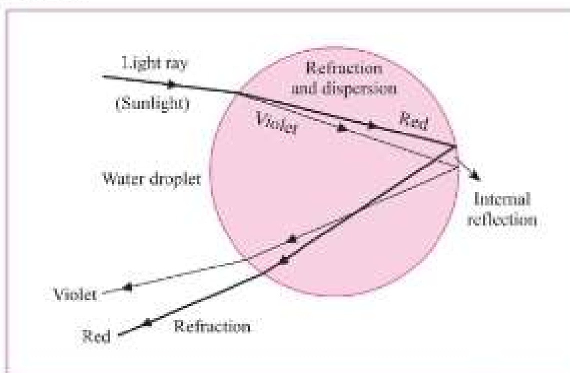


Fig. 6.24 : Formation of a rainbow (Schematic diagram) Here, for simplicity only violet and red colours are shown. The remaining five colours lie between these two.

(2) The sunlight is a mixture of seven colours : violet, indigo, blue, green, yellow, orange and red.

After it has stopped raining, the atmosphere contains a large number of water droplets. When sunlight is incident on a water droplet, there is (i) refraction and dispersion of light as it passes from air to water (ii) internal reflection of light inside the droplet and (iii) refraction of light as it passes from water to air.

(3) The refractive index of water is different for different colours, being maximum for violet and minimum for red. Hence, there is dispersion of light (separation into different colours) as it passes from air to water. [See Fig. 6.24 for reference.]

(4) The combined action of different water droplets, acting like tiny prisms, is to produce a rainbow with red colour at the outer side and violet colour at the inner side. The remaining five colours lie between these two.

The rainbow is seen when the sun is behind the observer and water droplets in the front.

(47) Observe the given figure and answer the following questions.

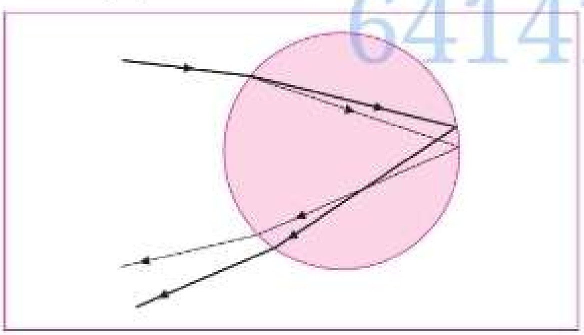


Fig. 6.25

(a) Identify and write the natural process shown in the figure.

(b) List the phenomena which are observed in this process.

(c) Redraw the diagram and show the above phenomena in it.

Ans. (a) The natural process shown in the figure is formation of rainbow.

(b) The phenomena observed in this process are refraction, internal reflection and dispersion of light.

(c) *See Fig. 6.24.*

• **Some Fun (Textbook page 78)**

Try to see if you can see dispersion of light using plastic jar, mirror and water.

- Take a plastic jar. Fill it with water up to two-thirds of its capacity.
- Hold a small mirror in the inclined position in water.
- By using a torch allow the white light to get incident on the mirror inside the water.
- Instead of torch light, you can also allow the sunlight from a window to get incident on the mirror inclined in the water.
- Adjust the angle of incidence of light so that you can see the reflection of light on the nearest wall.
- In this case, splitting up of white light into different colours takes place. The various colours obtained after splitting are in the sequence – Violet, Indigo, Blue, Green, Yellow, Orange and Red.

[Note : The acronym VIBGYOR can be used to remember the sequence.]

Q. 9 Write short notes on the following :

(1) Refraction observed in the atmosphere.

Ans. When a ray of light passes obliquely from an optically rarer medium to an optically denser medium, it bends towards the normal at the point of incidence. If opposite is the case, the ray bends away from the normal.

Atmosphere is never static. Air is mobile and its density and temperature are not uniform. As a result, in general, the path of a ray of light through atmosphere of varying refractive index is a curve. The refractive index of cool air is greater than that of hot air.

Atmospheric refraction of light results in many interesting optical phenomena such as twinkling of a star, advanced sunrise and delayed sunset, mirage and flickering of an object seen through a turbulent stream of hot air rising from a fire.

(2) Dispersion of light.

Ans. The process of separation of light into its component colours while passing through a medium is called dispersion of light. When white light passes through a glass prism, it spreads out into a band of different colours (components) called the spectrum of light. The colours in the spectrum of white light are violet, indigo, blue, green, yellow, orange and red.

Formation of a rainbow is an example of dispersion of light in nature. In this case, raindrops are responsible for dispersion of sunlight.

Dispersion takes place because the refractive index of a material such as glass or water, is different for different colours. It is maximum for violet colour and minimum for red colour. Hence, in the spectrum of white light (sunlight) obtained with a prism, violet light is deviated the most while red light is deviated the least. The deviation of light corresponding to other colours lies in between.

Q. 10 Give scientific reasons :

(1) A coin kept in a bowl is not visible when seen from one side. But, when water is poured in the bowl, the coin becomes visible.

Ans. (1) When the bowl is empty, the rays of light coming from the coin are obstructed by the side of the bowl, and hence the coin is not visible when seen from one side of the bowl.

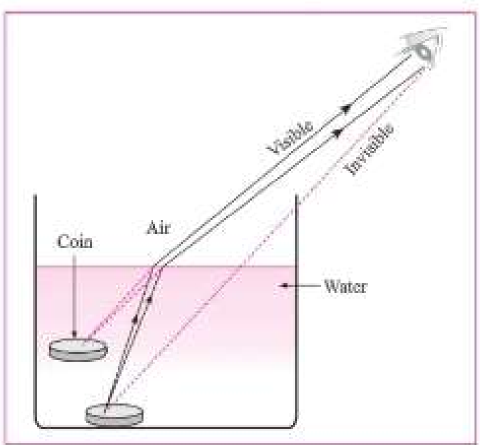


Fig. 6.26 : The coin becomes visible when water is poured in the bowl (Schematic diagram for reference)

(2) When water is poured in the bowl, the rays of light coming from the coin travel from water (denser medium) to air (rarer medium). Hence, they bend away from the normal on refraction. Therefore, the coin appears to be raised and becomes visible when observed from one side of the bowl.

(2) A pencil dipped in water obliquely appears bent at the surface of water. *OR*

When a pencil is partly immersed in water and held in a slanting position, it appears to be bent at the boundary separating water and air.

Ans. (1) When a pencil is partly immersed in water and held in a slanting position, the rays of light coming from the immersed part of the pencil emerge from water (a denser medium) and enter air (a rarer medium). During this propagation, they bend away from the normal on refraction.

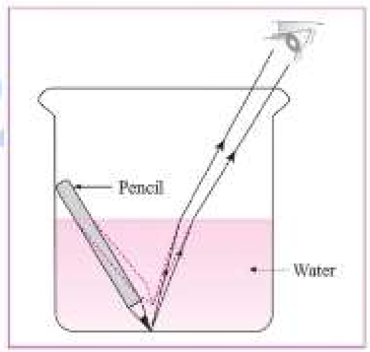


Fig. 6.27 : The pencil appearing bent at the boundary of water and air (Schematic diagram for reference)

(2) As a result, the immersed part of the pencil does not appear straight with respect to the part outside the water, but appears to be raised. Hence, a pencil dipped obliquely in water appears bent at the surface of the water.

(3) The shadow of the edge of an empty vessel is formed due to the slanting rays of the sun. When water is poured in the vessel, the shadow is shifted.

Ans. (1) When the slanting rays of the sun are obstructed by the edge of the empty vessel, the shadow of the edge is formed.

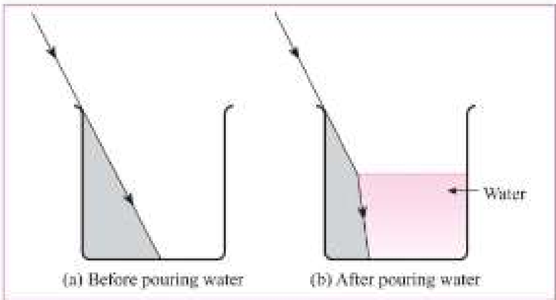


Fig. 6.28 : Shadow of the edge of the vessel (Schematic diagram for reference)

(2) When water is poured in the vessel, the slanting rays of the sun travel from air (rarer medium) to water (denser medium). During this propagation, they bend towards the normal on refraction. Hence, some part in the region of the shadow is now illuminated and the shadow appears to have shifted.

(4) The bottom of a pond appears raised.

Ans. (1) The rays of light coming from the bottom of a pond bend away from the normal as they travel from water (denser medium) to air (rarer medium).

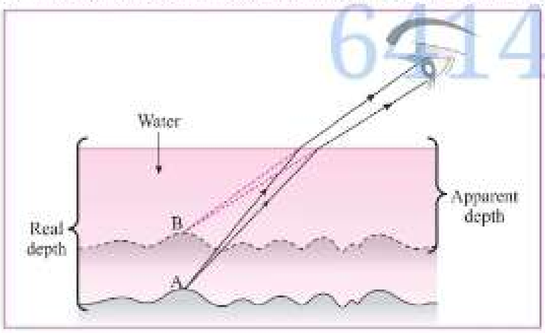


Fig. 6.29 : The bottom of a pond appears raised (schematic diagram for reference)

(2) Hence, they appear to come from a point above the actual point from which they come. Therefore, the bottom of the pond appears raised.

(5) While shooting a fish in a lake, the gun is aimed below the apparent position of the fish.

Ans. (1) The rays of light coming from the fish bend away from the normal as they travel from water (denser medium) to air (rarer medium).

(2) Hence, the position of the fish in water appears to be above its real position. Therefore, while shooting a fish in a lake, the gun is aimed below the apparent position of the fish.

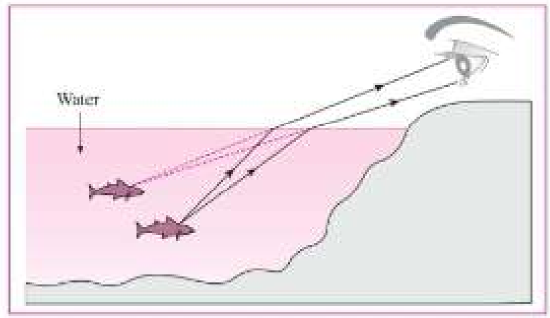


Fig. 6.30 : A fish in water (Schematic diagram for reference)

(6) Stars twinkle but we do not see the twinkling of planets. ***(March '20)***

Ans. (1) As a star is far away from the earth, it appears as a point source of light. Air is always in motion. The density and temperature of air change continuously resulting in the change in the refractive index of air in a given region of space. Hence, there is a continuous change in the apparent position and brightness of a star. Hence, the star appears to twinkle.

(2) Compared to stars, planets are relatively closer to the earth. Hence, a planet appears as a collection of a large number of point sources. Hence, though the refractive index of air in a given region of space changes continuously, there is no change in the average apparent position and brightness of a planet. Hence, we do not see the twinkling of planets.

(7) Stars appear to be twinkling at night. ***(Nov. '20)***

Ans. *See the answer to Q. 10 (6) above.*

(8) The sun is seen on the horizon a little before sunrise. *OR*

The sun is seen on the horizon for sometime even after sunset.

Ans. (1) The earth is surrounded by an atmosphere which is denser near the surface of the earth. When the rays of light from the sun enter the earth's atmosphere from outer space, they travel from a rarer medium to a denser medium. Hence, they bend towards the normal on refraction.

(2) Hence, even when the sun is below the horizon while rising or setting, its rays reach us due to refraction and it appears to be on the horizon.

Therefore, the sun is seen on the horizon a little before sunrise as well as for some time even after sunset.

Q. 11 Distinguish between :

- **Reflection of light and Refraction of light :**

Ans.

Reflection of light	Refraction of light
1. The rays of light, before and after reflection, travel in the same medium.	1. In refraction of light, the rays travel from one medium to another medium.
2. In reflection, the angle of incidence and the angle of reflection are equal.	2. In refraction, when the rays travel obliquely from one medium to another medium, the angle of incidence and the angle of refraction are not equal.
3. In reflection, there is no change in the speed and wavelength of light.	3. In refraction, there occurs a change in the speed and wavelength of light.
4. In reflection, there is no dispersion of light.	4. Generally, in refraction, there occurs dispersion of light.

[**Note** : The frequency of light remains the same in reflection and refraction.]

Q. 12 Complete the following or Solve and fill in the blanks :

Speed of light in the first medium (v_1)	Speed of light in the second medium (v_2)	Refractive index $_2n_1$	Refractive index $_2n_1$
3×10^8 m/s	1.2×10^8 m/s	....	....
....	2.25×10^8 m/s	4/3	....
2×10^8 m/s	....	....	1.5

Ans.

Speed of light in the first medium (v_1)	Speed of light in the second medium (v_2)	Refractive index $_2n_1$	Refractive index $_2n_1$
3×10^8 m/s	1.2×10^8 m/s	2.5	0.4
3×10^8 m/s	2.25×10^8 m/s	4/3	0.75
2×10^8 m/s	3×10^8 m/s	2/3	1.5

Formulae : $_2n_1 = v_1/v_2$, $_1n_2 = v_2/v_1$

Q. 13 Solve the following examples/ numerical problems : ($c = 3 \times 10^8$ m/s)

(1) The speed of light in a transparent medium is 2.4×10^8 m/s. Calculate the absolute refractive index of the medium.

Solution : Data : $c = 3 \times 10^8$ m/s, $v = 2.4 \times 10^8$ m/s, $n = ?$

$$n = \frac{c}{v} = \frac{3 \times 10^8 \text{ m/s}}{2.4 \times 10^8 \text{ m/s}}$$

$$= \frac{3}{2.4} = \frac{30}{24} = \frac{5}{4} = 1.25$$

The absolute refractive index of the medium = 1.25.

(2) The velocity of light in a medium is 2×10^8 m/s. What is the refractive index of the medium with respect to air, if the velocity of light in air is 3×10^8 m/s?

Solution : Data : $v_1 = 3 \times 10^8$ m/s, $v_2 = 2 \times 10^8$ m/s, $_2n_1 = ?$

$$_2n_1 = \frac{v_1}{v_2}$$

$$= \frac{3 \times 10^8}{2 \times 10^8}$$

$$= 1.5$$

The refractive index of the medium with respect to air is 1.5.

*** (3) If the speed of light in a medium is 1.5×10^8 m/s, what is the absolute refractive index of the medium?** ***(2 marks) (July '19)***

Solution : Data : $v = 1.5 \times 10^8$ m/s,

$c = 3 \times 10^8$ m/s, $n = ?$

$$n = \frac{c}{v} = \frac{3 \times 10^8 \text{ m/s}}{1.5 \times 10^8 \text{ m/s}} = \mathbf{2}.$$

This is the absolute refractive index of the medium.

(4) The absolute refractive index of water is 1.36. What is the velocity of light in water? (Velocity of light in vacuum = 3×10^8 m/s

(2 marks) (Board's Model Activity Sheet)

Solution :

Given : The absolute refractive index of water $(n) = 1.36$

Velocity of light in vacuum $(v_1) = 3 \times 10^8$ m/s

Formula : $n = \frac{v_1}{v_2}$

$$\therefore 1.36 = \frac{3 \times 10^8}{v_2}$$

$\therefore v_2 = 3 \times 10^8 / 1.36 = 2.21 \times 10^8$ m/s

The velocity of light in water is 2.21×10^8 m/s.

(5) Light travels with a velocity 1.5×10^8 m/s in a medium. On entering second medium its velocity becomes 1.25×10^8 m/s. What is the refractive index of the second medium with respect to the first medium?

Solution : Given :

Velocity of light in the first medium

$= v_1 = 1.5 \times 10^8$ m/s,

velocity of light in the second medium

$= v_2 = 1.25 \times 10^8$ m/s,

refractive index of the second medium with respect to the first medium $= {}_2n_1 = ?$

$${}_2n_1 = \frac{v_1}{v_2}$$

$$= \frac{1.5 \times 10^8}{1.25 \times 10^8} = 1.2$$

Hence, the refractive index of the second medium with respect to the first medium is 1.2.

(6) The refractive index of water is 4/3 and the speed of light in air is 3×10^8 m/s. Find the speed of light in water.

Solution : Data : ${}_2n_1 = 4/3$, $v_1 = 3 \times 10^8$ m/s, $v_2 = ?$

$${}_2n_1 = \frac{v_1}{v_2} \quad \therefore \; v_2 = \frac{v_1}{{}_2n_1}$$

$$\therefore \; v_2 = \frac{3 \times 10^8 \text{ m s}}{4/3} = \frac{9 \times 10^8 \text{ m/s}}{4} = 2.25 \times 10^8 \text{ m/s}$$

The speed of light in water = 2.25×10^8 m/s.

(7) The speed of light in water and glass is 2.2×10^8 m/s and 2×10^8 m/s respectively. What is the refractive index of (i) water with respect to glass (ii) glass with respect to water?

Solution : Data : $v_w = 2.2 \times 10^8$ m/s,

$v_g = 2 \times 10^8$ m/s, ${}_wn_g = ?$, ${}_gn_w = ?$

(i) $${}_wn_g = \frac{v_g}{v_w} = \frac{2 \times 10^8 \text{ m/s}}{2.2 \times 10^8 \text{ m/s}}$$

$$= \frac{2}{2.2} = \frac{1}{1.1} = 0.909 \text{ (approximately)}$$

The refractive index of water with respect to glass = 0.909 (approximately).

(ii) $${}_gn_w = \frac{v_w}{v_g} = \frac{2.2 \times 10^8 \text{ m/s}}{2 \times 10^8 \text{ m/s}}$$

$$= \frac{2.2}{2} = 1.1 \quad \text{OR} \quad {}_gn_w = \frac{1}{{}_wn_g} = \frac{1}{1/1.1} = 1.1$$

The refractive index of glass with respect to water = 1.1.

***(8) If the absolute refractive indices of glass and water are $\frac{3}{2}$ and $\frac{4}{3}$ respectively, what is the refractive index of glass with respect to water?**

Solution : Data : $n_g = \frac{3}{2}$, $n_w = \frac{4}{3}$, ${}_gn_w = ?$

$$n_g = \frac{c}{v_g}, \; n_w = \frac{c}{v_w}, \; {}_gn_w = \frac{v_w}{v_g}$$

$$\therefore \; {}_gn_w = \frac{n_g}{n_w} = \frac{\frac{3}{2}}{\frac{4}{3}} = \frac{3 \times 3}{4 \times 2} = \mathbf{\frac{9}{8}}.$$

This is the refractive index of glass with respect to water.

NUMERICAL PROBLEMS FOR PRACTICE

Given : $c = 3 \times 10^8$ m/s)

1. The speed of light in a transparent medium is 2×10^8 m/s. Find the absolute refractive index of the medium. (**Ans.** 1.5)
2. The absolute refractive index of a transparent medium is 5/3. Find the speed of light in the medium. (**Ans.** 1.8×10^8 m/s)
3. The absolute refractive index of a transparent medium is 2.4 and the speed of light in that medium is 1.25×10^8 m/s. Find the speed of light in air. (**Ans.** 3×10^8 m/s)
4. The speed of light in water is 2.25×10^8 m/s and that in glass is 2×10^8 m/s. Find the refractive index of (i) the glass with respect to water (ii) water with respect to the glass.

   [**Ans.** (i) 1.125 (ii) 0.889 (approximately)]
5. If the refractive index of a certain glass with respect to water is 1.25, find the refractive index of water with respect to the glass. (**Ans.** 0.8)
6. If the absolute refractive index of glass is 1.5 and that of water is $\frac{4}{3}$, find the refractive index of water with respect to glass. $\left(\textbf{Ans. } \frac{8}{9}\right)$

PROJECT

Using a laser and soap water, study the refraction of light under the guidance of your teacher.

Books are my friends (Textbook page 78)

1. Why the Sky is Blue – Dr. C. V. Raman talks about science : C. V. Raman and Chandralekha.
2. Optics : Principles and Applications : K. K. Sharma
3. Theoretical Concepts in Physics : M. S. Longair

MEMORY MAP / CONCEPT MAP

(1)

Refraction of light

- Change in the speed and wavelength of light. Refractive index, ${}_2n_1 = \frac{v_1}{v_2} = \frac{\sin i}{\sin r}$, ${}_1n_2 = \frac{v_2}{v_1}$, $n = \frac{v \text{ (in vacuum)}}{v \text{ (in a medium)}}$ = constant in a particular case
- Bending of light towards the normal when travelling obliquely from an optically rarer medium to an optically denser medium, $i > r$
- Bending of light away from the normal when travelling obliquely from an optically denser medium to an optically rarer medium, $r > i$
- No bending of light for normal incidence, $i = 0 = r$
- Atmospheric refraction, Twinkling of a star, Advanced sunrise and delayed sunset

(2)

Dispersion of light

- Separation of light into its component colours
- Formation of a spectrum
- Formation of a rainbow under appropriate conditions due to refraction, dispersion and internal reflection of sunlight by water droplets

(3)

Total internal reflection of light

- Light travels from a denser medium to a rarer medium
- $_2n_1 = \frac{\sin i}{\sin r} = \frac{\sin i}{\sin 90^\circ} = \sin i$

  i = critical angle

7 LENSES

CHAPTER OUTLINE

IMPORTANT POINTS

• **Can you recall? (Textbook page 80)**

(1) Indicate the following terms related to spherical mirrors in figure 7.1 : pole, centre of curvature, radius of curvature, principal focus.

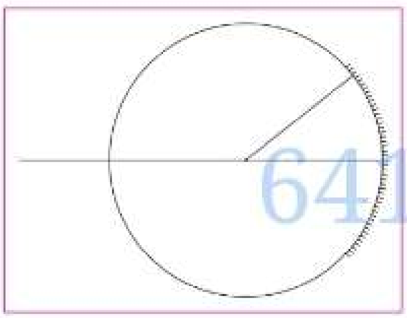


Fig. 7.1 : Spherical mirror

Ans.

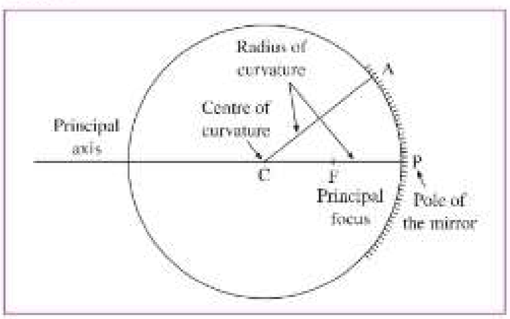


Fig. 7.2 : Terms related to spherical mirrors

(2) How are concave and convex mirrors constructed?

Ans. The given part of a hollow spherical glass can be converted into a concave mirror by (i) polishing (silvering) its inner side (inner surface or concave surface) to make it reflecting or (ii) coating its outer side with a thin layer of silver and painting it with red colour to protect the silver coating.

[**Note :** Case (i) corresponds to the front surface silvered concave mirror.]

The given part of a hollow spherical glass can be converted into a convex mirror by (i) polishing (silvering) its outer side (outer surface or convex surface) to make it reflecting or (ii) coating its inner side with a thin layer of silver and painting it with red colour to protect the silver coating.

[**Note :** Case (i) corresponds to the front surface silvered convex mirror.]

7.1 Lenses :

1. **Lens :** A lens is a transparent material bound by two surfaces, out of which at least one surface is spherical.
2. **Convex lens :** A lens having both spherical surfaces puffed up outwards is called a convex lens or double convex lens or biconvex lens. A lens having one surface plane and the other (spherical surface) bulging outward is called a planoconvex lens. A convex lens is thicker in the middle than at the edges. It is a converging lens. The concavo-convex lens has one spherical surface concave and the other convex such that it behaves as a convex lens.
3. **Concave lens :** A lens having both spherical surfaces curved inwards is called a concave lens or double concave lens or biconcave lens. A lens

having one surface plane and the other (spherical surface) curved inwards is called a plano-concave lens. A concave lens is thicker at the edges than in the middle. It is a diverging lens. The convexo-concave lens has one spherical surface convex and the other concave such that it behaves as a concave lens.

4. **Centre of curvature (C) of a lens :** The centres of the spheres whose parts form the surfaces of a lens are called the centres of curvature of the lens. A lens has two centres of curvature C_1 and C_2 for its two spherical surfaces.
5. **Radii of curvature (R_1, R_2) of a lens :** The radii of the spheres whose parts form surfaces of a lens are called the radii of curvature of the lens.
6. **Principal axis of a lens :** The imaginary straight line passing through the two centres of curvature of a lens is called the principal axis of the lens.
7. **Optical centre (O) of a lens :** The point inside a lens on the principal axis, through which light rays pass without changing their path is called the optical centre (O) of the lens.
8. **Principal focus (F) of a lens :** When light rays parallel to the principal axis are incident on a convex lens, they converge at a point on the principal axis. This point is called the principal focus (F) of the convex lens. Light rays travelling parallel to the principal axis of a concave lens diverge after refraction in such a way that they appear to be coming out of a point on the principal axis. This point is called the principal focus of the concave lens. A lens has two principal foci F_1 and F_2.
9. **Focal length (f) of a lens :** The distance between the optical centre and the principal focus of a lens is called the focal length (f) of the lens.

7.2 Ray diagram for refracted light :

1. **Rules for obtaining an image formed by a convex lens :**
   (1) When the incident ray is parallel to the principal axis, the refracted ray passes through the principal focus.
   (2) When the incident ray passes through the principal focus, the refracted ray is parallel to the principal axis.
   (3) When the incident ray passes through the optical centre of the lens, it passes without changing its direction.

[**Note :** Here, a ray means a ray of light.]

2. **Image formation by a convex lens :**

Sr. No.	Position of the object	Position of the image	Size of the image (relative to the size of the object)	Nature of the image
1.	At infinity	At focus F_2	Point image	Real and inverted
2.	Beyond $2F_1$	Between F_2 and $2F_2$	Smaller	Real and inverted
3.	At $2F_1$	At $2F_2$	Same size	Real and inverted
4.	Between F_1 and $2F_1$	Beyond $2F_2$	Larger	Real and inverted
5.	At focus F_1	At infinity	Very large	Real and inverted
6.	Between F_1 and O	On the same side of the lens as the object	Very large	Virtual and erect

[**Note :** In this chapter, no distinction is made between the terms focus and principal focus. Focus is also called focal point.]

• Can you recall? (Textbook page 82)

• What are real and virtual images? How will you find out whether an image is real or virtual? Can a virtual image be obtained on a screen?

Ans. An image formed by convergence of reflected or refracted rays of light at a point is called a real image.

An image formed at a point from which the reflected or refracted rays of light appear to diverge is called a virtual image.

A real image can be obtained on a screen. A virtual image cannot be obtained on a screen. Thus, if an image can be obtained on a screen, it must be real; if it cannot be obtained on a screen, it must be virtual. This is how we can find out whether an image is real or virtual.

3. Rules for obtaining an image formed by a concave lens :

(1) When the incident ray is parallel to the principal axis, the refracted ray, when extended backwards, passes through the principal focus.

(2) When the incident ray is directed towards the principal focus F_2, the refracted ray is parallel to the principal axis.

(3) When the incident ray passes through the optical centre of the lens, it passes without changing its direction.

4. The image formed by a concave lens is always virtual, erect and smaller than the object. It is on the same side of the lens as the object. Generally, it is formed between the optical centre of the lens and the principal focus F_1. If the object is at infinity, the image is a point image formed at F_1.

Sr. No.	Position of the object	Position of the image	Size of the image (relative to the size of the object)	Nature of the image
1.	At infinity	On the first focus F_1	Point image	Virtual and erect
2.	Anywhere between optical centre O and infinity	Between optical centre and focus F_1	Small	Virtual and erect

• Can you recall? (Textbook page 84)

• What is the Cartesian sign convention used for spherical mirrors?

Ans. According to the Cartesian sign convention, the pole (P) of a spherical mirror is taken as the origin and the principal axis is taken as X-axis of the coordinate system.

(1) The object is always placed on the left of the mirror.

(2) All distances parallel to the principal axis are measured from the pole of the mirror.

(3) All distances measured to the right of the origin (pole) are taken as positive while distances measured to the left of the origin (pole) are taken as negative.

(4) Distances measured perpendicular to and above the principal axis are taken as positive.

(5) Distances measured perpendicular to and below the principal axis are taken as negative.

(6) The focal length of a convex mirror is positive while that of a concave mirror is negative.

7.3 Sign convention :

1. **Sign convention for a lens :** In this case, the optical centre (O) of the lens is taken as the origin and the principal axis of the lens is taken as X-axis of the coordinate system. The sign

conventions regarding the measurement of distances parallel to the principal axis and those perpendicular to the principal axis are the same as for a spherical mirror. Hence, the focal length of a convex lens is positive and that of a concave lens is negative.

2. **Lens formula :** The relationship between the object distance (u), image distance (v) and focal length (f) of a lens is called the lens formula and is given as

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

3. **Magnification by a lens :** The magnification (M) produced by a lens

$$= \frac{\text{height of the image } (h_2)}{\text{height of the object } (h_1)}=\frac{v}{u}$$

Magnification is positive for a virtual image and negative for a real image.

4. **Power of a lens :** The power (P) of a lens

$$= \frac{1}{\text{focal length } (f) \text{ of the lens}}$$

Its SI unit is the dioptre (D).

If $f = 1$ metre, $P = 1$ dioptre.

5. **Combination of lenses :** If two lenses with focal lengths f_1 and f_2 are kept in contact with each other, the effective focal length of the combination, f, is given by $\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}$.

The effective power of the combination of the lenses, P, is given by $P = P_1 + P_2$, where $P=\frac{1}{f}$, $P_1=\frac{1}{f_1}$ and $P_2=\frac{1}{f_2}$.

7.4 Working of the human eye and lens :

1. **Power of accommodation of the eye :** The ability of the eye lens to adjust its focal length is called the power of accommodation of the eye.

2. **The minimum distance of distinct vision and the near point :** The minimum distance from the normal eye at which an object is clearly visible without stress on the eye is called the minimum distance of distinct vision. It is 25 cm for the normal human eye.

The position of the object at the minimum distance of distinct vision is called the near point of the eye. For a normal human eye, the near point is at 25 cm from the eye.

(Textbook page 87)

The minimum distance of an object from a normal eye, at which it is clearly visible without stress on the eye, is called as minimum distance of distinct vision. The position of the object at this distance is called the near point of the eye, for a normal human eye, the near point is at 25 cm. The farthest distance of an object from a human eye, at which it is clearly visible without stress on the eye is called farthest distance of distinct vision. The position of the object at this distance is called the far point of the eye. For a normal human eye, the far point is at infinity.

• Do you know? (Textbook page 87)

The eye ball is approximately spherical and has a diameter of about 2.4 cm. The working of the lens in human eye is extremely important. The lens can change its focal length to adjust and see objects at different distances. In a relaxed state, the focal length of healthy eyes is 2 cm. The other focus of the eye is on the retina.

7.5 Defects of vision and their correction :

1. **Myopia or Nearsightedness :** Myopia or near-sightedness is the defect of vision in which a human eye can see nearby objects distinctly but is unable to see distant objects clearly. In this case, the image of a distant object is formed in front of the retina. This defect can be corrected using a concave lens of suitable focal length.

2. **Hypermetropia or Farsightedness :** Hypermetropia or farsightedness is the defect of vision in which a human eye can see distant objects distinctly but is unable to see nearby objects clearly. In this case, the image of a nearby object would fall behind the retina. This

defect can be corrected using a convex lens of suitable focal length.

3. **Presbyopia (also called old age hypermetropia) :** Presbyopia is the defect of vision in which aged people find it difficult to see the nearby objects comfortably and clearly without spectacles. This defect can be corrected using a convex lens of suitable focal length.

7.6 Uses of lenses :

1. **Uses of a convex lens :** Simple microscope, compound microscope, telescope, camera, projector, spectrometer, spectacles, etc., make use of one or more convex lenses. A simple microscope is used by watch repairers, jewellers, etc. A compound microscope is used to observe bacteria, cells, microorganisms, etc. A telescope is used to observe distant terrestrial objects or astronomical objects like planets, stars and comets.
2. **Uses of a concave lens :** A concave lens is used in spectacles to correct myopia. It is also used in optical instruments.
3. **Persistence of vision :** The image of an object remains imprinted on our retina for $\frac{1}{16}$th of a second after the object is removed from the sight. The sensation on the retina persists for a while. This is called persistence of vision.
4. The retina in our eyes is made of many light sensitive cells. Due to these cells, we get information about the brightness or dimness of the object as well as the colour of the object.

QUESTIONS & ANSWERS

Q. 1 Fill in the blanks and rewrite the statements :

(1) The focal length of a .... lens is positive.

(2) The focal length of a .... lens is negative.

(3) The magnification produced by a .... lens is always positive.

(4) The power of a .... lens is positive.

(5) The power of a .... lens is negative.

(6) The focal length of a lens with power 2.5 D is ....

(7) The power of a lens with focal length 20 cm is ....

(8) The minimum distance of distinct vision for a normal human eye is ....

(9) If two lenses with focal lengths 10 cm and 20 cm respectively are kept in contact with each other, the effective power of the combination is ....

(10) A .... lens is used as a simple microscope.

Ans.

(1) The focal length of a convex lens is positive.

(2) The focal length of a concave lens is negative.

(3) The magnification produced by a concave lens is always positive.

(4) The power of a convex lens is positive.

(5) The power of a concave lens is negative.

(6) The focal length of a lens with power 2.5 D is 40 cm (0.4 m).

(7) The power of a lens with focal length 20 cm is 5 D.

(8) The minimum distance of distinct vision for a normal human eye is 25 cm.

(9) If two lenses with focal lengths 10 cm and 20 cm respectively are kept in contact with each other, the effective power of the combination is 15 D.

(10) A convex lens is used as a simple microscope.

Q. 2 Choose the correct alternative and write it along with its allotted alphabet : *(1 mark each)*

(1) Inside water, an air bubble behaves ....

(a) like a flat plate *(b) like a concave lens*

(c) like a convex lens *(d) like a concave mirror*

(2) ...... represents the lens formula.

(a) $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ (b) $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

(c) $\frac{1}{v}+\frac{1}{u}=\frac{2}{f}$ (d) $\frac{1}{u}-\frac{1}{v}=\frac{1}{f}$

(3) The power of a convex lens of focal length 25 cm is ......

(a) +4.0 D (b) 0.25 D (c) −4.0 D (d) −0.4 D

(4) A lens does not produce any deviation of a ray of light passing through ......

(a) its centre of curvature

(b) its optical centre

(c) its principal focus

(d) an axial point at a distance 2F from its centre

(5) The image formed by a concave lens is always ......

(a) virtual and erect *(b) real and erect*

(c) virtual and inverted *(d) real and inverted*

(6) A convex lens forms a virtual image of an object placed ......

(a) at infinity

(b) at a distance 2F from the lens

(c) at a distance F from the lens

(d) between the principal focus and the optical centre of the lens

(7) When an object is placed at $2F_1$ of a convex lens, its image is formed ......

(a) at F_1

(b) at $2F_2$

(c) beyond $2F_2$

(d) on the same side as the object

(8) To obtain an image of the same size as that of an object with the help of a convex lens, the object should be placed ......

(a) at infinity *(b) beyond F_1*

(c) between F_1 and $2F_1$ *(d) at $2F_1$*

(9) When an object is placed between O and F_1 in front of a convex lens, the image formed is ......

(a) enlarged and erect

(b) diminished and erect

(c) real and enlarged

(d) diminished and inverted

(10) When an object is placed at any finite distance from a concave lens, the image is formed ......

(a) between F_1 and $2F_1$

(b) beyond $2F_1$

(c) at F_1

(d) between F_1 and O on the same side as the object

(11) A student obtained a clear image of window grills on the screen. But the teacher told him to get the image of a tree far away, instead of the window. To get a clear image, the lens must be ....

(a) moved towards the screen

(b) moved away from the screen

(c) moved behind the screen

(d) moved far away from the screen

(12) The image obtained while finding the focal length of a convex lens is ....

(Board's Model Activity Sheet)

(a) real and erect *(b) virtual and erect*

(c) real and inverted *(d) virtual and inverted*

(13) For the normal human eye, the near point is at ...... cm. ***(March '20)***

(a) 10 (b) 20 (c) 25 (d) 30

Ans.

(1) (b) like a concave lens

(2) (b) $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

(3) (a) +4.0 D

(4) (b) its optical centre

(5) (a) virtual and erect

(6) (d) between the principal focus and the optical centre of the lens

(7) (b) at $2F_2$

(8) (d) at $2F_1$

(9) (a) enlarged and erect

(10) (d) between F_1 and O on the same side as the object

(11) (a) moved towards the screen

(12) (c) real and inverted

(13) (c) 25.

Q. 3 State whether the following statements are *true* or *false* : (If a statement is false, correct it and rewrite it.) ***(1 mark each)***

Group (A)

(1) Power of a lens, $P = \frac{1}{f}$.

(2) If the power of a lens is 2 D, its focal length = 0.5 m.

(3) A concave lens is a converging lens. ***(March '19)***

(4) A convex lens is a diverging lens.

(5) A concave lens always forms a virtual image.

(6) A convex lens always forms a virtual image.

(7) Due to the light sensitive cells in the eye, we get information about the brightness or dimness of the object and the colour of the object.

(8) The focal length of a concave lens is negative.

(9) The magnification produced by a concave lens is positive or negative depending on the object distance.

(10) The magnification produced by a convex lens is positive or negative depending on the object distance.

(11) A concave lens is used as a magnifying glass.

(12) A convex lens is used as a simple microscope.

(13) A concave lens is used to correct myopia.

(14) A convex lens is used to correct hypermetropia.

(15) A simple microscope is used for watch repairs. ***(July '19)***

Ans.

(1) **True.**

(2) **True.**

(3) **False.** (A concave lens is a diverging lens.)

(4) **False.** (A convex lens is a converging lens.)

(5) **True.**

(6) **False.** (A convex lens forms a real image or a virtual image depending on the object distance.)

(7) **True.**

(8) **True.**

(9) **False.** (The magnification produced by a concave lens is always positive.)

(10) **True.**

(11) **False.** (A convex lens is used as a magnifying glass.)

(12) **True.** (13) **True.** (14) **True** (15) **True.**

Group (B)

(1) When red light falls on the eyes, the cells responding to red light get excited more than those responding to other colours and we get the sensation of red colour.

(2) When an object is placed in front of a concave lens, its image is obtained on the opposite side of the object.

(3) The image formed by a concave lens is always virtual.

(4) The principal focus of a convex lens is virtual.

(5) An object of height 2 cm forms an image of height 3 cm when placed in front of a concave lens.

(6) Absence of rod like cells results in colour blindness.

(7) Nearsightedness can be corrected using spectacles having convex lenses.

(8) Farsightedness can be corrected using spectacles having convex lenses of suitable focal length.

(9) As one grows old, ciliary muscles become weak.

(10) In a simple microscope, the object is placed within the focal length of the convex lens.

(11) A compound microscope forms an erect and real image of a small object.

(12) In a compound microscope, a real image acts as an object for the eyepiece.

(13) In television, we see a continuous picture due to persistence of vision.

(14) The conical cells can respond differently to red, green and blue colours.

(15) The rod like cells respond to colours and communicate the presence of colours in the retinal image of the brain.

(16) The conical cells respond to the intensity of light and communicate the degree of brightness and darkness to the brain.

(17) Generally, using the same objective lens, but different eyepieces, different magnification can be obtained.

Ans.

(1) **True.**

(2) **False.** (When an object is kept in front of a concave lens, its image is obtained on the same side of the lens as the object.)

(3) **True.**

(4) **False.** (The principal focus of a convex lens is real.)

(5) **False.** (An object of height 2 cm forms an image of height less than 2 cm when placed in front of a concave lens.)

(6) **False.** (Absence of conical cells results in colour-blindness.)

(7) **False.** (Nearsightedness can be corrected using spectacles having concave lenses.)

(8) **True.** (9) **True.** (10) **True.**

(11) **False.** (A compound microscope forms an inverted and virtual image of a small object.)

(12) **True.** (13) **True.** (14) **True.**

(15) **False.** (The rod like cells respond to the intensity of light and communicate the degree of brightness and darkness to the brain.)

(16) **False.** (The conical cells respond to colours and communicate the presence of colours in the retinal image to the brain.)

(17) **True.**

Q. 4 Find the odd one out and give the reason :

(1) Simple microscope, Compound microscope, Telescope, Myopia.

(2) Myopia, Presbyopia, Hypermetropia, Spectrometer.

(3) Presbyopia, Retina, Nearsightedness, Far-sightedness.

(4) Compound microscope, Kaleidoscope, Simple microscope, Astronomical telescope.

(5) TV, Motion picture, Complete circle formed by a revolving burning incense stick, Colour-blindness.

(6) Planets, Stars, Satellites, Rainbow.

Ans.

(1) **Myopia.** It is a defect of vision; others are instruments.

(2) **Spectrometer.** It is an instrument; others are defects of vision.

(3) **Retina.** It is a part of the eye; others are defects of vision.

(4) **Kaleidoscope.** Others are optical instruments.

(5) **Colour-blindness.** Others are examples of persistence of vision.

(6) **Rainbow.** Others are celestial bodies.

Q. 5 Considering the correlation between the words of the first pair, pair the third word accordingly with proper answer OR Write the correlated answer :

(1) Nearsightedness : Elongated eyeball : : Farsightedness : ......

(2) Convex lens : Converging : : Concave lens : ......

(3) Object at $2F_1$ of a convex lens : Image at $2F_2$: : Object at F_1 : ......

(4) Magnification positive : Erect image : : Magnification negative : ......

(5) Convex lens : Positive power of the lens : : Concave lens : ......

(6) $\frac{1}{f\text{(in metre)}}$: Power of the lens (in dioptre) : : $\frac{\text{Image distance}}{\text{Object distance}}$: ......

(7) Focal length : Metre : : Power of a lens : ......

(8) Iris : Pupil : : Ciliary muscles : ......

(9) Nearsightedness : Concave lens : : Farsightedness : ......

(10) Nearsightedness : Image in front of the retina : : Farsightedness : ......

(11) Observation of stars and planets : Telescope : : Repairing a watch : ......

(12) Cinema : Persistence of vision : : Rainbow : ......

(13) Torch : Concave lens : : Camera : ......

(Nov. '20)

Ans. (1) Flattened eyeball (2) Diverging (3) Image on the opposite side at infinity (4) Inverted image (5) Negative power of the lens (6) Magnification (7) Dioptre (8) Eye lens (9) Convex lens (10) Image behind the retina (11) Simple microscope (12) Refraction, dispersion and internal reflection of light (13) Convex lens.

***Q. 6 Match the columns in the following table and explain them :**

Column 1	Column 2	Column 3
Farsightedness	Nearby object can be seen clearly	Bifocal lens
Presbyopia	Faraway object can be seen clearly	Concave lens
Nearsightedness	Problem of old age	Convex lens

Ans.

Column 1	Column 2	Column 3
Farsightedness	Faraway object can be seen clearly	Convex lens
Presbyopia	Problem of old age	Bifocal lens
Nearsightedness	Nearby object can be seen clearly	Concave lens

For explanation, see the answer to Qs. 10 (66), (70), (74).

Q. 7 Match the following :

(1) Column A	Column B
(1) Conical cells	(a) Intensity of light
(2) Rod like cells	(b) Colour of an image
	(c) Iris
	(d) Aperture

Ans. (1) Conical cells – Colour of an image

(2) Rod like cells – Intensity of light.

(2) Column A	Column B
(1) Magnification	(a) $\frac{1}{f}$
(2) Power of a lens	(b) $\frac{h_2}{h_1}$
	(c) f
	(d) u

Ans. (1) Magnification : $\frac{h_2}{h_1}$

(2) Power of a lens : $\frac{1}{f}$.

(3) Column A	Column B
(1) Lens : $\frac{1}{f}$	(a) $\frac{1}{v}+\frac{1}{u}$
(2) Magnification	(b) $\frac{\sin i}{\sin r}$
	(c) $\frac{1}{v}-\frac{1}{u}$
	(d) $\frac{h_2}{h_1}$

Ans. (1) Lens : $\frac{1}{f} : \frac{1}{v} - \frac{1}{u}$

(2) Magnification : $\frac{h_2}{h_1}$.

(4) Column A	Column B
(Convex lens)	(a) Image virtual, erect and enlarged
(1) Object at $2F_1$	(b) Image real, inverted and of the same size
(2) Object between F_1 and $2F_1$	(c) Image real, inverted and highly diminished
	(d) Image real, inverted and enlarged

Ans.

(1) Object at $2F_1$ – Image real, inverted and of the same size

(2) Object between F_1 and $2F_1$ – Image real, inverted and enlarged.

(5) Column A	Column B
(1) Nearsightedness	(a) Ciliary muscles become weak
(2) Farsightedness	(b) Image in front of the retina
	(c) Colour-blindness
	(d) Image behind the retina

Ans.

(1) Nearsightedness – Image in front of the retina

(2) Farsightedness – Image behind the retina.

(6) Column A	Column B
(1) Convex lens	(a) To see small objects clearly
(2) Astronomical telescope	(b) To observe minute objects
	(c) To observe astronomical objects such as stars, planets, etc.
	(d) Presbyopia

Ans. (1) Convex lens – Presbyopia

(2) Astronomical telescope – To observe astronomical objects such as stars, planets, etc.

(7) Column A	Column B
(1) Persistence of vision	(a) Lenses and mirrors are used
(2) Reflecting telescope	(b) To see objects far away from us
	(c) Motion picture
	(d) To observe blood corpuscles

Ans. (1) Persistence of vision – Motion picture

(2) Reflecting telescope – Lenses and mirrors are used.

Q. 8 Complete the following table for convex lens : ***(3 marks) (Nov. '20)***

Position of object	Position of image	Size of image	Nature of image
(a)	At focus F_2	Point image	Real and inverted
(b) At $2F_1$	At $2F_2$	....	Real and inverted
(c) Between F_1 and O (within the focal length)	On the same side (object side)	Very large	....

Ans.

Position of object	Position of image	Size of image	Nature of image
(a) **At infinity**	At focus F_2	Point image	Real and inverted
(b) At $2F_1$	At $2F_2$	**Same size**	Real and inverted
(c) Between F_1 and O (within the focal length)	On the same side (object side)	Very large	**Virtual and erect**

Q. 9 Name the following :

(1) Name the lens which forms a real image or a virtual image depending on the position of the object.

Ans. A convex lens.

(2) Name the lens which produces magnification always less than 1.

Ans. A concave lens.

(3) Name the lens which always forms an image virtual and smaller than the object.

Ans. A concave lens.

(4) Name the lens used to obtain the image on a screen.

Ans. A convex lens.

(5) Name the lens for which the image always lies between the object and the lens.

Ans. A concave lens.

(6) Name the instrument used to observe bacteria.

Ans. A compound microscope.

(7) Name the instrument used to observe planets.

Ans. An astronomical telescope.

Q. 10 Answer the following questions :

(1) What is a lens?

Ans. A lens is a transparent material bound by two surfaces, out of which at least one surface is spherical.

[Note : A lens is normally made of glass or plastic.]

(2) In which instruments have you seen a lens?

Ans. We have seen a lens in a microscope and a telescope.

(3) How is a lens different from a mirror?

Ans. A mirror has one reflecting surface. By reflection of light, it forms an image of the object placed in front of it. A mirror is not transparent. A lens has two surfaces that form an image by refraction of light. A lens is transparent.

(4) Make a list of optical devices you know.

Ans. Microscope, telescope, binoculars, camera, projector.

(5) Do you know which is the natural optical device?

Ans. Yes. The eye is the natural optical device.

(6) What is a convex lens?

Ans. A lens having both spherical surfaces puffed up outwards is called a convex lens or double convex lens or biconvex lens. It is thicker in the middle than at the edges.

[Note : A convex lens is also called a converging lens.]

(7) What is a concave lens?

Ans. A lens having both spherical surfaces curved inwards is called a concave lens or double concave lens or biconcave lens. It is thicker at the edges than in the middle.

[Note : A concave lens is also called a diverging lens.]

(8) Draw neat labelled diagrams : Types of lenses.

Ans.

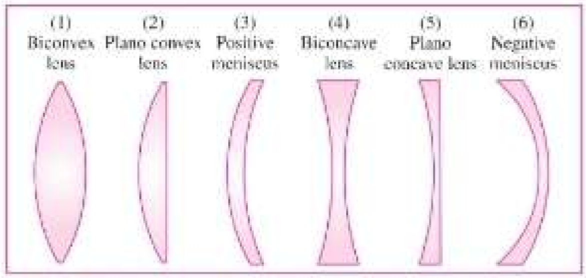


Fig. 7.3 : Types of lenses

[Note : Positive meniscus behaves as a convex lens as it is thicker in the middle than at the edges. Negative meniscus behaves as a concave lens as it is thicker at the edges than in the middle.]

(9) In general, when a ray of light passes through a lens, there occurs a change in its direction of propagation. Why?

Ans. The working of a lens is similar to that of a triangular prism. When a ray of light passes through a lens, it is refracted twice : When entering the lens and when emerging from the lens. There is a change in its direction of propagation every time and as both the changes occur in the same sense, the direction of propagation of the emergent ray is different from that of the incident ray.

(10) With reference to spherical lenses, state the meaning of the following terms or define the following terms and draw the diagrams to illustrate the same : (1) centre of curvature (C) (2) radii of curvature (R_1, R_2) (3) principal axis (4) optical centre (O) (5) principal focus (F) (6) focal length (f). *OR*

*** Draw a figure explaining various terms related to a lens.**

Ans.

(1) **Centre of curvature (C) :** The centres of the spheres whose parts form the surfaces of a lens are called the centres of curvature of the lens. A lens has two centres of curvature C_1 and C_2 for its two spherical surfaces.

(2) **Radii of curvature (R_1, R_2) :** The radii of the spheres whose parts form surfaces of a lens are called the radii of curvature of the lens.

(3) **Principal axis :** The imaginary straight line passing through the two centres of curvature of a lens is called the principal axis of the lens.

(4) **Optical centre (O) :** The point inside a lens on the principal axis, through which light rays pass without changing their path is called the optical centre (O) of the lens.

(5) **Principal focus (F) :** When light rays parallel to the principal axis are incident on a convex lens, they converge at a point on the principal axis. This point is called the principal focus (F) of the convex lens. Light rays travelling parallel to the principal axis of a concave lens diverge after refraction in such a way that they appear to be coming out of a point on the principal axis. This point is called the principal focus of the concave lens. A lens has two principal foci F_1 and F_2.

[**Note** : In this chapter, the terms focus and the principal focus are used in the same sense.]

(6) **Focal length (f) :** The distance between the optical centre and the principal focus of a lens is called the focal length (f) of the lens.

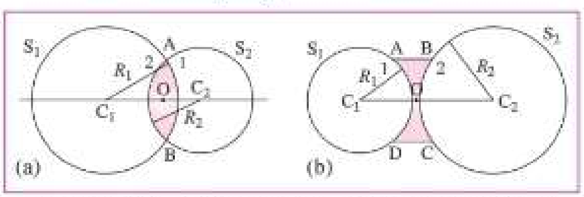


Fig. 7.4 : Cross sections of convex and concave lenses
C_1, C_2 : Centres of curvature, R_1, R_2 : Radii of curvature, O : Optical centre

The cross sections of convex and concave lenses are shown in parts (a) and (b) of Fig. 7.4. The surface marked as 1 is part of sphere S_1 while the surface marked as 2 is part of sphere S_2.

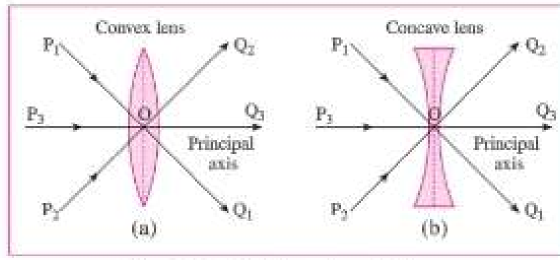


Fig. 7.5 : Optical centre of a lens
P_1, P_2, P_3 : Incident rays of light,
Q_1, Q_2, Q_3 : Refracted rays of light, O : Optical centre

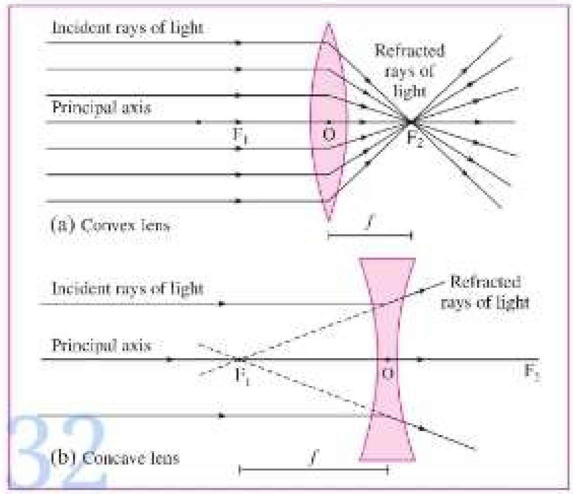


Fig. 7.6 : Principal focus and focal length of a lens
F_1, F_2 : Principal foci of the lens, f : Focal length of the lens

• Try this (Textbook page 81)

Material : Convex lens, screen, meter scale, stand for the lens, etc.

Method : Keeping the screen fixed, obtain a clear image of a distant object like a tree or a building with the help of the lens on the screen. Measure the distance between the screen and the lens with the help of the metre scale. Now turn the other side of the lens towards the screen. Again obtain a clear image of the distant object on the screen by moving the lens forward or backward. Measure the distance between the screen and the lens again.

The image of a distant object is obtained close to the focus of the lens, hence, the above distance is the focal length of the lens.

(1) Discuss the relation between this distance and the radius of curvature of the lens with your teacher.

(2) What will happen if you use a concave lens in this experiment?

Ans. (1) The focal length of a lens depends upon the radii of curvature (R_1, R_2) of the lens and the refractive index of the material of the lens (e.g. glass) with respect to the surrounding medium, i.e., air.

(2) If ${}_{g}n_{a} = 1.5$ and $R_1 = R_2 = R$, then $f = R$. If a concave lens is used in the above experiment, no image will be formed on the screen.

(11) State the rules used for drawing ray diagrams for the formation of an image by a convex lens. *OR*

Write any two rules used for drawing ray diagrams for the formation of an image by a convex lens. ***(2 marks) (July '19)***

Ans. Rules used for drawing ray diagrams for the formation of an image by a convex lens :

(1) When the incident ray is parallel to the principal axis, the refracted ray passes through the principal focus. (Fig. 7.7)

(2) When the incident ray passes through the principal focus, the refracted ray is parallel to the principal axis. (Fig. 7.8)

(3) When the incident ray passes through the optical centre of the lens, it passes without changing its direction. (Fig. 7.9)

(12) In the case of a convex lens, show the path of the refracted ray when the incident ray of light (1) is parallel to the principal axis of the lens (2) passes through the focus of the lens (3) passes through the optical centre of the lens.

Ans. (1)

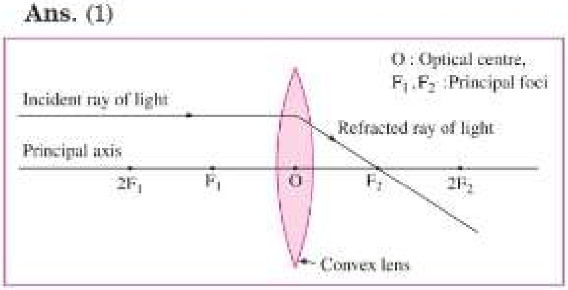


Fig. 7.7 : Incident ray of light parallel to the principal axis of a convex lens

(2)

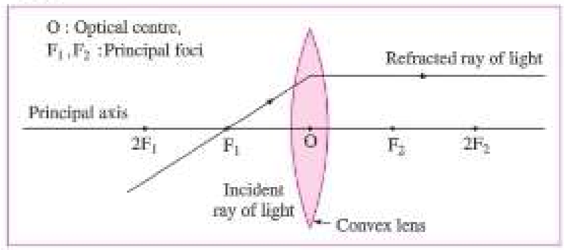


Fig. 7.8 : Incident ray of light passing through the focus of a convex lens

(3)

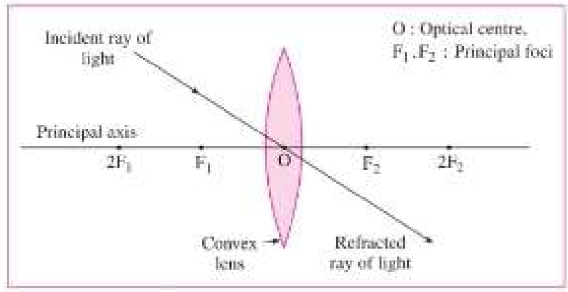


Fig. 7.9 : Incident ray of light passing through the optical centre of a convex lens

• Try this (Textbook page 82)

Material : A convex lens, screen, metre scale, stand for the lens, chalk, candle, etc.

Method :

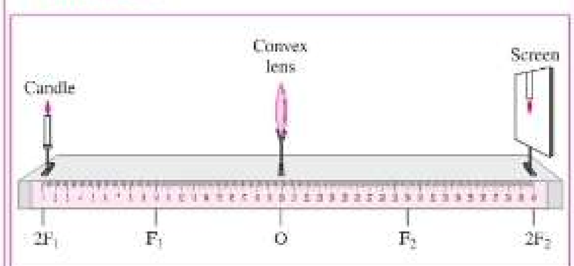


Fig. 7.10 : Arrangement for the experiment

(1) Draw a straight line along the centre of a long table.

(2) Place the lens on the stand at the central point (O) of the line.

(3) Place the screen on one side, of the lens. Move it along the line so as to get a clear image of a distant object. Mark its position as F_1.

(4) Measure the distance between O and F_1. Mark a point at distance $2F_1$ from O on the same side of F_1 and mark it as $2F_1$.

(5) Repeat actions 3 and 4 on the other side of the lens and mark F_2 and $2F_2$ on the straight line.

(6) Now place the burning candle on the other side of lens far beyond $2F_1$. Place the screen on the opposite side of the lens and obtain a clear image of the candle by moving it forward or backward along the line. Note the position, size and nature of the image.

(7) Repeat action 6 by placing the candle beyond $2F_1$, at $2F_1$, between $2F_1$ and F_1, at F_1 and between F_1 and O. Note your observations.

Ans. Images formed by a convex lens for different positions of the object

Sr. No.	Position of the object	Position of the image	Size of the image relative to that of the object	Nature of the image
(1)	At infinity	At focus F_2	Point image	Real and inverted
(2)	Beyond $2F_1$	Between F_2 and $2F_2$	Smaller	Real and inverted
(3)	At $2F_1$	At $2F_2$	Same size	Real and inverted
(4)	Between F_1 and $2F_1$	Beyond $2F_2$	Larger	Real and inverted
(5)	At focus F_1	At infinity	Very large	Real and inverted
(6)	Between F_1 and O	On the same side of the lens as the object	Very large	Virtual and erect

• Observe (Textbook page 83)

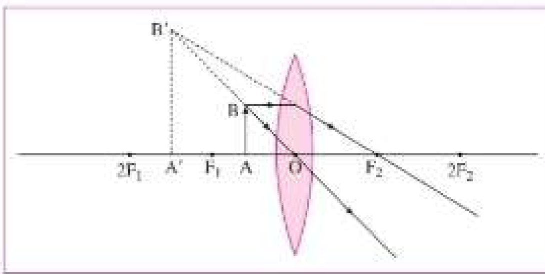


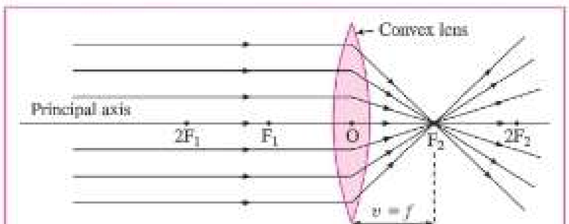
Fig. 7.11

Study figure 7.11. Determine the position, size and nature of images formed for different positions of an object with the help of ray diagrams. Check your conclusions and observations in the previous activity with those given in the table.

[*See the answer given above this box.*]

(13) Draw neat and well labelled ray diagrams for image formation by a convex lens when an object is (1) at infinity (2) beyond $2F_1$ (3) at $2F_1$ (4) between F_1 and $2F_1$ (5) at focus F_1 (6) between focus F_1 and optical centre O. Also, in each case, state the position, nature and size of the image relative to that of the object.

Ans. (1) Object at infinity :

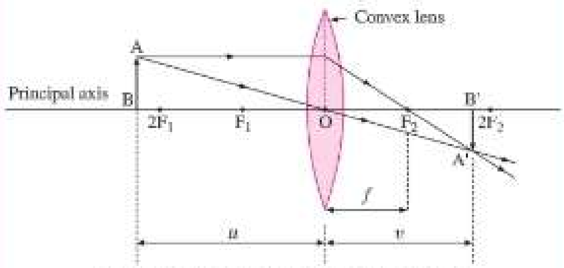


O : Optical centre, F_1, F_2 : Principal foci, f : Focal length, v : Image distance

Fig. 7.12 : Object at infinity

In this case, the image is formed at focus F_2 of the convex lens. It is real, inverted and highly diminished (point-sized).

(2) Object beyond $2F_1$:

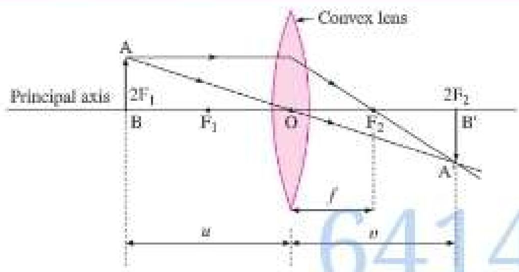


O : Optical centre, F_1, F_2 : Principal foci, f : Focal length, AB : Object, A'B' : Image, u : Object distance, v : Image distance

Fig. 7.13 : Object beyond $2F_1$

In this case, the image is formed between F_2 and $2F_2$. It is real, inverted and diminished.

(3) Object at $2F_1$:

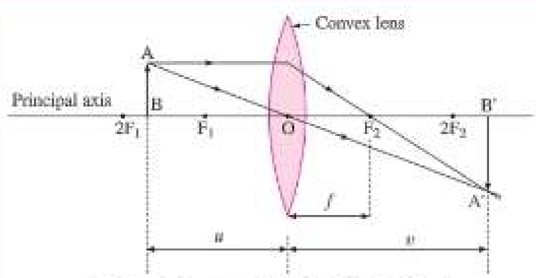


O : Optical centre, F_1, F_2 : Principal foci, f : Focal length, AB : Object, A'B' : Image, u : Object distance, v : Image distance

Fig. 7.14 : Object at $2F_1$

In this case, the image is formed at $2F_2$. It is real, inverted and of the same size as that of the object.

(4) Object between F_1 and $2F_1$:

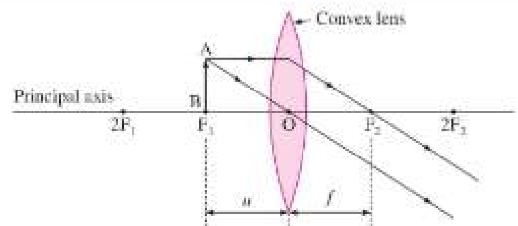


O : Optical centre, F_1, F_2 : Principal foci, f : Focal length, AB : Object, A'B' : Image, u : Object distance, v : Image distance

Fig. 7.15 : Object between F_1 and $2F_1$

In this case, the image is formed beyond $2F_2$. It is real, inverted and magnified (enlarged).

(5) Object at focus F_1 :

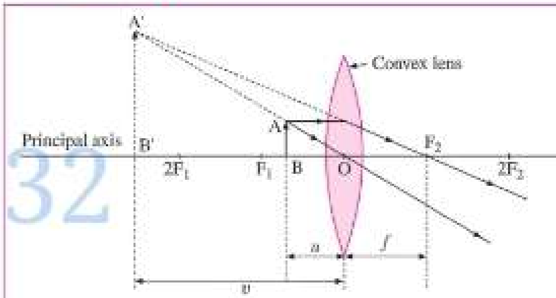


O : Optical centre, F_1, F_2 : Principal foci, f : Focal length, AB : Object, u : Object distance

Fig. 7.16 : Object at focus F_1

In this case, the image is formed at infinity. It is real, inverted and infinitely large (highly magnified).

(6) Object between focus F_1 and optical centre O :



O : Optical centre, F_1, F_2 : Principal foci, f : Focal length, AB : Object, A'B' : Image, u : Object distance, v : Image distance

Fig. 7.17 : Object between focus F_1 and optical centre O

In this case, the image is formed on the same side of the lens as the object. It is virtual, erect and larger than the object.

[**Note** : Here, the image is virtual. Hence, it is shown by a dotted line.]

(14) Observe the following figure and complete the table : ***(2 marks) (March '19)***

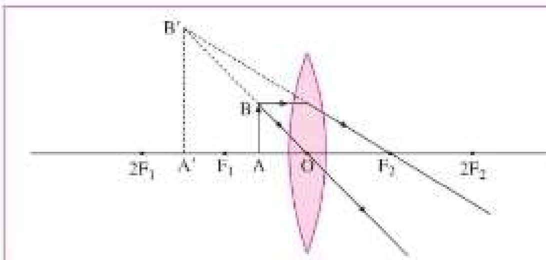


Fig. 7.18

Point	Answer
(i) Position of the object	Between F_1 and O
(ii) Position of the image	On the same side of the lens as the object
(iii) Size of the image	Very large
(iv) Nature of the image	Virtual and erect

(15) At which position will you keep an object in front of a convex lens to get a real image smaller than the object? Draw a figure.

Ans. The object should be placed beyond $2F_1$. *See figure 7.13.*

***(16) At which position will you keep an object in front of a convex lens so as to get a real image of the same size as the object? Draw a figure.**

Ans. At $2F_1$. *See figure 7.14.*

(17) State the rules used for drawing ray diagrams for the formation of an image by a concave lens.

Ans.

(1) When the incident ray is parallel to the principal axis, the refracted ray, when extended backwards, passes through the principal focus.

(2) When the incident ray is directed towards the principal focus F_2, the refracted ray is parallel to the principal axis.

(3) When the incident ray passes through the optical centre of the lens, it passes without changing its direction.

(18) State the characteristics of an image formed by a concave lens.

Ans. The image formed by a concave lens is always virtual, erect and smaller than the object. It is on the same side of the lens as the object. Generally, it is formed between the optical centre of the lens and the principal focus F_1. If the object is at infinity, the image is a point image formed at F_1.

(19) In the case of image formation by a concave lens, what can you say about the position, nature and size of the image relative to the size of the object?

Ans. Image formation by a concave lens :

(1) If the object is at infinity, the image is formed at the focus of the lens, on the same side of the lens as the object. It is virtual, erect and much smaller than the object (point image).

(2) If the object is at any finite distance from the lens, the image is formed on the same side of the lens as the object and between the focus and the optical centre of the lens. It is virtual, erect and smaller than the object. The image distance is less than the object distance.

(20) Draw a ray diagram to show image formation by a concave lens.

Ans.

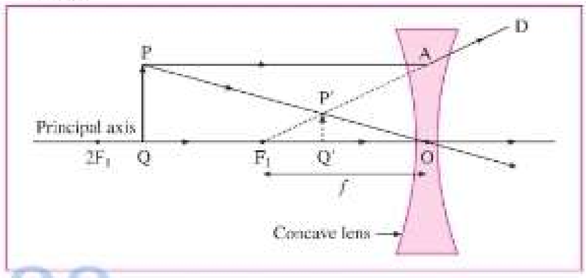


Fig. 7.19 : Image formed by a concave lens

PQ : Object, P'Q' : Image (virtual, therefore shown by a dotted line), O : Optical centre, F_1 : Principal focus, f : Focal length of the lens

[**Note** : If in a Board examination, incomplete diagram (as shown below) is given, students should complete it and label its parts as shown in Fig 7.19.]

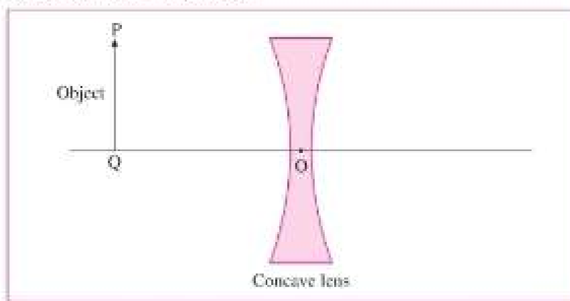


Fig. 7.20

(21) State the Cartesian sign convention for refraction of light (image formation) by a lens.

Ans. Cartesian sign convention for refraction of light (image formation) by a lens :

In this case, the optical centre (O) of the lens is taken as the origin and the principal axis of the lens is taken as X-axis of the coordinate system.

(1) The object is always placed at the left of the lens.

All distances parallel to the principal axis are measured from the optical centre of the lens.

(2) All distances measured to the right of the origin are taken as positive while distances measured to the left of the origin are taken as negative.

(3) Distances measured perpendicular to and above the principal axis are taken as positive.

(4) Distances measured perpendicular to and below the principal axis are taken as negative.

(5) The focal length of a convex lens is positive and that of a concave lens is negative. (Fig. 7.21)

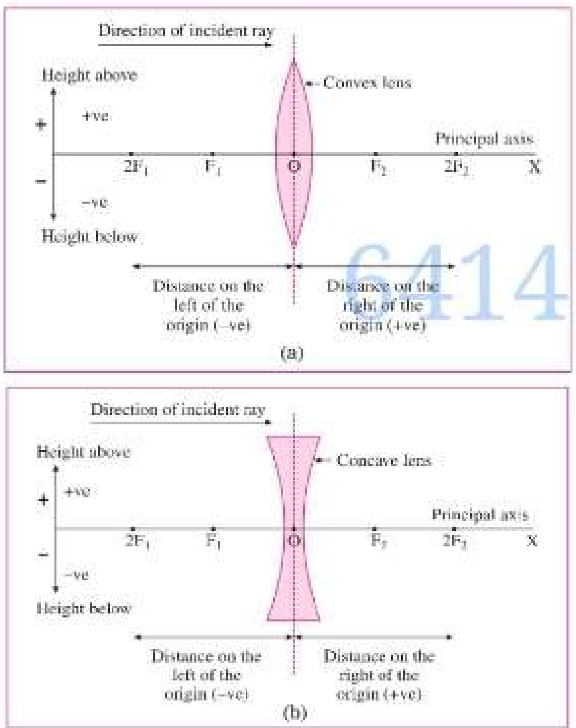


Fig. 7.21 : Cartesian sign convention

(22) (i) What is a lens formula? (ii) State it.

Ans. (i) The relationship between the object distance (u), image distance (v) and focal length (f) of a lens is called the lens formula.

(ii) It is $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

[**Note :** The lens formula holds good for all values of u and v and is applicable to a convex lens as well as a concave lens. The sign convention for u, v and f must be used in solving numerical examples.]

(23) What is meant by the magnification produced by a lens? State the formulae for it.

Ans. The magnification (M) produced by a lens is the ratio of the height of the image (h_2) to the height of the object (h_1).

$$M = \frac{h_2}{h_1} \quad \text{... (1)}$$

$$\text{Also, } M = \frac{v \text{ (image distance)}}{u \text{ (object distance)}} \quad \text{... (2)}$$

• **Use your brain power! (Textbook page 85)**

From equations (1) and (2) what is the relation between h_1, h_2, u and v?

Ans. $\frac{h_2}{h_1} = \frac{v}{u}$.

(24) When is the magnification produced by a lens (1) positive (2) negative?

Ans. The magnification produced by a lens is (i) positive when the image is virtual (as it is erect) (ii) negative when the image is real (as it is inverted).

(25) Express the magnification produced by a lens in terms of the focal length of the lens and (1) the object distance (2) the image distance.

Ans. Magnification (M) produced by a lens

$$= \frac{h_2 \text{ (height of the image)}}{h_1 \text{ (height of the object)}}$$

$$= \frac{v \text{ (image distance)}}{u \text{ (object distance)}}$$

$$\text{Now, } \frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \text{... (Lens formula)}$$

where f is the focal length of the lens.

$$\therefore \frac{u}{v} - \frac{u}{u} = \frac{u}{f} \quad \text{... (1)}$$

$$\text{and } \frac{v}{v} - \frac{v}{u} = \frac{v}{f} \quad \text{... (2)}$$

(1) From Eq. (1), we have

$$\frac{u}{v} - 1 = \frac{u}{f}$$

$$\therefore \frac{u}{v} = \frac{u}{f} + 1 = \frac{u+f}{f}$$

$$\therefore M = \frac{v}{u} = \frac{f}{u+f}$$

(2) From Eq. (2), we have

$$1-\frac{v}{u}=\frac{v}{f} \quad \therefore \frac{v}{u}=1-\frac{v}{f}=\frac{f-v}{f}$$

$$\therefore M=\frac{v}{u}=\frac{f-v}{f}$$

(26) An object is kept in front of a lens of focal length + 10 cm. Describe the nature of the image in the following cases : (1) The object distance is 25 cm. (2) The object distance is 5 cm.

Ans. Since, the focal length of the lens (+ 10 cm) is positive, it is a convex lens.

(1) If an object is kept at 25 cm from the lens, the image will be real, inverted and smaller than the object.

(2) If an object is kept at 5 cm from the lens, the image will be virtual, erect and larger than the object.

(27) Anu and Anand have concave and convex lenses respectively. They took lenses in sunlight and tried to burn two pieces of paper of equal areas and temperature. State which lens will burn the paper. Give the reason. Explain with the help of a diagram, why the other paper did not burn.

Ans.

(1) The convex lens will burn the paper. See Fig. 7.22 for reference. The ray of sunlight will converge at the principal focus of the lens. Hence, if the paper is held at the focus, it will burn due to concentration of heat energy.

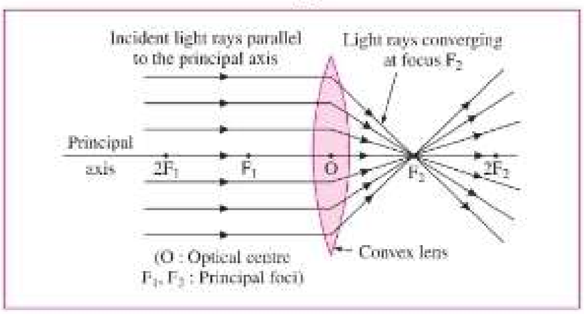


Fig. 7.22 : Action of a convex lens (Convergence of light rays)

(2) The paper held in front of the concave lens, will not burn. For reference, see Fig. 7.23. The concave lens will diverge the rays of sunlight falling on it. Hence, the paper will not burn.

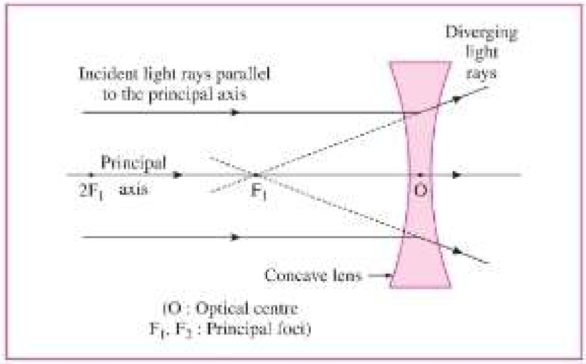


Fig. 7.23 : Action of a concave lens (Divergence of light rays)

(28) To obtain a magnified real image of a small film strip, which type of lens is used? Where is the film strip placed to obtain the image on the screen?

Ans. To obtain a magnified real image of a small film strip, a convex lens is used. The film strip is placed between F_1 and $2F_1$ and the screen is placed on the other side of the lens.

(29) When an object of height 2 cm is placed in front of a convex lens, the height of the image is found to be 3 cm. State the nature and position of the image giving reason.

Ans. When an object is placed between the optical centre and the principal focus of a convex lens, the image formed by the lens is virtual and larger than the object. When an object is placed between F_1 and $2F_1$, the image formed by the lens is real and larger than the object.

In the above case, if the image is virtual, it will be erect and on the same side of the lens as that of the object. If the image is real, it will be inverted and beyond $2F_2$ on the other side of the lens with respect to the object.

(30) You are given a lens which gives a virtual, erect and enlarged image. What type of lens is it?

Ans. Since the lens gives a virtual, erect and enlarged image, it must be a convex lens.

(31) When an object of height 3 cm is placed in front of a concave lens, the height of the image is found to be 6 cm. State, giving the reason, whether the given statement is true or false.

Ans. When an object is placed in front of a concave lens, the image formed by the lens is always smaller than the object. In the statement given in the question, the height of the image is reported as greater than that of the object. Hence, the statement given in the question is false.

(32) State two uses of a concave lens.

Ans.

(1) A concave lens is used to correct myopia (nearsightedness).

(2) In some optical instruments, a combination of a concave lens and a convex lens is used.

(33) State two uses of a convex lens.

Ans. A convex lens is used (1) to read words in small print (2) to correct hypermetropia (Far-sightedness).

(34) An object is kept in front of a lens of focal length -20 cm. Describe the nature of the image when the object distance is 25 cm.

Ans. Since the focal length of the lens (-20 cm) is negative, it is a concave lens.

If an object is kept at 25 cm from the lens, the image will be virtual, erect and smaller than the object.

[**Note** : The nature of the image is independent of the object distance as it is a concave lens.]

(35) An object is placed in front of a convex lens of focal length 20 cm. If the object distance is changed from 60 cm to 40 cm, what can you say about the size of the image relative to that of the object?

Ans. In this case, the focal length (f) of the lens is 20 cm. $\therefore\ 2f = 40$ cm. When the object distance is 60 cm (which is greater than $2f$), the image will be smaller than the object. When the object distance becomes 40 cm (which is equal to $2f$), the image will be of the same size as that of the object.

- **Use your brain power! (Textbook page 85)**

Take two convex lenses of different sizes. Collect sunlight on a paper using one of the lenses. The paper will start burning after a while. Note the time required for the paper to start burning. Repeat the process for the second lens. Is the time required the same in both cases? What can you tell from this?

Students should perform this experiment. When the heat radiation is focused on the paper at a higher rate, the time required for the paper to start burning is less.

(36) What is the power of a lens?

Ans. The capacity of a lens to converge or diverge incident rays is called its power. The power (P) of a lens is the inverse of the focal length (f) of the lens.

$$P = \frac{1}{f}$$

(37) What is the unit of power of a lens? Define it.

Ans. The unit of power of a lens is the dioptre (D).

One dioptre is the power of a lens whose focal length is one metre.

$$1 \text{ dioptre (D)} = \frac{1}{1 \text{ metre (m)}}$$

[**Note** : The dioptre, the SI unit of power of a lens, is denoted by D.]

(38) What is the sign of the power of (i) a convex lens (ii) a concave lens?

Ans. The power of a convex lens is positive while that of a concave lens is negative.

(39) If there is an increase or decrease in the focal length of a lens, what will be the effect on the power of the lens?

Ans. The power of a lens is the inverse of its focal length. Hence, if there is an increase in the focal length of a lens, the power of the lens will decrease accordingly. Similarly, if there is a decrease in the focal length of a lens, the power of the lens will increase accordingly.

(40) If two lenses of focal lengths f_1 and f_2 are kept in contact with each other, state the formula for the focal length of the combination. If P_1 and P_2 are the powers of these lenses, state the formula for the power of the combination.

Ans. If two lenses of focal lengths f_1 and f_2 are kept in contact with each other, the focal length (f) of the combination is given by $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$.

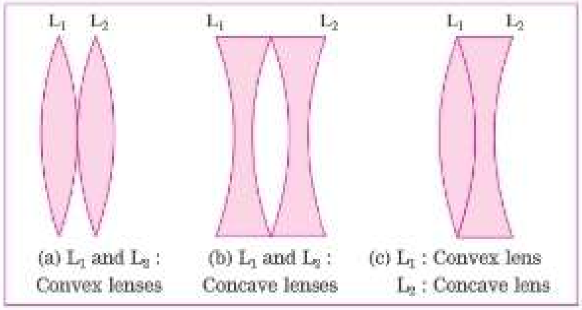


Fig. 7.24 : Combination of two lenses
[Two lenses kept in contact with each other]

If P_1 and P_2 are the powers of these lenses, the power (P) of the combination is given by $P = P_1 + P_2$.

[**Note** : The figures are given only for reference.]

(41) Draw a neat labelled diagram to show the structure of the human eye.

Ans.

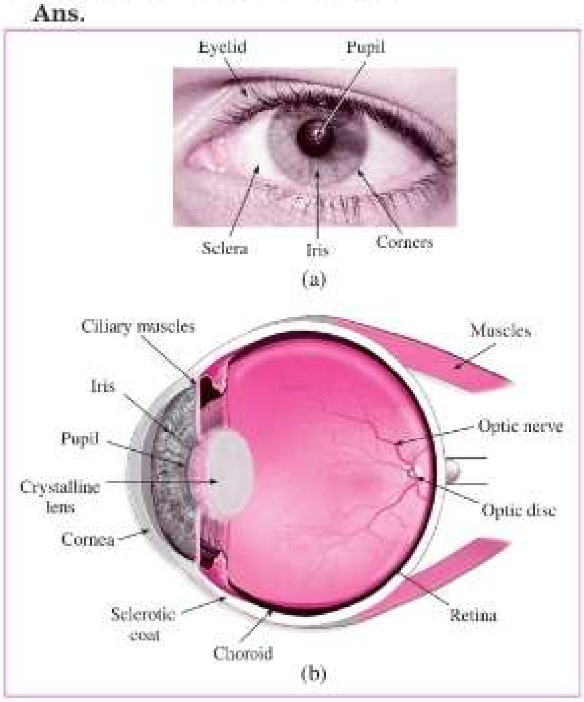


Fig. 7.25 : Construction of the human eye

(42) What is cornea?

Ans. The cornea is a thin and transparent cover (membrane) on the human eye through which light enters the eye. Maximum refraction of light rays entering the eye occurs at the cornea.

(43) What is iris?

Ans. The iris is a dark fleshy screen (muscular diaphragm) behind the cornea in the human eye. Its colours are different for different people.

(44) What is pupil?

Ans. The pupil is a small circular opening of changing diameter at the centre of the iris in the human eye.

(45) What is the use of the pupil in the human eye?

Ans. The pupil in the human eye is useful for controlling and regulating the amount of light entering the eye. The pupil contracts in the presence of too much light and dilates when light is insufficient, thus changing the amount of light entering the eye.

(46) With reference to the functioning of the pupil in the human eye, what is adaptation?

Ans. The tendency of the pupil in the human eye to adjust the opening for light, depending on the intensity of incident light, to control and regulate the amount of light entering the eye is called adaptation.

(47) What is the shape and the size of the human eyeball?

Ans. The human eyeball is approximately spherical in shape with a diameter of about 2.4 cm.

(48) Name the part of the human eye that forms a transparent bulge on the surface of the eyeball.

Ans. The cornea forms a transparent bulge on the surface of the eyeball.

(49) Which part of the human eye is located just behind the pupil?

Ans. A transparent biconvex crystalline lens is located just behind the pupil in the human eye.

(50) What is retina?

Ans. The retina is a light sensitive screen consisting of a delicate membrane with a large number of light sensitive cells.

(51) What is the nature of the eye lens and what does the eye lens do?

Ans. The eye lens is a double convex transparent crystalline lens, just behind the pupil. The eye lens provides small adjustment of focal length to form a real and inverted sharp image on the retina.

(52) What happens when light falls on the retina?

Ans. When light falls on the retina, light sensitive cells of the retina are activated. They generate electrical signals which are passed by optic nerves to the brain. The brain interprets the signals and processes the information such that we perceive the object as it is.

(53) What are ciliary muscles?

Ans. The muscles which hold the eye lens in its position, and bring about changes in the shape (curvature) of the eye lens, and hence of focal length are known as ciliary muscles.

(54) What is the focal length of the eye lens of a normal eye in relaxed position of eye muscles?

Ans. The focal length of the eye lens of a normal eye in relaxed position of eye muscles is about 2 cm.

(55) Where does the second focal point of the eye lens of a normal eye in relaxed position of eye muscles lie?

Ans. The second focal point of the eye lens of a normal eye in relaxed position of eye muscles lies on the retina.

(56) What is meant by power of accommodation of the eye?

Ans. The ability of the eye lens to adjust its focal length is called the power of accommodation of the eye.

(57) Explain the term power of accommodation of the eye. *OR* **Write a short note on the power of accommodation of the eye.**

Ans. Power of accommodation of the eye : The eye lens is held in its position by the ciliary muscles. When we look at a nearby object, the ciliary muscles compress the eye lens so that it becomes rounded. Hence, the focal length of the eye lens decreases. Therefore, the image is formed on the retina of the eye and hence the nearby object is seen clearly. When we look at a distant object, the ciliary muscles relax so that the eye lens becomes flat. Hence, the focal length of the eye lens increases. Therefore, the image is formed on the retina of the eye and hence the distant object is seen clearly. This ability of the eye lens to adjust its focal length is called the power of accommodation of the eye.

(58) What is meant by accommodation? How is it brought about?

Ans. The process of focusing the eye on objects at different distances is called accommodation. It is brought about by changing the curvature of the elastic eye lens making it thinner or thicker.

* **(59) What is the function of the iris and the muscles connected to the lens in the human eye?**

Ans. When the incident light is very bright, the muscles of the iris stretch to reduce the size of the pupil. When the incident light is dim, the muscles of the iris relax to increase the size of the pupil. Thus, the iris controls the size of the pupil and thereby regulates the amount of light entering the eye. (Fig. 7.26)

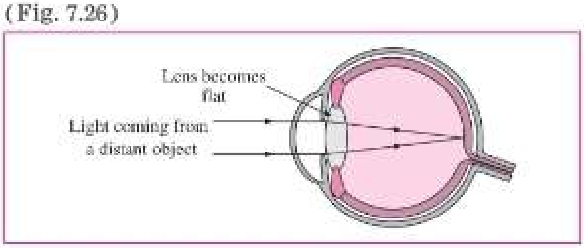


Fig. 7.26 : Formation of an image of a distant object

When a distant object is to be observed, the ciliary muscles relax so that the eye lens becomes flat. This increases the focal length of the lens. Therefore, a sharp image of the distant object is formed on the retina.

Thus, we can see a distant object clearly.

(Fig. 7.27)

When an object closer to the eye is to be observed, the ciliary muscles contract increasing the curvature of the eye lens. The eye lens, therefore, becomes rounded. This decreases the focal length of the lens. Therefore, a sharp image of the nearby object is formed on the retina. Thus, we can see a nearby object clearly. (Fig. 7.27)

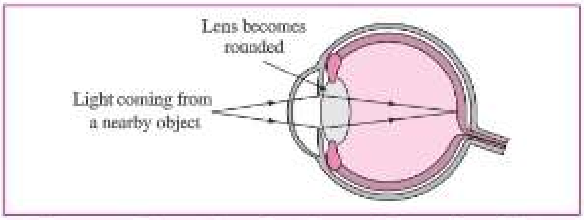
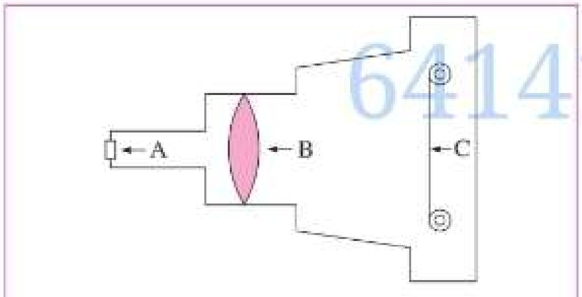


Fig. 7.27 : Formation of an image of a nearby object (Schematic diagram)

(60) The human eye is very similar to a photographic camera. The figure given shows the main parts of a photographic camera. Now answer the following questions :



A → Aperture, B → Lens, C → Photographic film

Fig. 7.28

(1) Name the parts of the human eye similar to the following parts of the photographic camera :

(a) Photographic film (b) Aperture.

(2) State one difference between the human eye lens and camera lens.

(3) Name the muscles which adjust the curvature of the eye lens.

(4) Which phenomenon of light is responsible for the working of the eye?

Ans.

(1) (a) The **retina** in the human eye is similar to the photographic film in a camera. (b) The **pupil** in the human eye is similar to the aperture in a camera.

(2) In a photographic camera, the focal length of the lens is fixed and the distance of the image from the lens changes when the position of the lens is changed. In the human eye, the focal length of the eye lens is changed by the ciliary muscles and the distance of the image from the eye lens is fixed.

(3) The ciliary muscles adjust the curvature of the eye lens.

(4) The refraction of light is responsible for the working of the eye.

(61) Have you seen a photographic camera in which a film is used? Compare the human eye with it. State similarities between them. State the points of difference between them. [HOTS]

Ans. Yes, we have seen a photographic camera in which a film is used.

Cameras, in general, have various shapes and sizes. Some cameras are much bigger than the human eye while some are smaller than the human eye. Here we shall consider a simple camera.

Similarities : In the case of a camera as well as the human eye, it is possible to control the amount of incoming light with the help of a diaphragm and an aperture. Both use a convex lens for focusing. The photographic film in a camera is coated with a photosensitive material. The retina in the eye consists of a large number of light sensitive cells. The photographic film in a camera is processed using chemicals and then prints (photographs) can be obtained using the appropriate paper.

In the human eye, the electrical signals generated by light sensitive cells are passed by optic nerves to the brain which interprets them.

Differences : Cameras come in a variety of sizes and shapes unlike the human eye. Unlike the human eye, a wide variation in exposure time is possible in the case of cameras. The human eye is sensitive in the visible region (red to violet) of the electromagnetic spectrum, while a much wider range of the electromagnetic spectrum can be covered with cameras designed for specific purposes. In comparison with the human eye, a wider view and range can be covered by a camera. In comparison with the human eye, a wider intensity (of light) range can be covered with a camera. The retina is indispensable in the human eye, while cameras without a photographic film have been designed with the help of photosensitive materials and are in current use.

[**Note :** With advances in technology, improved cameras are designed all the time, and the list of differences between the human eye and a camera in general would be practically endless.]

(62) Draw a scientifically correct labelled diagram of the human eye and answer the questions based on it :

(a) Name the type of lens in the human eye.

(b) Name the screen at which the maximum amount of incident light is refracted.

(c) State the nature of the image formed of the object on the screen inside the eye.

(5 marks) (March '20)

Ans. *See Fig. 7.25.*

(a) Double convex transparent crystalline lens.

(b) Cornea.

(c) Real and inverted image.

(63) What is meant by the minimum distance of distinct vision?

Ans. The minimum distance from the normal eye, at which an object is clearly visible without stress on the eye is called the minimum distance of distinct vision.

(64) Explain the term minimum distance of distinct vision. *OR* **Write a short note on distance of distinct vision.**

Ans. Minimum distance of distinct vision : Though the focal length of the eye lens is adjustable, it cannot be decreased below a certain limit. Hence, if an object is very close to the eye, it cannot be seen clearly. For a normal human eye, the minimum distance from the eye at which an object is clearly visible without stress on the eye, is called the minimum distance of distinct vision. For the normal human eye, it is 25 cm.

• Try this (Textbook page 88)

(1) Try to read a book keeping it very far from your eyes.

(2) Try to read a book keeping it very close to your eyes.

(3) Try to read a book keeping it at a distance of 25 cm from your eyes.

At which time do you see the alphabets clearly? Why?

Ans. *See the answer to Q. 10 (64).*

(65) State four reasons related to problems of vision.

Ans. Problems of vision are related to (i) weakening of ciliary muscles (ii) change in the size of the eyeball (iii) irregularities on the surface of cornea (iv) formation of a membrane over the eye lens.

(66) What is myopia or nearsightedness? What are the possible reasons of myopia? How is myopia corrected? Explain with diagrams.

Ans. Myopia or nearsightedness is the defect of vision in which a human eye can see nearby objects distinctly but is unable to see distant objects clearly as they appear indistinct.

In this case the image of a distant object is formed in front of the retina instead of on the retina.

[Figs. 7.29 (a), 7.29 (b)]

Possible reasons of myopia : (1) The curvature of the cornea and the eye lens increases. The muscles near the lens cannot relax so that the converging power of the lens remains large. (2) The distance between the eye lens and the retina increases as the eyeball elongates.

Myopia is corrected using a suitable concave lens. Light rays are diverged by the concave lens before they strike the eye lens. A concave lens of proper focal length is chosen to produce the required divergence. Hence, after the converging action of the eye lens, the image is formed on the retina. [Fig. 7.29 (c)]

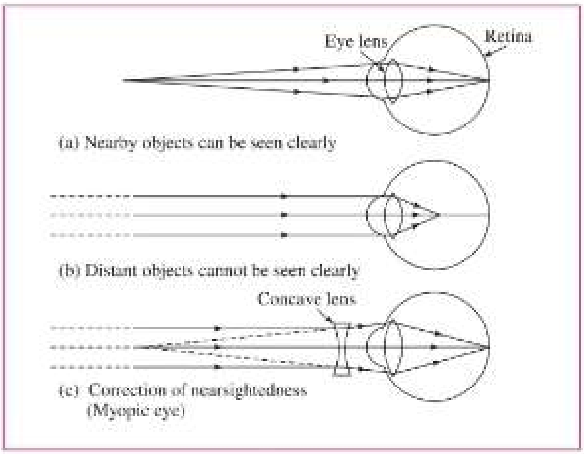


Fig. 7.29

(67) Observe the following diagram and answer the questions.

(a) Which eye defect is shown in this diagram?

(b) What are the possible reasons for this eye defect?

(c) How is this defect corrected? Write it in brief.

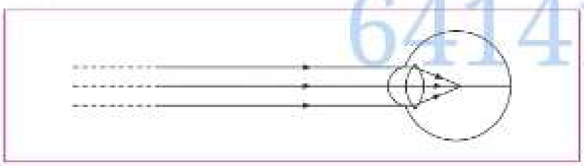


Fig. 7.30

Ans. (a) Myopia or Nearsightedness

(b) Possible reasons of the defect :

(i) The curvature of the cornea and the eye lens increases. The muscles near the lens cannot relax so that the converging power of the lens remains large.

(ii) The eyeball elongates so that the distance between the lens and the retina increases.

(c) Correction of the defect : This defect can be corrected using spectacles with concave lenses. A concave lens diverges the incident rays and these diverged rays can be converged by the lens in the eye to form an image on the retina.

(68) What is the sign of the power of the lens used to correct myopia?

Ans. The power of the lens used to correct myopia is negative.

[**Note :** It is a concave lens. ∴ Negative focal length ∴ Negative power.]

(69) In a Std. X class, out of 40 students, 10 students use spectacles, 2 students have positive power and 8 students have negative power of lenses in their spectacles.

Answer the following questions :

(1) What does the negative power indicate?

(2) What does the positive power indicate?

(3) Generally which type of spectacles do most of the students use?

(4) What defect of eyesight do most of the students suffer from?

(5) Give two possible reasons for the above defect.

Ans.

(1) The negative power indicates a concave lens or myopia.

(2) The positive power indicates a convex lens or hypermetropia.

(3) Generally, most of the students use spectacles with concave lenses.

(4) Most of the students suffer from myopia.

(5) Two possible reasons for myopia : *For reference, see the answer to Q. 10 (66).*

(70) What is hypermetropia or farsightedness? What are the possible reasons of hypermetropia? How is hypermetropia corrected? Explain with figures.

Ans. Hypermetropia or farsightedness is the defect of vision in which a human eye can see distant objects clearly but is unable to see nearby objects clearly.

In this case the image of a nearby object would fall behind the retina instead of on the retina.

[Figs. 7.31 (a), 7.31 (b)]

Possible reasons of hypermetropia : (1) The curvature of the cornea and the eye lens decreases. Hence, the converging power of the eye lens becomes less. (2) The distance between the eye lens and retina decreases (relative to the normal eye) and the focal length of the eye lens becomes very large due to the flattening of the eyeball.

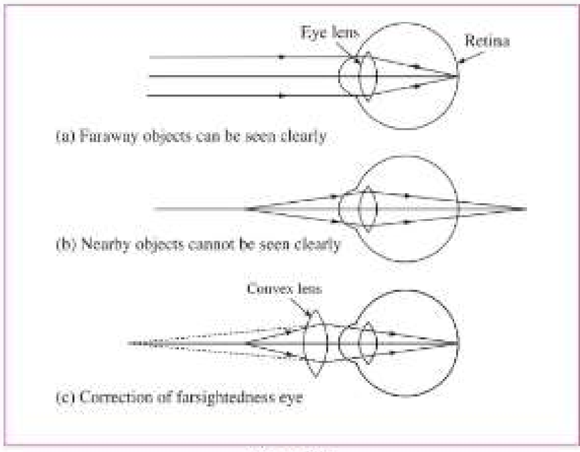


Fig. 7.31

Hypermetropia is corrected using a suitable convex lens. Light rays are converged by the convex lens before they strike the eye lens. A convex lens of proper focal length is chosen to produce the required convergence. Hence, after the converging action of the eye lens, the image is formed on the retina. [Fig. 7.31 (c)]

(71) What is the sign of the power of the lens used to correct hypermetropia?

Ans. The power of the lens used to correct hypermetropia is positive.

[**Note** : It is a convex lens. ∴ Positive focal length ∴ Positive power.]

(72) Given below is a diagram showing a defect of human eye.

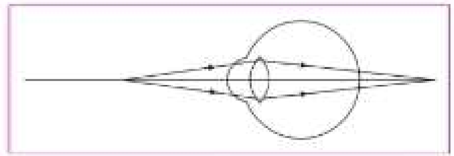


Fig. 7.32

Study it and answer the following questions :

(1) Name the defect shown in the figure.

(1 mark) (Board's Model Activity Sheet)

(2) Give two possible reasons for this defect of eye in human beings.

(3) Name the type of lens used to correct the eye defect.

(4) Draw a labelled diagram to show how the defect is rectified by using the lens.

For reference, see the answer to Q. 10 (70).

(73) Observe the following figures and complete the table.

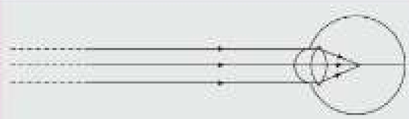
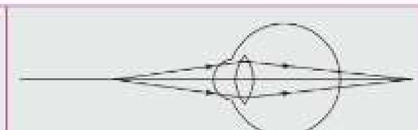
Points		
(1) Name of the defect.	Myopia (nearsightedness)	Hypermetropia (farsightedness)
(2) Where will the image form?	In front of the retina instead of on the retina	Behind the retina instead of on the retina
(3) Focusing power of the lens.	Negative	Positive
(4) Which type of lens is used in the spectacle to remove the defect?	A concave lens of proper focal length	A convex lens of proper focal length

Fig. 7.33

(74) What is presbyopia? State the reason for this defect. How is presbyopia corrected?

Ans. Presbyopia is the defect of vision in which aged people find it difficult to see nearby objects comfortably and clearly without spectacles.

Reason of presbyopia : The power of accommodation of eye usually decreases with ageing. The muscles near the eye lens lose their ability to change the focal length of the lens. Therefore, the near point of the eye lens shifts farther from the eye.

This defect is corrected using a convex lens of appropriate power. The lens converges light rays before they fall on the eye lens such that the action of the eye lens forms the image on the retina.

(75) What is a bifocal lens?

Ans. A biofocal lens is a lens of which the upper part is a concave lens to correct myopia and the lower part is a convex lens to correct hypermetropia.

[**Note :** A person suffering from myopia as well as hypermetropia, uses a bifocal lens. Nowadays, the defects of vision such as myopia and hypermetropia can be corrected using contact lenses or by laser surgery.]

(76) (A) Anil cannot see the blackboard writing clearly, but he can see nearby objects clearly.

(i) What is the eye defect he is suffering from?

(ii) How is it corrected?

(B) Anil's uncle cannot see nearby objects clearly, but he can see distant objects clearly.

(i) What is the eye defect he is suffering from?

(ii) How is it corrected?

Ans.

(A) Anil cannot see the blackboard writing clearly, but he can see nearby objects clearly.

(i) This defect is called myopia (nearsightedness).

(ii) It is corrected using spectacles having concave lenses of appropriate power.

(B) Anil's uncle cannot see nearby objects clearly, but he can see distant objects clearly.

(i) This defect is called hypermetropia (farsightedness).

(ii) It is corrected using spectacles having convex lenses of appropriate power.

(77) When are bifocal lenses used in spectacles?

Ans. When a person cannot see nearby objects as well as distant objects clearly, bifocal lenses are used in spectacles.

(78) Aniket from Std. X uses spectacles. The power of the lenses in his spectacles is – 0.5 D. Answer the following questions :

(1) State the type of lenses used in his spectacles.

(2) Name the defect of vision Aniket is suffering from.

(3) Find the focal length of the lenses used in his spectacles.

Ans. (1) Concave lenses are used in the spectacles used by Aniket.

(2) Aniket is suffering from myopia (near-sightedness).

(3) Focal length of the lenses used in his spectacles

$= \dfrac{1}{\text{power of the lens}} = \dfrac{1}{-0.5\text{ D}}$

$= -2$ m (Concave lens $\therefore$ Minus sign)

(79) Sunita from Std. X uses spectacles. Her spectacle number is – 1.5 D. Answer the following questions :

(1) Name the defect of eye from which she is suffering.

(2) What type of lens is she using?

(3) Find the focal length of the lens.

Ans. (1) Myopia. (2) Concave.

(3) $P = \dfrac{1}{f}$

$\therefore f = \dfrac{1}{P} = \dfrac{1}{-1.5\text{ D}} = \dfrac{10}{-15}\text{ m} = -\dfrac{2}{3}\text{ m} = \mathbf{-0.667\text{ m}}$

(Concave lens $\therefore$ minus sign)

This is the focal length of the lens.

(80) Surabhi from Std. X uses spectacles. The power of the lenses in her spectacles is 0.5 D. Answer the following questions from the given information : ***(3 marks) (March '19)***

(i) Identify the type of lenses used in her spectacles.

(ii) Identify the defect of vision Surabhi is suffering from.

(iii) Find the focal length of the lenses used in her spectacles.

Ans. (i) Convex lenses are used in the spectacles used by Surabhi.

(ii) Surabhi is suffering from hypermetropia (farsightedness).

(iii) Focal length of the lenses used in her spectacles

$$= \frac{1}{\text{power of the lens}} = \frac{1}{0.5\ D} = 2\ m.$$

(81) My grandfather uses a bifocal lens in his spectacles. Explain why.

Ans. In old age, people usually suffer from both myopia and hypermetropia. Therefore, they need spectacles having bifocal lenses.

The upper part of a bifocal lens is a concave lens to correct myopia. The lower part of a bifocal lens is a convex lens to correct hypermetropia.

• Try this (Textbook page 89)

(1) Make a list of students in your class using spectacles.

(2) Record the power of their lenses.

Find out and note which type of defect of vision they suffer from. Which defect is most common among the students?

(*Students should carry out this activity.*)

(82) State uses of a concave lens.

Ans. (1) Concave lenses are used for proper working of medical equipment, scanner, CD player – the instruments that employ laser rays.

(2) One or more concave lenses are used in a small safety device, fitted in the peep hole in a door, due to which we can see a large area outside the door.

(3) Concave lenses are used in spectacles to correct nearsightedness (myopia).

(4) A concave lens is used to spread light emitted by the small bulb in a torch over a wide area.

(5) A concave lens is used in front of the eyepiece or inside the eyepiece fitted in a camera, telescope and microscope – the instruments employing convex lenses.

(83) State uses of a convex lens.

Ans. Convex lenses are used in a simple microscope, compound microscope, refracting telescope, camera, projector, spectroscope, spectacles for correcting farsightedness (hypermetropia) and binoculars.

(84) What is meant by the apparent size of an object? With a neat and labelled diagram, explain the relation between the apparent size of an object and the angle subtended by the object at the eye.

Ans. An object appears small or big depending upon the size of its image formed on the retina of the eye. The size of an object as perceived by the eye is called the apparent size of the object. Consider two objects of the same size, one held near the eye and the other away from the eye as shown in the following figure (Fig. 7.34). The nearby object (PQ) appears larger than the distant object (P_1Q_1).

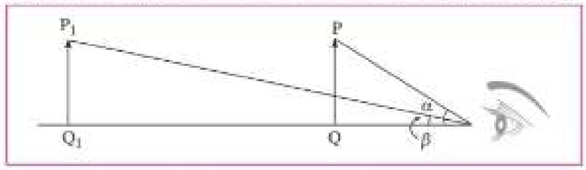


Fig. 7.34 : Apparent size of an object

Also, the angle α subtended by the nearby object at the eye is larger than the angle β subtended by the distant object at the eye. This shows that the apparent size of an object depends upon the angle subtended by the object at the eye. The greater the angle subtended by the object at the eye, the greater is the apparent size of the object. Similarly, the smaller the angle subtended by the object at the eye, the smaller is the apparent size of the object.

• Use your brain power! (Textbook page 89)

(1) Why do we have to bring a small object near the eyes in order to see it clearly?

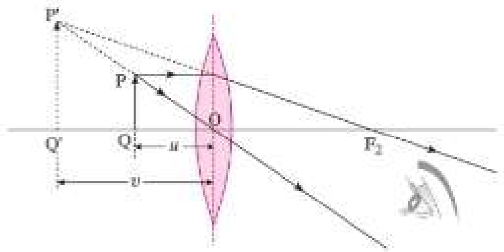
(2) If we bring an object closer than 25 cm from the eyes, when can we not see it clearly even though it subtends a bigger angle at the eye?

Ans. (1) When a small object is brought near the eyes, its apparent size increases. Therefore, it is seen clearly. (2) *See the answer to Q. 10 (64).*

(85) With a neat labelled diagram, explain the working of a simple microscope. State uses of a simple microscope. *OR*

What does a simple microscope consist of? What is the order of magnification obtained by a simple microscope? What is a simple microscope used for?

Ans. A simple microscope consists of a convex lens of short focal length, usually fixed in a suitable frame with a handle or mounted on a stand.



F_2 : Principal focus of the lens, PQ : Object, P'Q' : Image, u : Object distance, v : Image distance.

Fig. 7.35 : A simple microscope

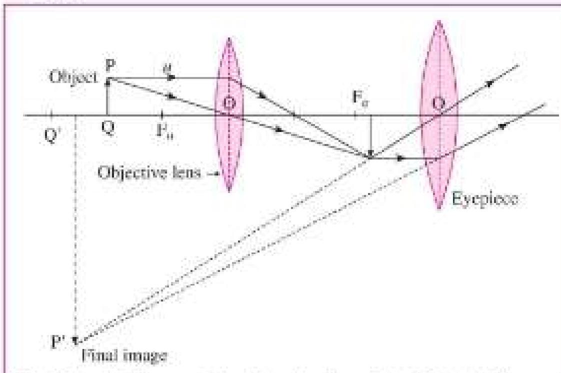
The object is placed in front of the convex lens of short focal length such that the object distance is less than the focal length. The image is virtual and larger than the object. It is formed on the same side of the lens as the object.

A maximum magnification of about 20 can be obtained by a simple microscope.

A simple microscope is used by watch repairers to observe small parts of a watch and by jewellers to examine ornaments. A simple microscope (also called a magnifying glass) is also used to read words in small print.

(86) With a neat labelled diagram, explain the construction and working of a compound microscope.

Ans.



F_o : Principal focus of the objective lens, F_e : Principal focus of the eyepiece, u : Distance between the object and the objective lens, PQ : Object, P'Q' : Final image.

Fig 7.36 : A compound microscope

Construction of a compound microscope :

(1) A compound microscope consists of a metal tube fitted with two convex lenses at the two ends. These lenses are called the objective lens (the lens directed towards the object) and the eyepiece (the lens directed towards the eye). Both the lenses are small in size, but the cross section of the objective lens is less than that of the eyepiece. The objective lens has a short focal length. The focal length of the eyepiece is more than that of the objective lens.

(2) The metal tube is mounted on a stand. The principal axes of the objective lens and the eyepiece are along the same line. The distance between the object and the objective lens can be changed with a screw. It is possible to change the distance between the objective lens and the eyepiece.

Working :

(1) The object to be observed is illuminated and placed in front of the objective lens, slightly beyond the focal length of the objective lens. Its real, inverted and enlarged image is formed by the objective lens on the other side.

(2) This intermediate image lies within the focal length of the eyepiece. It serves as an object for the eyepiece. The eyepiece works as a simple microscope. The final image is virtual, highly enlarged and inverted with respect to the original object. It can be formed at the minimum distance of distinct vision from the eyepiece. The final image is observed by keeping the eye close to the eyepiece.

(87) State two uses of a compound microscope.

Ans. Uses of a compound microscope :

(1) It is used to observe blood corpuscles, plant and animals cells, microorganisms like bacteria, etc.

(2) It is used in a pathological laboratory to observe blood, urine, etc.

(3) It is a part of a travelling microscope used for measurement of very small distance.

(88) What will happen if in a compound microscope, the objective lens is large in size and has a focal length?

Ans. If the objective lens of a compound microscope is large in size, in addition to the light coming from an object, other unwanted light will be incident on the objective lens. Hence, the image will not be seen clearly. If the objective lens has a large focal length, the magnification produced by it will be less.

(89) (a) In which type of microscope do you find the lens arrangement as shown in the following diagram?

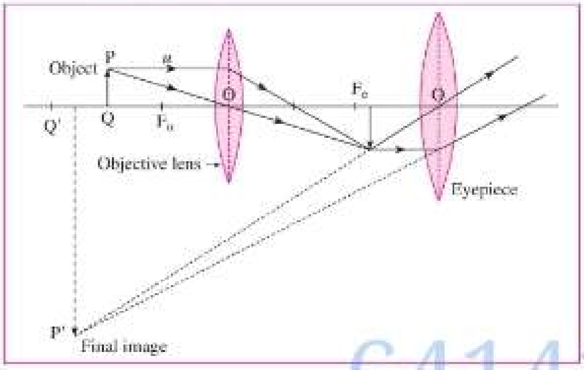


Fig. 7.37

(b) Write in brief, the working of this microscope.

(c) Where is this microscope used?

Ans. (a) Compound microscope.

(b) (1) *See the answer to Q. 10 (86).*

(c) *See the answer to Q. 10 (87).*

(90) Observe the following figure and answer the questions :

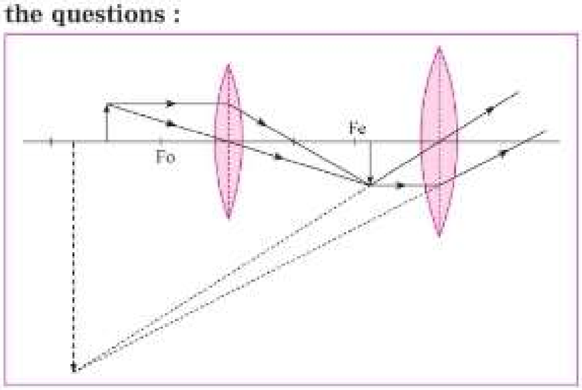


Fig. 7.38

(a) In which type of microscope do you find the lenses arrangement as shown in the following figure?

(b) Write in brief, the working of this microscope.

(c) How can we get different magnifications in this optical instrument?

(d) Draw the figure again and label it properly.

(5 marks) (Board's Model Activity Sheet)

Ans. (a) Compound microscope.

(b) *See the answer to Q. 10 (86).*

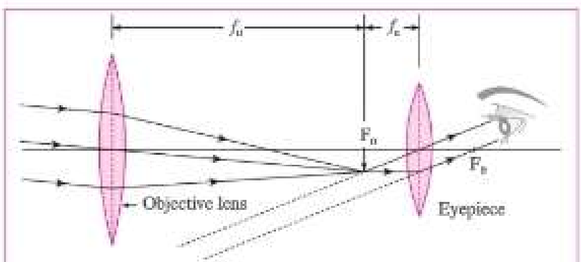
(c) We can get different magnifications by using the eyepieces of different focal lengths.

(d) *See Fig. 7.36.*

(91) With a neat labelled diagram, explain the working of a refracting telescope. *OR*

***Explain the working of an astronomical telescope using refraction of light.**

Ans. Construction of a refracting telescope : It consists of two convex lenses called the objective lens (directed towards the object) and the eyepiece (directed towards the eye). The focal length and diameter of the objective lens are respectively greater than the focal length and diameter of the eyepiece. The objective lens is fitted at one end of a long metal tube. A metal tube of smaller diameter is fitted in this metal tube and the eyepiece is fitted at the outer end of the smaller tube. With the help of a screw it is possible to change the distance between the eyepiece and the objective lens by sliding the tube fitted with the eyepiece. The principal axes of the objective lens and the eyepiece are along the same line. A telescope is usually mounted on a stand.



F_o : Principal focus of the objective lens, F_e : Principal focus of the eyepiece, f_o : Focal length of the objective lens, f_e : Focal length of the eyepiece.

Fig. 7.39 : Refracting telescope

Working : When the objective lens is pointed towards the distant object to be observed, the rays of light from the distant object, which are almost parallel to each other, pass through the objective lens. The objective lens collects maximum amount of light as it is large in size. It forms a real, inverted and diminished image in the focal plane of the objective lens. Now, the position of the eyepiece is adjusted such that this image falls just within the focal length of the eyepiece and serves as the object for the eyepiece which works as a simple microscope. The final image is highly magnified, virtual, on the same side as that of the object and inverted with respect to the original object. The final image can be observed by keeping the eye close to the eyepiece. If the image formed by the objective lens lies in the focal plane of the eyepiece, the final image is formed at infinity.

(92) State the use of a telescope.

Ans. A telescope is used to observe a distant object such as mountain, moon, planet, star in the magnified form.

• Try this (Textbook page 91)

(1) Take a burning incense stick in your hand and rotate it fast along a circle.

Ans. A circle of red light is seen.

(2) Draw a cage on one side of a cardboard and a bird on the other side. Hang the cardboard with the help of a thread. Twist the thread and leave it. What do you see and why?

Ans. The bird appears to be inside the cage.

This happens due to persistence of vision. For explanation, *see the answer to Q. 10 (94).*

(93) Observe the following figure and answer the questions.

(a) Which optical instrument shows arrangement of lenses as shown in the figure?

(b) Write in brief the working of this optical instrument.

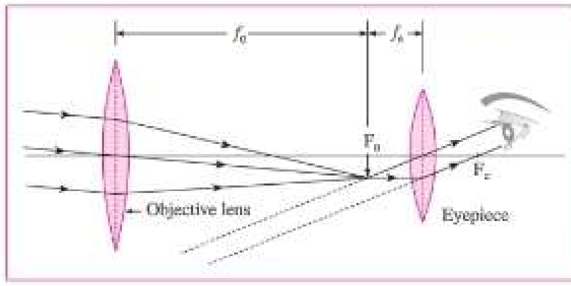


Fig. 7.40

(c) How can we get different magnifications in this optical instrument?

(d) Draw the figure again and labelled it properly.

Ans. (a) Refracting telescope.

(b) *See the answer to Q. 10 (91).*

(c) We can get different magnifications by using the eyepieces of different focal lengths.

(d) *See Fig. 7.39.*

(94) What is persistence of vision? Give one example of persistence of vision.

Ans. Persistence of vision : We see an object when its image is formed on the retina. The image disappears when the object is removed from our sight. But this is not instantaneous and the image remains imprinted on the retina for about $\frac{1}{16}$ th of a second after the removal of the object. The sensation on the retina persists for a while. This effect is known as the persistence of vision. It is due to persistence of vision that we continue to see the object in its position for about $\frac{1}{16}$ th of a second after it is removed.

Example : When a burning stick of incense is moved fast in a circle, a circle of red light is seen.

(95) Name two devices whose working is based on the phenomenon of persistence of vision. *OR*

Name any two applications based on persistence of vision.

Ans. The working of a television set and motion picture is based on the phenomenon of persistence of vision.

[**Note :** These are the examples of persistence of vision in daily life.]

(96) How is the phenomenon of persistence of vision used in motion pictures?

Ans. In motion pictures, photographs of a moving object are taken at the rate of more than sixteen pictures per second. These photographs are projected on the screen at the same rate.

Each picture is slightly different from the other. As a result of persistence of vision, we get the impression of observing the object in continuous motion.

(97) Name the two types of light sensitive cells present in the retina of the human eye. What are their functions ?

Ans. (1) The retina of the human eye contains a large number of light sensitive cells. These cells are of two shapes : (i) rods and (ii) cones.

(2) The rod-like cells respond to the intensity of light.

(3) The conical cells respond to various colours of light. They respond differently to red, green and blue colours. They do not respond to faint light.

(98) When do you say that a person is colour-blind?

Ans. When a person is unable to distinguish between certain colours, he is said to be colour-blind.

[**Note** : (i) Except for being colour-blind, their eyesight is normal. (ii) Rod-shaped cell = rod-like cell, cone-shaped cell = Conical cell.]

(99) Explain the perception of colour in the human eye. *OR*

Explain in short perception of colour. *OR*

Write a note on perception of colour.

Ans. (1) In nature we find objects of various colours. Perception of colour means to be able to respond to colour.

(2) We can distinguish between various colours due to perception of colour.

(3) The cone-shaped cells on the retina of the eye respond to the various colours when light is bright and communicate to the brain about the colours of the image formed on the retina. This gives us the proper idea about the colours of the object.

(4) If, in the retina of a person, the cone-shaped cells responding to certain specific colours are absent, the person is unable to distinguish between the colours. As a result, he lacks perception of colour.

• **Can you tell? (Textbook page 91)**

How do we perceive different colours?

Ans. *See the answer to Q. 10 (99).*

(100) What is colour-blindness?

Ans. (1) The retina of the human eye contains a large number of light sensitive cells. These cells are of two shapes : (i) rods and (ii) cones.

(2) The cone-shaped cells respond to various colours of light when light is bright.

(3) Thus, the perception of colour is due to the presence of the cone-shaped cells in the retina.

(4) In the retina of some persons, cone-shaped cells responding to certain specific colours are absent. Hence, these persons are unable to distinguish between certain colours, i.e., they are colour-blind. This defect is known as colour-blindness.

(101) Why are some persons colour-blind? What is the cause of this defect?

Ans. In the retina of some persons, cone-shaped cells responding to certain specific colours are absent. Hence, these persons are unable to distinguish between certain colours, i.e., they are colour-blind.

(102) What are the difficulties faced by a colour-blind person?

Ans. (1) A colour-blind person cannot distinguish between different colours. For example, he cannot distinguish between red and green colours. Also he cannot distinguish between blue and green colours. Red and green, both appear grey. Since a colour-blind person cannot distinguish between red and green colours, it is difficult for him to cross a road. There is a possibility of an accident while crossing a road.

(2) A colour-blind person cannot distinguish between two objects of different colours, which are otherwise identical, e.g., clothes.

(3) A colour-blind person may have an inferiority complex and hence may find it difficult to mix with other persons.

Q. 11 Give scientific reasons :

(1) A convex lens is known as a converging lens.

Ans. When rays of light parallel to the principal axis of a convex lens pass through the lens, they converge to a point on the principal axis. Hence, a convex lens is known as a converging lens.

(2) A concave lens is called a diverging lens.

Ans. When rays of light parallel to the principal axis of a concave lens pass through the lens, they appear to diverge from a point on the principal axis. Hence, a concave lens is called a diverging lens.

(3) A simple microscope is used for watch repairs.** ***(Nov. '20) *OR*

Watch repairers use a magnifying glass.

Ans. (1) When an object is placed within the focal length of a magnifying glass or simple microscope (convex lens), its larger and erect image is obtained on the same side of the lens as that of the object.

(2) By adjusting the distance between the object and the lens, the image can be obtained at the minimum distance of distinct vision. Thus, a watch repairer can see the minute parts of a watch more clearly with the aid of a magnifying glass (a simple microscope) than with the naked eye, without any stress on the eye. Hence, watch repairers use a magnifying glass (a simple microscope) while repairing the watches.

(4) In old age, a bifocal lens is necessary for some persons.

Ans. (1) Some people, in old age, suffer from myopia (nearsightedness) as well as hypermetropia (farsightedness).

(2) Myopia is corrected using a concave lens of appropriate power. Hypermetropia is corrected using a convex lens of appropriate power. Therefore, they need a bifocal lens.

(5) A person suffering from myopia (nearsightedness) uses spectacles of concave lenses.

Ans. (1) A person suffering from myopia can see nearby objects clearly as the image of a nearby object is formed on the retina, but cannot see distant objects clearly as the image of a distant object is formed in front of the retina instead of on the retina.

(2) A concave lens diverges the rays of light passing through it. When spectacles of concave lenses of appropriate power are used, the parallel rays coming from a distant object are diverged to proper extent before they are incident on the eye lens. Therefore, after the converging action of the eye lens, the image of a distant object is formed on the retina of the eye and hence the distant object can be seen clearly.

(6) A person suffering from hypermetropia (farsightedness) uses spectacles of convex lenses.

Ans. (1) A person suffering from hypermetropia can see distant objects clearly as the image of a distant object is formed on the retina, but cannot see nearby objects clearly as the image of a nearby object would be formed behind the retina instead of on the retina.

(2) A convex lens converges the rays of light passing through it. When spectacles of convex lenses of appropriate power are used, the rays of light coming from a nearby object are converged to proper extent before they are incident on the eye

lens. Therefore after the converging action of the eye lens, the image of a nearby object is formed on the retina of the eye and hence the nearby object can be seen clearly.

(7) You cannot enjoy watching a movie from a very short distance from the screen in a cinema hall. **[HOTS]**

Ans. (1) The less the distance between the screen in a cinema hall and the person watching the movie, the more is the intensity of light falling on the eye.

(2) This results in great contraction of the pupil of the eye causing a strain. Hence, you cannot enjoy watching a movie from a very short distance from the screen in a cinema hall.

***(8) We cannot clearly see an object kept at a distance less than 25 cm from the eye.**

Ans. (1) When we try to see a nearby object, the eye lens becomes more rounded and its focal length decreases. Then a clear image of the object is formed on the retina of the eye.

(2) The focal length of the eye lens cannot be decreased beyond some limit. Therefore we cannot clearly see an object kept at a distance less than 25 cm from the eye.

***(9) One can sense colours only in bright light.**

Ans. (1) The retina in the eye is made of many light sensitive cells. The rod-shaped cells respond to the intensity of light while the cone-shaped cells respond to various colours.

(2) The cone-shaped cells do not respond to faint light. They function only in bright light. Hence, one can sense colours only in bright light.

(10) The rays of light travelling through the optical centre of a lens pass without changing their path.

Ans. The portion of a lens near the optical centre is like a very thin slab of glass. Hence, the rays of light travelling through the optical centre of a lens pass without changing their path.

(11) A convex lens converges the rays of light falling on it.

Ans. (1) A convex lens can be regarded as made of a very large number of portions of triangular prisms. The bases of these prisms are towards the central thicker portion of the lens.

(2) A ray of light passing through a prism bends towards its base. Hence, a convex lens converges the rays falling on it.

(12) A concave lens diverges the rays of light falling on it.

Ans. (1) A concave lens can be regarded as made of a very large number of portions of triangular prisms. The bases of these prisms are towards the edges of the less, i.e., away from the central thinner portion of the lens.

(2) A ray of light passing through a prism bends towards its base. Hence, a concave lens diverges the rays of light falling on it.

(13) When a burning stick of incense is moved fast in a circle, a circle of red light is seen.

Ans. The impression of the image on the retina lasts for about $\frac{1}{16}$th of a second after the removal of the object. If a burning stick of incense is moved at a rate of more than sixteen revolutions per second, we see a circle of red light due to persistence of vision.

(14) Colour-blind persons are unable to distinguish between different colours.

Ans. (1) The cone-shaped cells in the retina of a person respond to colours. This makes the perception of colours possible.

(2) In the retina of colour-blind persons, cone-shaped cells responding to certain specific colours are absent. Hence, they are unable to distinguish between different colours.

(15) It is risky to issue a driving license to a person suffering from colour-blindness.

Ans. A colour-blind person cannot distinguish between different colours. If a driver is colour-blind, he will not be able to distinguish between the colours of the signal and the colours on different sign boards. This will lead to an accident. Hence, it is risky to issue a driving license to a person suffering from colour-blindness.

Q. 12 Distinguish between the following :

(1) Real image and Virtual image.

Ans.

Real image	Virtual image
1. A real image is formed when the light rays starting from an object meet after reflection or refraction.	1. A virtual image is formed when the light rays starting from an object (when extended backward) appear to meet after reflection or refraction.
2. It can be projected on a screen.	2. It cannot be projected on a screen.
3. It is inverted with respect to the object.	3. It is erect with respect to the object.
4. It can be obtained with a concave mirror and a convex lens.	4. It can be obtained with a plane mirror, a convex mirror and a concave lens.

***(2) Concave lens and Convex lens.**

Ans.

Concave lens	Convex lens
1. A concave lens has its surfaces curved inwards.	1. A convex lens has its surfaces puffed up outwards.
2. It is thicker at the edges than in the middle.	2. It is thicker in the middle than at the edges.
3. It can form only a virtual image.	3. It can form a real image as well as a virtual image.
4. It can form only a diminished image.	4. It can form a magnified, diminished or the same sized image (relative to the object) depending on the position of the object.

***(3) Farsightedness (Hypermetropia) and Nearsightedness (Myopia).**

Ans.

Farsightedness (Hypermetropia)	Nearsightedness (Myopia)
1. In hypermetropia, a human eye can see distant objects distinctly but is unable to see nearby objects clearly.	1. In myopia, a human eye can see near objects distinctly, but is unable to see distant objects clearly.
2. Possible reasons of the defect : (i) The curvature of the cornea and the eye lens decreases. Hence, the converging power of the eye lens becomes less. (ii) The distance between the eye lens and retina decreases (relative to the normal eye) and the focal length of the eye lens becomes very large due to the flattening of the eyeball.	2. Possible reasons of the defect : (i) The curvature of the cornea and the eye lens increases. The muscles near the lens cannot relax so that the converging power of the lens remains large. (ii) The eyeball elongates so that the distance between the lens and the retina increases.
3. In this case, the image of a nearby object would be formed behind the retina.	3. In this case, the image of a distant object is formed in front of the retina.
4. This defect can be corrected using a convex lens of appropriate power.	4. This defect can be corrected using a concave lens of appropriate power.

(4) Simple microscope and Compound microscope.

Ans.

Simple microscope	Compound microscope
1. In a simple microscope, only one convex lens is used.	1. In a compound microscope, two convex lenses, objective and eyepiece, are used.
2. In this case, the object is placed within the focal length of the convex lens.	2. In this case, the object is placed beyond the focal length of the objective lens.
3. Its magnifying power is much less than that of a compound microscope.	3. Its magnifying power is much greater than that of a simple microscope.
4. It is used to observe minute parts of a watch, to read words in small print, etc.	4. It is used to observe blood corpuscles, plant and animal cells, etc.

(5) Compound microscope and Astronomical refracting telescope.

Ans.

Compound microscope	Astronomical refracting telescope
1. In a compound microscope, the focal length and cross section of the objective lens are respectively smaller than the focal length and cross section of the eyepiece.	1. In an astronomical refracting telescope, the focal length and cross section of the objective lens are respectively greater than the focal length and cross section of the eyepiece.
2. In this case, to observe the object, the distance between the object and the objective lens is adjusted.	2. In this case, to observe the object, the distance between the objective lens and eyepiece is adjusted.
3. It forms a magnified image of a small object.	3. It forms a near image of a distant object.
4. It is used to observe blood corpuscles, plant and animal cells, etc.	4. It is used to observe satellites, planets, stars, etc.

(6) Simple microscope and Astronomical refracting telescope.

Ans.

Simple microscope	Astronomical refracting telescope
1. In a simple microscope, only one convex lens is used.	1. In an astronomical refracting telescope, two convex lenses, objective lens and eyepiece are used.
2. In this case, the object is placed within the focal length of the convex lens.	2. In this case, the object is far away from the objective lens.
3. In this case, the image is erect.	3. In this case, the image is inverted.
4. It is used to observe minute parts of a watch, to read words in small print, etc.	4. It is used to observe satellites, planets, stars, etc.

Q. 13 Read the following paragraph and answer the questions given below it :

Construction of a compound microscope :

(1) A compound microscope consists of a metal tube fitted with two convex lenses at the two ends. These lenses are called the objective lens (the lens directed towards the object) and the eyepiece (the lens directed towards the eye). Both the lenses are small in size, but the cross section of the objective lens is less than that of the eyepiece. The objective lens has a short focal length. The focal length of the eyepiece is more than that of the objective lens.

(2) The metal tube is mounted on a stand. The principal axes of the objective lens and the eyepiece are along the same line. The distance between the object and the objective lens can be changed with a

screw. It is possible to change the distance between the objective lens and the eyepiece.

Working :

(1) The object to be observed is illuminated and placed in front of the objective lens, slightly beyond the focal length of the objective lens. Its real, inverted and enlarged image is formed by the objective lens on the other side.

(2) This intermediate image lies within the focal length of the eyepiece. It serves as an object for the eyepiece. The eyepiece works as a simple microscope. The final image is virtual, highly enlarged and inverted with respect to the original object. It can be formed at the minimum distance of distinct vision from the eyepiece. The final image is observed by keeping the eye close to the eyepiece.

Use : This microscope is used to observe blood cells, microorganisms, etc.

Questions :

(1) In a compound microscope, which lens has greater focal length?

(2) Where do you place the object to be observed with a compound microscope?

(3) State which distance is adjusted to observe the object with a compound microscope.

(4) State the nature of the final image in a compound microscope relative to the object.

(5) State the use of a compound microscope.

Answers :

(1) In a compound microscope, the eyepiece has greater focal length.

(2) In a compound microscope, the object to be observed is placed in front of the objective lens, slightly beyond the focus of the objective lens.

(3) To observe the object with a compound microscope, the distance between the object and objective lens is adjusted.

(4) In a compound microscope, the final image is highly enlarged, inverted and virtual relative to the object.

(5) A compound microscope is used to observe blood cells, microorganisms, etc.

Q. 14 Fill in the blanks for a convex lens :

(1)

f (m)	0.2	......	0.1
P (D)	......	2	......

Ans. $\left[(P\text{ (D)} = \dfrac{1}{f\text{ (m)}} \right]$

f (m)	0.2	**0.5**	0.1
P (D)	**5**	2	**10**

(2)

h_1 (cm)	......	5	10
h_2 (cm)	– 30	– 20	......
M	– 2	......	– 0.5

Ans. $\left[M = \dfrac{h_2}{h_1} \right]$

h_1 (cm)	**15**	5	10
h_2 (cm)	– 30	– 20	**– 5**
M	– 2	**– 4**	– 0.5

Q. 15 Solve the following examples/ numerical problems :

(1) An object is kept at 60 cm in front of a convex lens. Its real image is formed at 20 cm from the lens. Find the focal length of the lens.

Solution : Data : Convex lens, $u = -60$ cm, $v = 20$ cm, $f = ?$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{20\text{ cm}} - \frac{1}{-60\text{ cm}} = \frac{1}{20\text{ cm}} + \frac{1}{60\text{ cm}}$$

$$= \frac{3+1}{60\text{ cm}} = \frac{4}{60\text{ cm}} = \frac{1}{15\text{ cm}}$$

$\therefore f = 15$ cm

The focal length of the lens = 15 cm.

(2) The focal length of a convex lens is 20 cm. If an object of height 2 cm is placed at 30 cm from the lens, find (i) the position and nature

of the image (ii) the height of the image (iii) the magnification produced by the lens.

Solution : Data : Convex lens, $f = 20$ cm,

$u = -30$ cm, $h_1 = 2$ cm, $v = ?$, $h_2 = ?$, $M = ?$

(i) $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\therefore \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{20 \text{ cm}} + \frac{1}{-30 \text{ cm}}$

$= \frac{1}{20 \text{ cm}} - \frac{1}{30 \text{ cm}}$

$= \frac{3-2}{60 \text{ cm}} = \frac{1}{60 \text{ cm}}$

$\therefore v = 60$ cm; v is positive.

The image will be formed at 60 cm from the lens and on the other side of the lens with respect to the object. It is a real image.

(ii) $\frac{h_2}{h_1} = \frac{v}{u}$

$\therefore \frac{h_2}{2 \text{ cm}} = \frac{60 \text{ cm}}{-30 \text{ cm}} = -2$

$\therefore h_2 = -2 \times 2 \text{ cm} = -4$ cm

h_2 is negative. This shows that the image is inverted.

The height of the image $= -4$ cm.

(iii) $M = \frac{h_2}{h_1} = \frac{-4 \text{ cm}}{2 \text{ cm}} = -2$

M is negative, indicating that the image is inverted.

The magnification produced by the lens $= -2$.

(3) When a pin of height 3 cm is fixed at 10 cm from a convex lens, the height of the virtual image formed is 12 cm. Find the focal length of the lens.

Solution : Data : Convex lens, $h_1 = 3$ cm,

$h_2 = 12$ cm (virtual image), $u = -10$ cm, $f = ?$

$\frac{h_2}{h_1} = \frac{v}{u}$

$\therefore \frac{12 \text{ cm}}{3 \text{ cm}} = \frac{v}{-10 \text{ cm}} \quad \therefore v = -40$ cm

Now, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\therefore \frac{1}{f} = \frac{1}{-40 \text{ cm}} - \frac{1}{-10 \text{ cm}} = \frac{1}{10 \text{ cm}} - \frac{1}{40 \text{ cm}}$

$= \frac{4-1}{40 \text{ cm}} = \frac{3}{40 \text{ cm}}$

$\therefore f = \frac{40}{3}$ cm $= 13.33$ cm (approximately)

The focal length of the lens $= 13.33$ cm [approximately].

(4) At what distance from a convex lens of focal length 2.5 m should a boy stand so that his image is half his height?

Solution : Data : Convex lens, $f = 2.5$ m,

$M = -\frac{1}{2}$, $u = ?$

$M = -\frac{1}{2} = \frac{v}{u} \quad \therefore v = -\frac{u}{2}$

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{-\frac{u}{2}} - \frac{1}{u}$

$= -\frac{2}{u} - \frac{1}{u} = -\frac{3}{u}$

$\therefore u = -3f = -3 \times 2.5 \text{ m} = -7.5$ m

This is the object distance.

The boy should stand at 7.5 m from the convex lens so that his image is half his height.

(5) A convex lens forms a real image of a pencil at a distance of 40 cm from the lens. The image formed is of the same size as the object. Find the focal length and power of the lens. At what distance is the pencil placed from the lens?

Solution : Data : Convex lens, $v = 40$ cm,

$M = -1$, $f = ?$ $h_1 = ?$, $u = ?$

$M = -1 = \frac{v}{u}$

$\therefore u = -v = -40$ cm (object distance)

The pencil is placed at 40 cm from the convex lens.

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{40 \text{ cm}} - \frac{1}{-40 \text{ cm}} = \frac{2}{40 \text{ cm}}$

$\therefore f = \frac{40 \text{ cm}}{2} = 20 \text{ cm}$

The focal length of the lens = 20 cm.

$P = \frac{1}{f} = \frac{1}{20 \text{ cm}} = \frac{1}{0.2 \text{ m}} = 5 \text{ D.}$

The power of the lens = 5 D.

(6) A spherical lens is used to obtain an image on a screen. The size of the image is four times the size of the object. What is the type of lens and at what distance is the screen placed from the lens?

Solution : Data : $M = -4$, type of lens? $v = ?$

As the image formed by the lens is obtained on a screen, it is a real image. The lens is, therefore, **a convex lens.**

$M = -4 = \frac{v}{u} \quad \therefore u = -\frac{v}{4}$

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{v} - \frac{1}{(-v/4)} = \frac{1}{v} + \frac{4}{v} = \frac{5}{v}$

$\therefore v = 5f$

The distance of the screen from the lens = $5f$.

(7) An object of height 5 cm is held 20 cm away from a converging lens of focal length 10 cm. Find the position, nature and size of the image formed.

Solution : Data : Converging lens (convex lens), $f = 10$ cm, $h_1 = 5$ cm, $u = -20$ cm, $v = ?$, $h_2 = ?$

(i) $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\therefore \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10 \text{ cm}} + \frac{1}{-20 \text{ cm}}$

$= \frac{1}{10 \text{ cm}} - \frac{1}{20 \text{ cm}} = \frac{2-1}{20 \text{ cm}}$

$= \frac{1}{20 \text{ cm}}$

$\therefore v = 20 \text{ cm}$

The image is real and inverted. It is formed at 20 cm from the lens and on the other side of the lens relative to the object.

(ii) $\frac{h_2}{h_1} = \frac{v}{u} \quad \therefore h_2 = h_1\left(\frac{v}{u}\right)$

$\therefore h_2 = 5 \text{ cm} \times \frac{20 \text{ cm}}{-20 \text{ cm}} = -5 \text{ cm}$

The height of the image, $h_2 = -5$ cm

Thus, it is numerically the same as the height of the object.

(8) An object is placed at 10 cm from a convex lens of focal length 12 cm. Find the position and nature of the image.

Solution : Data : Convex lens, $u = -10$ cm, $f = 12$ cm, $v = ?$

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad \therefore \frac{1}{v} = \frac{1}{f} + \frac{1}{u}$

$\therefore \frac{1}{v} = \frac{1}{12 \text{ cm}} + \frac{1}{(-10 \text{ cm})}$

$= -\left(\frac{1}{10 \text{ cm}} - \frac{1}{12 \text{ cm}}\right)$

$= -\left(\frac{6-5}{60 \text{ cm}}\right) = -\frac{1}{60 \text{ cm}}$

$\therefore v = -60$ cm It is negative.

The image is formed at 60 cm from the lens and on the same side of the lens relative to the object. It is virtual, erect, and enlarged.

***(9) 5 cm high object is placed at a distance of 25 cm from a converging lens of focal length of 10 cm. Determine the position, size and type of the image.**

Solution : Data : Converging lens, $f = 10$ cm

$u = -25$ cm, $h_1 = 5$ cm, $v = ?$, $h_2 = ?$

(i) $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad \therefore \frac{1}{v} = \frac{1}{f} + \frac{1}{u}$

$\therefore \frac{1}{v} = \frac{1}{10 \text{ cm}} + \frac{1}{-25 \text{ cm}} = \frac{1}{10 \text{ cm}} - \frac{1}{25 \text{ cm}}$

$= \frac{5-2}{50 \text{ cm}} = \frac{3}{50 \text{ cm}}$

$\therefore$ Image distance, $v = \frac{50}{3}$ cm

$\doteqdot 16.67 \text{ cm} \doteqdot$ **16.7 cm.**

(ii) $\frac{h_2}{h_1} = \frac{v}{u} \quad \therefore h_2 = \frac{v}{u} h_1$

$$\therefore h_2 = \frac{(50/3)\text{ cm}}{-25\text{ cm}} \times 5\text{ cm} = -\frac{50 \times 5}{25 \times 3}\text{ cm}$$

$$= -\frac{10}{3}\text{ cm} \doteqdot -3.333\text{ cm}$$

$$\doteqdot -3.3\text{ cm}$$

The height of the image = − 3.3 cm (inverted image ∴ minus sign).

(iii) **The image is real, inverted and smaller than the object.**

*** (10) Doctor has prescribed a lens having power + 1.5 D for correction of eye defect. What is the focal length of the lens? What is the type of the lens and what must be the defect of vision?** ***(3 marks) (July '19)***

Solution : Data : $P = +1.5$ D, $f = ?$

Focal length of the lens, $f = \frac{1}{P} = \frac{1}{1.5\text{ D}}$

$= \frac{10}{15}\text{ m} = 0.6667\text{ m} \doteqdot$ **0.67 m**

P **is positive. This shows that the lens is convex. The defect of vision is farsightedness (hypermetropia).**

---

(11) An object of height 4 cm is placed in front of a concave lens of focal length 40 cm. If the object distance is 60 cm, find the position and height of the image.

Solution : Data : $f = -40$ cm (concave lens), $u = -60$ cm, $h_1 = 4$ cm, $v = ?$, $h_2 = ?$

(i) $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad \therefore \frac{1}{v} = \frac{1}{f} + \frac{1}{u}$

$$\therefore \frac{1}{v} = \frac{1}{-40\text{ cm}} + \frac{1}{-60\text{ cm}} = -\left(\frac{1}{40\text{ cm}} + \frac{1}{60\text{ cm}}\right)$$

$$= -\left(\frac{3+2}{120\text{ cm}}\right) = -\frac{5}{120}\text{ cm}$$

$$\therefore v = -\frac{120}{5}\text{ cm} = -24\text{ cm}$$

The image is formed at 24 cm from the lens. It is on the same side as the object.

(ii) $\frac{h_2}{h_1} = \frac{v}{u} \quad \therefore h_2 = \frac{v}{u} h_1$

$$\therefore h_2 = \left(\frac{-24\text{ cm}}{-60\text{ cm}}\right) \times 4\text{ cm} = 0.4 \times 4\text{ cm} = 1.6\text{ cm}$$

The height of the image is 1.6 cm.

***(12) An object kept 60 cm from a lens gives a virtual image 20 cm in front of the lens. What is the focal length of the lens? Is it a converging lens or diverging lens?**

Solution : Data : $u = -60$ cm, $v = -20$ cm, $f = ?$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{-20\text{ cm}} - \frac{1}{-60\text{ cm}}$$

$$= -\left(\frac{1}{20\text{ cm}} - \frac{1}{60\text{ cm}}\right) = -\left(\frac{3-1}{60\text{ cm}}\right)$$

$$= -\frac{2}{60\text{ cm}} = -\frac{1}{30\text{ cm}}$$

∴ The focal length of the lens, *f* = − 30 cm. As *f* is negative, it is a diverging lens.

---

(13) What is the power of a convex lens having focal length 0.5 m?

Solution : Data : Convex lens, $f = 0.5$ m, $P = ?$

$$P = \frac{1}{f} = \frac{1}{0.5\text{ m}} = 2\text{ D}$$

The power of the lens = 2 D.

---

(14) The power of a convex lens is 2.5 dioptres. Find its focal length. *OR*

Calculate the focal length of a corrective lens having power + 2.5 D.

Solution : Data : Convex lens, $P = +2.5$ D, $f = ?$

$$P = \frac{1}{f} \quad \therefore 2.5\text{ D} = \frac{1}{f}$$

$$\therefore f = \frac{1}{2.5\text{ D}} = 0.4\text{ m} = 40\text{ cm}$$

The focal length of the lens = 40 cm.

---

(15) Calculate the focal length of a corrective lens having power + 2 D.

Ans. *See the solution to Ex. (14) above.*

The focal length of the lens = 50 cm.

---

*(16) **Three lenses having powers 2, 2.5 and 1.7 D are kept touching in a row. What is the total power of the lens combination?**

Solution : Data : $P_1 = 2$ D, $P_2 = 2.5$ D, $P_3 = 1.7$ D, $P = ?$

Total power of the lens combination,

$P = P_1 + P_2 + P_3$

$= 2\text{ D} + 2.5\text{ D} + 1.7\text{ D}$

$= \mathbf{6.2\ D}$.

(17) **Two convex lenses of focal length 20 cm each are kept in contact with each other. Find the power of their combination.**

Solution : Data : $f_1 = 20\text{ cm} = 0.2\text{ m}$, $f_2 = 20\text{ cm} = 0.2\text{ m}$, P (combination) = ?

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{0.2\text{ m}} + \frac{1}{0.2\text{ m}} = \frac{2}{0.2\text{ m}} = \frac{1}{0.1\text{ m}}$$

$\therefore$ Focal length of the combination of the lenses, $f = 0.1$ m.

$$P = \frac{1}{f} = \frac{1}{0.1\text{ m}} = 10\text{ D}$$

The power of the combination of the lenses, $P = 10$ D.

(18) **Two convex lenses of equal focal lengths are kept in contact with each other. If the power of their combination is 20 D, find the focal length of each convex lens.**

Solution : Data : Convex lens, $P = 20$ D, $f_1 = f_2 = ?$

The focal length (f) of the combination of the lenses is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\therefore \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_1} = \frac{2}{f_1}$$

But $P = \frac{1}{f}$ $\quad \therefore P = \frac{2}{f_1}$

$\therefore 20\text{ D} = \frac{2}{f_1}$ $\quad \therefore f_1 = \frac{2}{20}\text{ m} = 0.1\text{ m}$

$f_1 = 0.1$ m.

This gives the focal length of each convex lens.

(19) **If a convex lens of focal length 10 cm and a concave lens of focal length 50 cm are kept in contact with each other, (i) what will be the focal length of the combination? (ii) what will be the power of the combination? (iii) what will be the behaviour of the combination (behaviour as a convex lens / concave lens)?**

Solution : Data : $f_1 = +10\text{ cm} = +0.1\text{ m}$ (convex lens),

$f_2 = -50\text{ cm} = -0.5\text{ m}$ (concave lens),

f (combination) = ?, P (combination) = ?

(i) $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{0.1\text{ m}} + \frac{1}{-0.5\text{ m}}$

$= \frac{10}{\text{m}} - \frac{2}{\text{m}} = \frac{8}{\text{m}}$

$\therefore f = \frac{1}{8}\text{ m} = 0.125\text{ m} = 12.5\text{ cm}$

The focal length of the combination of the lenses = 0.125 m = 12.5 cm.

(ii) $P_1 = \frac{1}{f_1} = \frac{1}{0.1\text{ m}} = 10\text{ D}$,

$P_2 = \frac{1}{f_2} = \frac{1}{-0.5\text{ m}} = -2\text{ D}$

$\therefore P = P_1 + P_2 = 10\text{ D} - 2\text{ D}$

$= 8\text{ D}$ *OR*

$P = \frac{1}{f} = \frac{1}{0.125\text{ m}} = \mathbf{8\ D}$

The power of the combination of the lenses = 8 D.

(iii) **The focal length of the combination of the lenses is positive. This shows that the combination will behave as a convex lens.**

NUMERICAL PROBLEMS FOR PRACTICE

1. Find the focal length of a convex lens which produces a real image at 60 cm from the lens when an object is placed at 40 cm in front of the lens. (**Ans.** 24 cm)
2. Find the focal length of a convex lens which produces a virtual image at 10 cm from the lens when an object is placed at 5 cm from the lens. (**Ans.** 10 cm)
3. A real image is obtained at 30 cm from a convex lens of focal length 7.5 cm. Find the distance of the object from the lens. (**Ans.** $u = -10$ cm)
4. An object is kept at 20 cm in front of a convex lens and its real image is formed at 60 cm from the lens. Find (1) the focal length of the lens (2) the height of the image if the height of the object is 6 cm. [**Ans.** (1) 15 cm (2) $h_2 = -18$ cm]

5. An object is kept at 10 cm in front of a convex lens. Its image is formed on the screen at 15 cm from the lens. Calculate (1) the focal length of the lens (2) the magnification produced by the lens. [**Ans.** (1) 6 cm (2) $M = -1.5$]
6. An object is kept at 60 cm in front of a convex lens of focal length 15 cm. Find the image distance and the nature of the image. Also find the magnification produced by the lens. [**Ans.** $v = 20$ cm. The image is real, inverted and smaller than the object. $M = -\frac{1}{3}$]
7. An object of height 2 cm is kept at 30 cm from a convex lens. Its real image is formed at 60 cm from the lens. Find the focal length and power of the lens. (**Ans.** $f = 20$ cm, $P = 5$ D)
8. If the power of a lens is 4 dioptres, find its focal length. (**Ans.** 25 cm)
9. Find the power of a convex lens of focal length 40 cm. (**Ans.** 2.5 D)
10. Find the power of a convex lens of focal length 12.5 cm. (**Ans.** 8 D)
11. If for a lens, $f = -20$ cm, what is the power of the lens? (**Ans.** -5 D)
12. An object of height 4 cm is kept in front of a concave lens of focal length 20 cm. If the object distance is 30 cm, find the position and the height of the image. (**Ans.** $v = -12$ cm, $h_2 = 1.6$ cm)
13. If two convex lenses of focal lengths 10 cm and 5 cm are kept in contact with each other, what is their combined focal length? (**Ans.** $\frac{10}{3}$ cm [approximately 3.33 cm])
14. If a convex lens of focal length 20 cm and a concave lens of focal length 30 cm are kept in contact with each other. (i) What will be the focal length of the combination? (ii) What will be the power of the combination? (iii) What will be the behaviour of the combination? (**Ans.** (i) $f = 60$ cm (ii) $P = \frac{5}{3}$ D $= 1.6667$ D (approximately) (iii) The combination will behave as a convex lens.)
15. A concave lens of focal length 12 cm and a convex lens of focal length 20 cm are kept in contact with each other. (i) Find the focal length of the combination. (ii) What will be the behaviour of the combination? (**Ans.** (i) $f = -30$ cm (ii) The combination will behave as a concave lens.)

PROJECT

* Make a Power point presentation about the construction and use of binoculars.

MEMORY MAP / CONCEPT MAP

(1)

Light

- Reflection
  - Plane mirror, Concave mirror, Convex mirror
- Refraction
  - Convex lens, Concave lens, Plano-convex lens, Plano-concave lens, Concavo-convex lens, Convexo-concave lens

(2)

Convex lens (Converging lens)

- $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$, $M=\frac{h_2}{h_1}=\frac{v}{u}$
- Object at infinity : Image at F_2, real, inverted and very much smaller than the object
- Object beyond $2F_1$: Image between F_2 and $2F_2$, real, inverted and smaller than the object
- Object at $2F_1$: Image at $2F_2$, real, inverted and of the same size as that of the object
- Object between F_1 and $2F_1$: Image beyond $2F_2$, real, inverted and enlarged
- Object at focus F_1 : Image at infinity, real, inverted and infinitely large
- Object between F_1 and O : Image on the same side of the lens as the object, virtual, erect and enlarged
- Used in a simple microscope, compound microscope, telescope, camera, spectacles, spectrometer

(3)

Concave lens (Diverging lens)

- $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$, $M=\frac{h_2}{h_1}=\frac{v}{u}$
- Object at infinity : Image at F_1, virtual, erect and very much smaller than the object
- Object at finite distance : Image between F_1 and the optical centre, virtual, erect and smaller than the object
- Used in spectacles and optical instruments

(4)

Combination of lenses

- $\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}$
- $P=P_1+P_2$

(5)

Human eye

- Cornea, pupil, iris, lens, retina, optic nerve, etc.
- Response to the intensity of light and perception of colours
- Persistence of vision
- Minimum distance of distinct vision : 25 cm
- Defects of vision
  - Myopia or nearsightedness : corrected by concave lenses
  - Hypermetropia or far-sightedness : corrected by convex lenses
  - Presbyopia : Corrected by convex lenses. In old age, often bifocal lenses are used.

8 METALLURGY

CHAPTER OUTLINE

IMPORTANT POINTS

8.1 Physical properties of metals :

8.2 Physical properties of nonmetals :

• **Can you recall? (Textbook page 93)**

Q. What are the physical properties of metals and nonmetals?

Ans. (1) Properties of metals : (1) Solid state (Exception : Mercury and gallium) (2) Typical lustre (3) Malleability and ductility (4) Hardness (Exception : Lithium, sodium and potassium) (5) Good conductors of heat and electricity (6) High melting and boiling points (On the other hand, the melting and boiling points of the metals sodium, potassium, mercury and galium are very low.) (7) Sonorous and produce sound on striking a hard surface.

(2) Properties of nonmetals : (1) Gaseous or solid state (Exception : Bromine in liquid state) (2) Lack of any typical lustre (Exception : Iodine and Diamond) (3) Brittleness in the solid state (Exception : Diamond is the hardest natural substance) (4) Bad conductors of heat and electricity (Exception : Graphite) (Diamond is good conductor of heat) (5) Low melting and boiling points.

8.3 Chemical properties of metals :

1. **Reaction of metals with oxygen :** Metals combine with oxygen on heating in air and metal oxides are formed. Sodium and potassium are highly reactive metals. Sodium metal combines with oxygen in the air at room temperature to form sodium oxide.

$$4Na_{(s)} + O_{2(g)} \longrightarrow 2Na_2O_{(s)}$$

Sodium readily catches fire on keeping exposed to air producing a lot of heat. Therefore, to prevent accident in the laboratory or elsewhere it is kept in kerosene.

Sodium oxide reacts with water to form sodium hydroxide (alkali)

$$Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH_{(aq)}$$

Magnesium ribbon burns in air form magnesium oxide.

$$2Mg_{(s)} + O_{2(g)} \xrightarrow{\Delta} 2MgO_{(s)}$$

2. **Reaction of metals with water :** Sodium and potassium react vigorously with water to evolve hydrogen. Calcium reacts with water less vigorously to evolve hydrogen. Magnesium reacts with hot water to evolve hydrogen. Aluminium, iron and zinc do not react with cold or hot water but they react with steam to evolve their oxides and hydrogen.

3. **Reaction of metals with acids :** Metals react with dilute hydrochloric acid or dilute sulphuric acid to form metal chloride or metal sulphate and hydrogen gas. The rate of evolution of H_2 is maximum in case of magnesium. The reactivity decreases in the order Mg > Al > Zn > Fe.

4. **Reaction of metals with nitric acid :** Metals react with nitric acid to form nitrate salts. Depending on the concentration of nitric acid, various oxides of nitrogen (NO, NO_2) are formed.

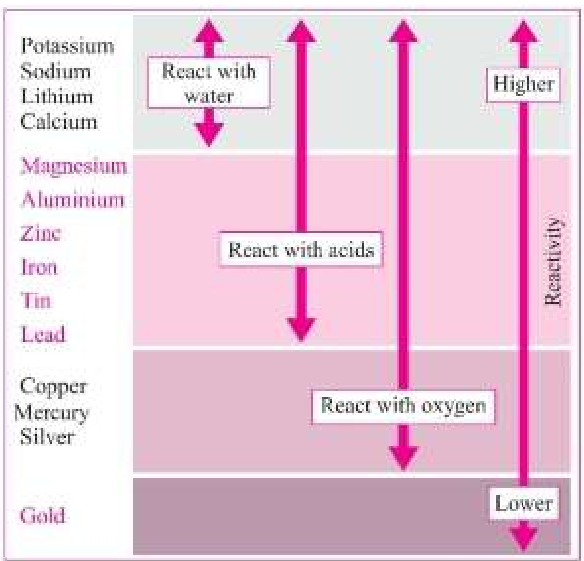
5. **Aqua Regia :** Aqua Regia is freshly prepared by mixing concentrated hydrochloric acid and concentrated nitric acid in the ratio 3 : 1. Aqua Regia is a highly corrosive and fuming liquid. It is one of the few reagents which can dissolve the noble metals like gold and platinum.

6. **Reactions of metals with salts of other metals :** The reactivity of all metals is not the same. All metals do not react with oxygen, water and acids. As a result, the relative reactivity of metals cannot be determined using these reagents. If a metal A displaces another metal B from the solution of its salt, it means that the metal A is more reactive than the metal B.

   Metal A + Salt solution of metal B $\longrightarrow$ Salt solution of metal A + Metal B.

8.4 Reactivity series of metals :

- **Reactivity series of metals :** The arrangement of metals in the increasing or decreasing order of reactivity is called the reactivity series of metals. Metals are divided into the following groups according to their reactivity.



(1) Highly reactive metal.

(2) Moderately reactive metals.

(3) Less reactive metals.

8.5 Chemical properties of nonmetals :

1. **Reaction of metals with nonmetals :** The ionic compound is formed when metal reacts with nonmetal.

   $\underset{\text{(Metal)}}{2Na} + \underset{\text{(Nonmetal)}}{Cl_2} \rightarrow \underset{\text{(Ionic compound)}}{2NaCl}$ (sodium chloride)

   Ionic compound is formed as sodium loses one electron while chlorine accepts one electron.

2. **Reaction of nonmetals with oxygen :** Nonmetals combine with oxygen to form acidic oxides. In some cases, neutral oxides are formed.

3. **Reaction of nonmetals with water :** Non-metals do not react with water, (Exception – Halogen). Chlorine dissolves in water giving the following reaction.

   $Cl_{2(g)} + H_2O_{(l)} \longrightarrow \underset{\text{Hypochlorous acid}}{HOCl_{(aq)}} + HCl_{(aq)}$

4. **Reaction of dilute acid with nonmetals :** Nonmetals do not react with dilute acids, (Exception – Halogen). Chlorine reacts with dilute hydrobromic acid to form bromine and HCl.

   $Cl_{2(g)} + 2HBr_{(aq)} \longrightarrow 2HCl_{(aq)} + Br_{2(aq)}$

5. **Reaction of nonmetals with hydrogen :** Non-metals react with hydrogen under certain conditions such as proper temperature, pressure and use of catalyst.

   $S + H_2 \longrightarrow H_2S_{(g)}$

   $N_2 + 3H_2 \longrightarrow 2NH_{3(g)}$

8.6 Ionic compounds :

1. **Ionic compounds :** The compounds formed from two units, i.e. cation and anion are called ionic compounds. An electrostatic force of attraction between oppositely charged ions (cations and anions) is called an ionic bond.

2. **General properties of ionic compounds :**

   (1) Ionic compounds are crystalline solids have a definite shape and hard due to strong electrostatic force of attraction between oppositely charged ions.

   (2) They are generally brittle. When pressure is applied they break into pieces.

(3) They have high melting and boiling points.

(4) They are soluble in water and insoluble in solvents such as kerosene and petrol.

(5) They conduct electricity in the molten state and also in an aqueous solution.

8.7 Metallurgy : Various concepts :

1. **Minerals and ores :** The compounds of metals that occur in nature along with the impurities are called minerals. The minerals from which metals are extracted economically are called ores.

2. **Metallurgy :** The process of extraction of metal in pure form from the ores. The metals are further purified by different methods of purification. All this process is called metallurgy.

3. **Concentration of ores :** The process of separating gangue from the ores is called concentration of ores. Some general methods of concentration of ores as follows :

   (A) Separation based on gravitation : The gravitational method is used to separate the heavy particles of ores from the light particles of gangue. The processes to do this separation are as follows : (1) Wilfley table method (Separation based on gravitation) (2) Hydraulic separation method.

   (B) Magnetic separation method

   (C) Froth floatation method

   (D) Leaching

• Can you recall? (Textbook page 102)

What is the electronic definition of oxidation and reduction?

Ans. When a metal loses electrons the process is called an oxidation while when a nonmetal gains electrons, it is called a reduction,

$Na \longrightarrow Na^{+} + e^{-}$ (oxidation)

$Cl + e^{-} \longrightarrow Cl^{-}$ (reduction)

4. **Extraction of reactive metals :** The extraction of highly reactive metals has to be done by electrolytic reduction.

5. **Extraction of aluminium :** Atomic number : 13, Electronic configuration : 2, 8, 3, Valency : 3. Aluminium is extracted from its main ore bauxite ($Al_2O_3 \cdot nH_2O$).

   Extraction of aluminium involves the following steps :

   (1) Concentration of bauxite ore (Bayer's process)

   (2) Electrolytic reduction of pure alumina

   (3) Refining.

   (1) **Concentration of bauxite ore :** Powdered bauxite is heated with NaOH under high pressure and at 140 °C to 150 °C for 2 to 8 hours in a digester. Al_2O_3 being amphoteric in nature forms sodium aluminate ($NaAlO_2$) which is water soluble. The iron oxide impurities does not dissolve in aqueous NaOH and are separated by filtration. However, silica reacts with sodium hydroxide to form soluble sodium silicate. $NaAlO_2$ is hydrolysed to form insoluble $Al(OH)_3$ by diluting it with water and cooling to 50 °C. Aluminium hydroxide precipitate is then filtered, dried and calcinated by heating at 1000 °C to obtain pure alumina.

   $$\underset{\text{Alumina}}{Al_2O_3} + 2NaOH \rightarrow \underset{\text{Sodium aluminate}}{2NaAlO_2} + H_2O$$

   $$NaAlO_2 + 2H_2O \longrightarrow NaOH + Al(OH)_3\downarrow$$

   $$2Al(OH)_3 \xrightarrow[1000\ ^\circ C]{heat} Al_2O_3 + 3H_2O$$

   (2) **Electrolytic reduction of alumina :** Cell – A steel tank with graphite lining; Electrolyte – Alumina dissolved in fused cryolite; Cathode – The graphite (carbon) in the form of lining of the steel tank; Anode – Graphite (carbon) rods dipped in the electrolyte; cryolite (Na_3AlF_6) and fluorspar (CaF_2) are added in the mixture to lower its melting point up to 1000°C.

Electrolysis products : Cathode – Aluminium metal, Anode – Oxygen gas.

$$\underset{\text{(fused)}}{Al_2O_3} \rightarrow 2Al^3 + 3O^{2-}$$

At the anode : $2O^{2-} \longrightarrow O_2 + 4e^-$

At the cathode : $Al^{3+} + 3e^- \longrightarrow Al$

6. **Extraction of moderately reactive metals :** In metals, in the middles of the reactivity series such as iron, zinc, lead, copper are moderately reactive. These metals occur in the form of their sulphide salts or carbonate salts.

The sulphides ores are strongly heated in air to convert them into oxides. This process is called **roasting**. Carbonate ores are strongly heated in a limited supply of air to convert them into oxides. This process is called **calcination.**

The following reaction occur during roasting and cacination of zinc ore.

Roasting : $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2\uparrow$

Calcination : $ZnCO_3 \longrightarrow ZnO + CO_2\uparrow$

The zinc oxide is reduced to zinc by using suitable reductant such as carbon.

$ZnO + C \longrightarrow Zn + CO\uparrow$

7. **Extraction of less reactive metals :** The less reactive metals are at the bottom of reactivity series of metal. These metals are found in free state in nature. For example, gold, silver, platinum. The reserves of copper in free state are exhausted long ago. Copper is found mainly in the form of Cu_2S. Copper is obtained from Cu_2S ore just by heating in air.

$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2\uparrow$

$2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2\uparrow$

8. **Refining of metals :** Metals obtained by various reduction processes contain impurities. Electrolysis method is used to remove impurities to obtain pure metals.

• Can you recall? (Textbook page 106)

(1) What is meant by corrosion?

Ans. Corrosion is degradation of a material due to reaction with its environment.

(2) Have you observed the following things?

(1) Old iron bars in the buildings.

Ans. When old iron bars in the buildings are exposed to moist air for a long time, they acquire a coating of brown flaky substance called rust. $(Fe_2O_3 \cdot H_2O)$

(2) Copper vessels not cleaned for a long time.

Ans. If copper vessels are not cleaned for a long time, they react with moist carbon dioxide in the air, lose their shine and gain a green coat of copper carbonate. $(CuCO_3)$

(3) Silver ornaments or idols exposed to air for a long time.

Ans. When silver ornaments or idols are kept exposed to air for a long time, silver reacts with sulphur in the air to form a coating of black silver sulphide. (Ag_2S)

(4) Old vehicles fit to be thrown away.

Ans. The metallic parts of the body of old cars are corroded, eaten up and sometimes become perforated. The old cars also lose the original colour due to formation of flakes of rust.

9. **Prevention of corrosion :**

(1) By coating with some substance on the metal surface so that the contact of the metal with moisture and oxygen in the air is prevented and no reaction would occur between them.

(2) By applying a layer of paint, oil, grease or varnish on the surface of a metal to prevent corrosion. For example, corrosion of iron can be prevented by this method.

(3) Corrosion is prevented by coating a corrosive metals with a noncorrosive metal. This can be done in many ways :

(1) Galvanizing

(2) Tinning

(3) Anodization

(4) Electroplating

(5) Alloying.

QUESTIONS & ANSWERS

Q. 1 Fill in the blanks :

(1) ...... has the highest melting point.

(2) Mercury and ...... are two metals in the liquid state at room temperature.

(3) ...... is the hardest natural substance.

(4) The naturally occurring compounds of metals along with other impurities are known as ....

(5) The minerals from which metals are extracted profitably and conveniently are called ......

(6) An ore contains some of the impurities like soil, sand, etc. These impurities are called ....

(7) The process of extraction of a metal from its ore is called ....

(8) Bauxite is a common ore of ....

(9) ...... process is used for the purification of bauxite.

(10) During the electrolysis of alumina, ... is liberated at the anode.

(11) The reaction of iron oxide with aluminium is known as ...... reaction.

(12) The process of coating a thin layer of zinc on iron is known as ....

(13) The metal that produces a sound on striking a hard surface is said to be ....

(14) The process in which carbonate ores are changed into oxides by heating strongly in limited air is known as ....

(15) ...... compounds are insoluble in solvents like kerosene and petrol.

(16) ...... is used to obtain pure metals from impure metals.

(17) Corrosion can be prevented by putting a layer of ...... metal on corrosionable metal.

Ans.

(1) Tungsten has the highest melting point.

(2) Mercury and galium are two metals in the liquid state at room temperature.

(3) Diamond is the hardest natural substance.

(4) The naturally occurring compounds of metals along with other impurities are known as minerals.

(5) The minerals from which metals are extracted profitably and conveniently are called ores.

(6) An ore contains some of the impurities like soil, sand, etc. These impurities are called gangue.

(7) The process of extraction of a metal from its ore is called metallurgy.

(8) Bauxite is a common ore of aluminium.

(9) Bayer's process is used for the purification of bauxite.

(10) During the electrolysis of alumina, oxygen is liberated at the anode.

(11) The reaction of iron oxide with aluminium is known as thermit reaction.

(12) The process of coating a thin layer of zinc on iron is known as galvanising.

(13) The metal that produces a sound on striking a hard surface is said to be sonorous.

(14) The process in which carbonate ores are changed into oxides by heating strongly in limited air is known as calcination.

(15) Ionic compounds are insoluble in solvents like kerosene and petrol.

(16) Electrolysis method is used to obtain pure metals from impure metals.

(17) Corrosion can be prevented by putting a layer of noncorrosionable metal on corrosionable metal.

Q. 2 Choose the correct alternative and write it along with its allotted alphabet : *(1 mark each)*

(1) ...... is a metal.

(a) Mg *(b)* S *(c)* P *(d)* Br

(2) ...... is a nonmetal.

(a) Au *(b)* Hg *(c)* Br *(d)* Cu

(3) ...... is a metalloid.

(a) Aluminium *(b) Antimony*

(c) Zinc *(d) Mercury*

(4) Metalloids have properties of ......

(a) metals (b) nonmetals
(c) both metals and nonmetals
(d) neither metals nor nonmetals

(5) ...... is a good conductor of electricity.

(a) Bromine (b) Iodine
(c) Graphite (d) Sulphur

(6) ...... is a metal which is in liquid form at ordinary temperature and pressure.

(a) Magnesium (b) Sodium
(c) Scandium (d) Mercury

(7) ...... is an amphoteric oxide.

(a) Na_2O (b) MgO (c) ZnO (d) SO_2

(8) ...... is an acidic oxide.

(a) Na_2O (b) CO_2 (c) FeO_3 (d) H_2O

(9) ...... is a basic oxide.

(a) CO_2 (b) K_2O (c) SO_2 (d) Al_2O_3

(10) ...... is an ore of aluminium.

(a) Cryolite (b) Bauxite
(c) Haematite (d) Aluminium carbonate

(11) Bronze is an alloy of ......

(a) copper and tin (b) copper and zinc
(c) copper and iron (d) iron and nickel

(12) An alloy prepared from iron, nickel and chromium is known as ......

(a) brass (b) bronze
(c) stainless steel (d) amalgam

(13) ...... is an allotropic form of a nonmetal which conducts electricity.

(a) Sulphur (b) Graphite
(c) Chlorine (d) Iodine

(14) ...... has an oxide which is soluble in sodium hydroxide.

(a) Calcium (b) Magnesium
(c) Iron (d) Zinc

(15) ...... prevents the rusting of iron.

(a) Copper (b) Zinc
(c) Aluminium (d) Silver

(16) ...... is obtained by the reduction of its oxide by carbon.

(a) Zinc (b) Aluminium
(c) Sodium (d) Potassium

(17) ...... is used as an anode during the electrolytic reduction of bauxite.

(a) Sulphur (b) Graphite
(c) Platinum (d) Aluminium

(18) Silver gets corroded due to ...... in air.

(a) oxygen (b) hydrogen sulphide
(c) carbon dioxide (d) nitrogen

(19) ...... is the hardest substance and has the highest melting and boiling points.

(a) Iodine (b) Sulphur
(c) Diamond (d) Phosphorus

(20) Jewellery articles are gold plated ......

(a) to prevent corrosion
(b) to prevent rusting of the base metal
(c) to make articles attractive
(d) all of these

(21) To show that zinc is more reactive than copper, the correct procedure is to ......

(a) prepare copper sulphate solution and dip a zinc strip in it
(b) prepare zinc sulphate solution and dip a copper strip in it
(c) heat together zinc and copper strips
(d) add dil. nitric acid to both the strips

(22) Iron is ......

(a) more reactive than zinc
(b) more reactive than aluminium
(c) less reactive than copper
(d) less reactive than aluminium

(23) What would be the correct order if Zn, Fe, Al and Cu are arranged in increasing order of reactivity?

(a) Cu, Fe, Zn, Al (b) Al, Cu, Fe, Zn
(c) Zn, Al, Cu, Fe (d) Fe, Zn, Al, Cu

*(24) During the extraction of aluminium ......

(a) Ingredients and gangue in bauxite
(b) Use of leaching during the concentration of ore
(c) Chemical reaction of transformation of bauxite into alumina by Hall's process.
(d) Heating the aluminium ore with concentrated caustic soda.

(25) In the Wilfley table method, the particles of gangue are separated by ______ separation method.

(a) magnetic *(b) froth floatation*
(c) hydraulic *(d) gravitational*

(March '20)

(26) Which of the following process is to be carried out to avoid the formation of greenish layer on brass vessels due to corrosion?

(a) Electroplating *(b) Anodization*
(c) Tinning *(d) Alloying*

Ans.

(1) (a) Mg
(2) (c) Br
(3) (b) Antimony
(4) (c) both metals and nonmetals
(5) (c) Graphite (6) (d) Mercury
(7) (c) ZnO (8) (b) CO_2
(9) (b) K_2O (10) (b) Bauxite
(11) (a) copper and tin
(12) (c) stainless steel
(13) (b) Graphite
(14) (d) Zinc (15) (b) Zinc (16) (a) Zinc
(17) (b) Graphite
(18) (b) hydrogen sulphide
(19) (c) Diamond
(20) (d) all of these
(21) (a) prepare copper sulphate solution and dip a zinc strip in it
(22) (d) less reactive than aluminium
(23) (a) Cu, Fe, Zn, Al
(24) (c) Chemical reaction of transformation of bauxite into alumina by Hall's process
(25) (d) gravitational
(26) (c) Tinning

Q. State whether the following statements are *True* or *False* (If a statement is false, correct it and rewrite it.) :

(1 mark each)

(1) Metals are known as sonar metals.
(2) Diamond is the softest natural substance.
(3) Electrolysis method is used to obtain pure metals from impure metals.
(4) Iodine and diamond are lustrous substances.
(5) Aquaregia is a mixture of conc. HCl and conc. HNO_3 in the ratio of 1 : 3.
(6) Corrosion of metals can be stopped by detaching the air from metals.
(7) Due to corrosion a greenish layer forms on the surface of copper or brass vessel.
(8) Ionic compounds are soluble in kerosene.
(9) Ionic compounds in the solid state conduct electricity.
(10) Mercury, silver and gold are very reactive metals.
(11) In electroplating, a metal is coated with another metal using electrolysis.
(12) In anodising method, the copper or aluminium article is used as anode.
(13) Silver plated spoon, gold plated ornaments are the examples of alloying.
(14) Silver amalgam is mainly used by dentists.
(15) Aluminium oxide is an acidic oxide.
(16) Copper reacts with moist carbon dioxide to form copper carbonate.
(17) Corrosion is degradation of a material due to reaction with its environment.

Ans.

(1) **True.**
(2) **False.** (Diamond is the hardest natural substance.)
(3) **True.** (4) **True.**
(5) **False.** (Aquaregia is a mixture of conc. HCl and conc. HNO_3 in the ratio of 3 : 1.)
(6) **True.** (7) **True.**
(8) **False.** (Ionic compounds are soluble in water and insoluble in kerosene.)
(9) **False.** (Ionic compounds in the solid state do not conduct electricity.)
(10) **False.** (Mercury, silver and gold are least reactive metals.)
(11) **True.** (12) **True.**
(13) **False.** (Silver plated spoon, gold plated ornaments are the examples of electroplating)
(14) **True.**

(15) **False.** (Aluminium oxide is an amphoteric oxide.) (16) **True.** (17) **True.**

Q. 4 Find the correlation in the given pair and rewrite the answer : *(1 mark each)*

(1) Brass : Copper and Zinc : : Bronze : ....

(2) Tinning : Tin : : Galvanizing : ....

(3) Pressure cooker : Anodizing : : Silver plated spoons : ....

(4) The sulphides ores are strongly heated in air : Roasting : : The carbonates ores are strongly heated in a limited supply of air : ....

(5) Sulphide ores : Froth floatation method : Cassiterite ore : ......

Ans. (1) Copper and tin **(2)** Zinc **(3)** Electro-plating **(4)** Calcination **(5)** Magnetic separation method.

Q. 5 Find the odd one out : *(1 mark each)*

(1) Sodium, Potassium, Silver, Sulphur

(2) Boron, Chlorine, Bromine, Fluorine

(3) Copper, Iron, Mercury, Brass

(4) Brass, Bronze, Phosphorus, Stainless steel

(5) Magnesium chloride, Sodium chloride, Water, Zinc chloride

(6) Tinning, Anodization, Alloying, Froth floatation ***(March '19)***

(7) Zinc, Iron, Phosphorus, Sodium ***(Nov. '20)***

Ans.

(1) **Sulphur.** (All except sulphur, others are metals.)

(2) **Boron.** (All except boron, others are nonmetals.)

(3) **Brass.** (All except brass, others are metals.)

(4) **Phosphorus.** (All except phosphorus, others are alloys.)

(5) **Water.** (All except water, others are ionic compounds.)

(6) **Froth floatation.** (All except froth floatation, others are processes of coating a thin layer of metal on the surface of other metals.)

(7) **Phosphorus.** (All except phosphorus, others are metals.)

Q. 6 Match the following :

(1) Column I	Column II
(1) ZnS	(a) Cuprous sulphide
(2) HgS	(b) Bauxite
	(c) Zinc blend
	(d) Cinnabar

Ans. (1) ZnS – Zinc blend

(2) HgS – Cinnabar.

*(2) Column I	Column II
Substance	**Property**
(1) Potassium bromide	(a) Combustible
(2) Gold	(b) Soluble in water
(3) Sulphur	(c) No chemical reaction
(4) Neon	(d) High ductility

Note : In examination match the column question will have 2 components in Column 'A' with 4 alternatives in Column 'B'.

Ans. (1) Potassium bromide – Soluble in water

(2) Gold – High ductility

(3) Sulphur – Combustible

(4) Neon – No chemical reaction.

*(3) Column I (ores)	Column II (metals)
(1) Bauxite	(a) Mercury
(2) Cassiterite	(b) Aluminium
(3) Cinnabar	(c) Tin

Note : In examination match the column question will have 2 components in Column 'A' with 4 alternatives in Column 'B'.

Ans. (1) Bauxite – Aluminium

(2) Cassiterite – Tin

(3) Cinnabar – Mercury.

(4) Column I	Column II
(1) Copper and zinc	(a) Stainless steel
(2) Copper and tin	(b) Zinc amalgam
	(c) Bronze
	(d) Brass

Ans. (1) Copper and zinc – Brass

(2) Copper and tin – Bronze.

(5) Column I	Column II
(1) Galvanising	(a) Pressure cooker
(2) Tinning	(b) Silver plated spoons
	(c) Coating of tin on copper
	(d) Coating of Zn on iron

Ans. (1) Galvanising – Coating of Zn on iron

(2) Tinning – Coating of tin on copper.

Q. 7 Translate the following statements into chemical equations and then balance them : *(1 mark each)*

(1) Steam is passed over aluminium.

Ans. $2Al_{(s)} + \underset{\text{Steam}}{3H_2O} \rightarrow \underset{\text{Aluminium oxide}}{Al_2O_{3(s)}} + \underset{\text{Hydrogen}}{3H_{2(g)}}$

(2) Extraction of copper from its sulphide ore.

Ans. $\underset{\text{Cuprous sulphide}}{2Cu_2S_{(s)}} + \underset{\text{Oxygen}}{3O_{2(g)}} \xrightarrow{\text{heat}} \underset{\text{Cuprous oxide}}{2Cu_2O} + \underset{\text{Sulphur dioxide}}{2SO_{2(g)}}$

$\underset{\text{Cuprous oxide}}{2Cu_2O_{(s)}} + \underset{\text{Cuprous sulphide}}{Cu_2S_{(s)}} \xrightarrow{\text{heat}} \underset{\text{Copper}}{6Cu_{(s)}} + \underset{\text{Sulphur dioxide}}{SO_{2(g)}}$

(3) Thermit reaction.

Ans. $\underset{\text{Iron oxide}}{3Fe_3O_2} + \underset{\text{Aluminium}}{4Al} \rightarrow \underset{\text{Iron}}{9Fe} + \underset{\text{Aluminium oxide}}{2Al_2O_3} + \text{heat}$

(4) Magnesium reacts with hot water.

Ans. $\underset{\text{Magnesium}}{Mg_{(s)}} + \underset{\text{Hot water}}{2H_2O} \rightarrow \underset{\text{Magnesium hydroxide}}{Mg(OH)_{2(aq)}} + \underset{\text{Hydrogen}}{H_{2(g)}}$

(5) What happens when aluminium oxide dissolves in aqueous sodium hydroxide?

Ans. $\underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Sodium hydroxide}}{2NaOH} \rightarrow \underset{\text{Sodium aluminate}}{2NaAlO_2} + \underset{\text{Water}}{H_2O}$

(6) Zinc reacts with sulphuric acid.

Ans. $\underset{\text{Zinc}}{Zn_{(s)}} + \underset{\text{Sulphuric acid}}{H_2SO_{4(aq)}} \rightarrow \underset{\text{Zinc sulphate}}{ZnSO_{4(aq)}} + \underset{\text{Hydrogen}}{H_2\uparrow}$

(7) Iron reacts with sulphuric acid.

Ans. $\underset{\text{Iron}}{Fe_{(s)}} + \underset{\text{Sulphuric acid}}{H_2SO_4} \rightarrow \underset{\text{Ferrous sulphate}}{FeSO_{4(aq)}} + \underset{\text{Hydrogen}}{H_2\uparrow}$

Q. 8 Name the following : *(1 mark each)*

(1) A metal which forms an amphoteric oxide.

Ans. Aluminium forms an amphoteric oxide.

(2) An alloy of copper and zinc.

Ans. An alloy of copper and zinc is termed as brass.

(3) A compound which is added to lower the fusion temperature.

Ans. Cryolite (AlF_3, 3NaF) and fluorspar (CaF_2) are added to lower the fusion temperature.

(4) A metal which does not react with cold water but reacts with steam.

Ans. Aluminium does not react with cold water but reacts with steam.

(5) A common ore of aluminium.

Ans. Bauxite ($Al_2O_3 \cdot H_2O$) is a common ore of aluminium.

(6) A metal which is in liquid state at ordinary temperature.

Ans. Mercury is in liquid state at ordinary temperature.

(7) Two metals which are malleable.

Ans. Iron and aluminium are malleable metals.

(8) Two metals which are ductile.

Ans. Gold and silver are ductile metals.

(9) Two metals which are good conductors of heat.

Ans. Silver and copper are good conductors of heat.

(10) Two metals which are good conductors of electricity.

Ans. Copper and aluminium are good conductors of electricity.

(11) Two metals which are used for making cooking vessels.

Ans. Copper and aluminium are used in making cooking vessels.

(12) Two metals having low melting points.

Ans. Sodium and potassium have low melting points.

(13) Two highly reactive metals.

Ans. Sodium and potassium are highly reactive metals.

(14) A nonmetal which is in liquid state at room temperature.

Ans. Bromine is in liquid state at room temperature.

(15) Two ionic compounds.

Ans. Sodium chloride (NaCl) and magnesium chloride ($MgCl_2$) are ionic compounds.

*(16) **The nonmetal having electrical conductivity.**

Ans. Graphite having electrical conductivity.

(17) The process of heating the sulphide ore to a high temperature in the excess of air.

Ans. In roasting, sulphide ore is heated to a high temperature in the excess of air.

(18) The process of heating the carbonate ore to a high temperature in limited air.

Ans. In calcination, carbonated ore is heated to a high temperature in limited air.

(19) The compound formed by the reaction between aluminium oxide and sodium hydroxide.

Ans. Sodium aluminate is formed by the reaction between aluminium oxide and sodium hydroxide.

(20) Two metals which are found in the free state in nature.

Ans. Gold (Au) and silver (Ag) are found in the free state in nature.

(21) A metal which has the highest melting point.

Ans. Tungsten has the highest melting point.

(22) Two nonmetals which are lustrous.

Ans. Iodine and diamond are lustrous in nature.

*(23) **The reagent that dissolves noble metals.**

Ans. Aqua regia is the reagent that dissolves noble metals like gold and platinum.

*(24) **The device used for grinding an ore.**

Ans. The device used for grinding an ore is grinding mill.

*(25) **The oxide that forms salt and water by reacting with both acid and base.**

Ans. Aluminium oxide (Al_2O_3).

*(26) **Molecular formula of common ore of aluminium.**

Ans. $Al_2O_3 \cdot nH_2O$

*(27) **Alloy of sodium with mercury.**

Ans. Sodium amalgam.

(28) The reaction in which aluminium is used as a reducing agent.

Ans. The thermit reaction.

Q. 9 Answer the following questions :

(1) Distinguish between the physical properties of metals and nonmetals with respect to the following points :

(1) Physical state (2) Lustre (3) Ductility and malleability (4) Conduction of heat and electricity (5) Hardness (6) Melting and boiling points.

Ans. (1) **Physical state :** Under ordinary conditions, metals are generally solids. Exceptions : mercury and gallium are liquids. Under ordinary conditions, nonmetals may be solids or gases. Exception : bromine is in liquid state.

(2) **Lustre :** Metals usually have a high lustre (called metallic lustre). They can be polished to give a highly reflective surface. With the exceptions of gold and copper, metals usually have silvery grey colour. Nonmetals lack lustre, exceptions : graphite and iodine. Some nonmetals are colourless and others possess a variety of colours.

(3) **Ductility and malleability :** Metals are ductile and malleable. Nonmetals are not ductile and malleable.

(4) **Conduction of heat and electricity :** Metals are good conductors of heat and electricity. Nonmetals are bad conductors of heat and electricity. Exception : Graphite is a good conductor of electricity.

(5) **Hardness :** Metals are usually hard, but not brittle, exceptions : sodium, potassium, lead, zinc. Nonmetals are brittle in the solid state, exception : diamond.

(6) **Melting and boiling points :** The melting and boiling points of metals are high, exceptions :

sodium, potassium, mercury, gallium. The melting and boiling points of nonmetals are low, exceptions : carbon, silicon.

(2) Write any three physical properties of nonmetals.

Ans. (1) Nonmetals may be solid or gaseous. (2) Nonmetals lack lusture. They are not ductile and malleable. (3) The melting and boiling points of nonmetals are low. (4) Nonmetals are bad conductors of heat and electricity.

(3) Metals are good conductors of heat. Explain why.

Ans. (1) The electrons in the outermost shells of atoms of a metal are free to move throughout the metal. (2) When a metal is heated, these electrons start moving with higher velocity and conduct heat. Hence, metals are good conductors of heat.

(4) Metals are good conductors of electricity. Explain why.

Ans. (1) The electrons in the outermost shells of atoms of a metal are free to move throughout the metal. (2) When a potential difference is applied between the ends of a metal wire, the net movement of the electrons in a particular direction, from a point at lower potential to a point at higher potential, constitutes an electric current. Hence, metals are good conductors of electricity.

(5) A metal can be drawn into a wire. Explain why.

Ans. (1) The property due to which a substance can be drawn into a thin wire without cracking or breaking is called ductility. (2) Metals are ductile. Thus, a metal can be drawn into a wire.

(6) A metal can be hammered into a thin sheet. Explain why.

Ans. (1) The property due to which a substance can be hammered (or rolled) into a thin sheet without cracking is called malleability. (2) Metals are malleable. Thus, a metal can be hammered to form a thin sheet.

(7) How do metals react with oxygen?

Ans. Metals combine with oxygen on heating in air and metal oxides are formed.

Metal + Oxygen $\longrightarrow$ Metal oxide

$$2Na_{(s)} + O_{2(g)} \longrightarrow \underset{\text{Sodium oxide}}{Na_2O_{(s)}}$$

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

(8) How does a metal react with water?

Ans. Sodium and potassium react vigorously with water to evolve hydrogen. Calcium reacts with water slowly and less vigorously to evolve hydrogen and the metal floats on water. Magnesium reacts with hot water to evolve hydrogen. Aluminium, iron and zinc do not react with cold or hot water but they react with steam to evolve their oxides and hydrogen.

$$2Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)} + \text{heat energy}$$

$$2K_{(s)} + 2H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_{2(g)} + \text{heat energy}$$

$$2Ca_{(s)} + 2H_2O_{(l)} \longrightarrow 2Ca(OH)_{2(aq)} + H_{2(g)}$$

$$Mg_{(s)} + 2H_2O_{(hot)} \longrightarrow Mg(OH)_{2(aq)} + H_{2(g)}$$

$$2Al_{(s)} + 3H_2O_{steam} \longrightarrow Al_2O_{3(s)} + 3H_{2(g)}$$

$$3Fe_{(s)} + 4H_2O_{steam} \longrightarrow Fe_3O_4 + 4H_{2(g)}$$

$$Zn_{(s)} + H_2O_{steam} \longrightarrow ZnO_{(s)} + H_{2(g)}$$

(9) How does a metal react with an acid?

Ans. Reaction of metals with acids : Metals react with dilute hydrochloric acid or dilute sulphuric acid to form metal chloride or metal sulphate and hydrogen gas. The rate of evolution of H_2 is maximum in case of magnesium. The reactivity decreases in the order

Mg > Al > Zn > Fe.

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

$$2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_{2(g)}$$

$$Zn_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$$

$$Fe_{(s)} + 2HCl_{(aq)} \longrightarrow FeCl_{2(aq)} + H_{2(g)}$$

$$Fe_{(s)} + H_2SO_{4(aq)} \longrightarrow FeSO_4 + H_{2(g)}$$

$$Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_4 + H_{2(g)}$$

$$Mg_{(s)} + H_2SO_{4(aq)} \longrightarrow MgSO_{4(aq)} + H_{2(g)}$$

(10) How does a metal react with nitric acid?

Ans. Metals react with nitric acid to form nitrate salts. Depending on the concentration of nitric acid, various oxides of nitrogen (NO, NO_2) are formed.

$$Cu_{(s)} + \underset{\text{(Conc.)}}{4HNO_3} \longrightarrow Cu(NO_3)_{2(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}$$

$$Cu_{(s)} + \underset{\text{(dilute)}}{8HNO_3} \longrightarrow 3Cu(NO_3)_{2(aq)} + 2NO_{(g)} + 4H_2O_{(l)}$$

(11) Arrange the following metals in the decreasing order of chemical reactivity : Cu, Mg, Fe, Ca, Zn, Na.

Ans. The reactivity of metal decreases in the following order :

Na > Mg > Ca > Zn > Fe > Cu.

(12) What is meant by aqua regia ?

Ans. Aqua regia is a highly corrosive and fuming liquid. It is a freshly prepared mixture of conc. HCl and conc. HNO_3 in the ratio of 3 : 1. Most of the substances dissolve in it. Aqua regia is a reagent which dissolves gold and platinum.

(13) How does a metal react with salts of other metals?

Ans. The reaction of metals with solutions of salts of other metals is the displacement reaction. If a metal A displaces other metal B from the solution of its salt, it means that the metal A is more reactive than the metal B.

Metal A + Salt solution of metal B $\longrightarrow$

Salt solution of metal A + metal B

$$\underset{\text{Iron}}{Fe} + \underset{\text{Copper sulphate}}{CuSO_4} \longrightarrow FeSO_4 + \underset{\text{copper}}{Cu}$$

In this reaction Fe has displaced Cu from $CuSO_4$. It means Fe is more reactive than Cu.

(14) Explain the reactivity series of the metals.

Ans. The arrangement of metals in decreasing order of their reactivity in the form of a series is called the reactivity or activity series of the metals.

The most reactive metal is placed at the top of the list and least reactive metal is placed at the bottom of the list.

On the basis of reactivity, we can classify metals into the following categories :

(1) High reactivity metals (2) Moderately reactive metals (3) Less reactive metals.

(1) **Extraction of High reactivity metals :** The metals which are placed at the top of the reactivity series are very reactive. They are never found in nature as free elements, e.g., sodium, potassium, calcium and aluminium. These metals are obtained by electrolytic reduction.

(2) **Extraction of Moderately reactive metals :** The metals in the middle of reactivity series such as iron, zinc, lead, copper are moderately reactive. These elements are present as sulphides or carbonates in nature. Generally metals are obtained from their oxide as compared to their sulphides and carbonates.

(3) **Extraction of Less reactive metals :** The metals which are placed at the bottom of the reactivity series are least reactive. They occur in free state, e.g. gold, silver and copper. Copper and silver are also found in the combined state as sulphide and oxide ores. These metals are obtained from their ores by just heating the ores in air.

***(15) Divide the metals Cu, Zn, Ca, Mg, Fe, Na, Li into three groups, namely, reactive metals, moderately reactive metals and less reactive metals.**

Ans.

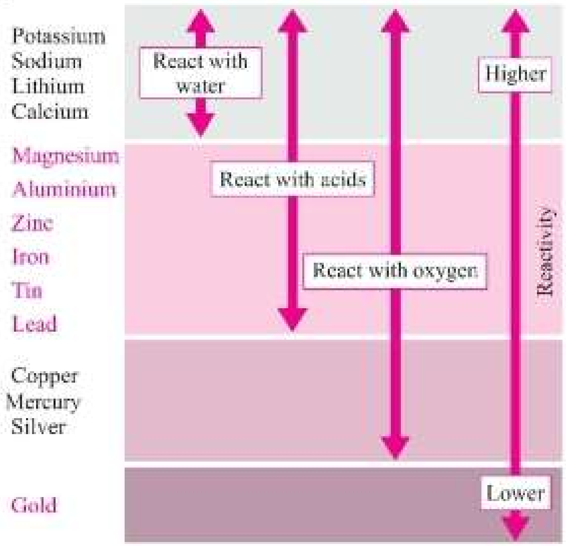
Reactive metals	: Na, Li, Ca
Moderately reactive metals	: Zn, Fe, Mg,
Less reactive metals	: Cu

(16) Arrange the following metals in the increasing order of their activity : Copper, Silver, Aluminium, Iron.

Ans. The arrangement of metals in the increasing order of their activity :

Silver < Copper < Iron < Aluminium

(17) Observe the given figure of reactivity series of metals and answer the following questions :



Reactivity series of metals

(a) Name *two* metals which react with water.

(b) Name *two* moderately reactive metals.

(c) Name the most highly reactive metal and the most less reactive metal.

(3 Marks) (March '20)

Ans. (a) Metals which react with water : Potassium, Sodium.

(b) Two moderately reactive metals : Magnesium, aluminium.

(c) The most highly reactive metal : Potassium.

The most less reactive metal : Gold.

***(18) When a copper coin is dipped in silver nitrate solution, a glitter appears on the coin after some time. Why does this happen? Write the chemical equation.**

Ans. When a copper coin is dipped in a silver nitrate solution, more reactive copper displaces silver from silver nitrate solution. The silver so liberated deposits on the copper coin. As a result, a shiny coat of silver is formed on the coin.

$$Cu_{(s)} + 2AgNO_{3(aq)} \longrightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$$

***(19) The electronic configuration of metal 'A' is 2, 8, 1 and that of metal 'B' is 2, 8, 2. Which of the two metals is more reactive? Identify these metals. Write their reaction with dilute hydrochloric acid.**

Ans. If the number of electrons in the outermost orbit is less, then the metal is more reactive. Metal A contains one electron in the outermost shell, while metal B contains two electrons. Hence, metal A is more reactive than metal B.

Metal A is sodium and metal B is magnesium. Reactions of Na and Mg with dil. HCl are,

$$\underset{\text{Sodium}}{2Na} + 2HCl \rightarrow \underset{\text{Sodium chloride}}{2NaCl_{(aq)}} + \underset{\text{Hydrogen}}{H_{2(g)}}$$

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{dil. HCl}}{2HCl} \rightarrow \underset{\text{Magnesium chloride}}{MgCl_2} + \underset{\text{Hydrogen}}{H_{2(g)}}$$

(20) Atomic number of metal "A" is 11, while atomic number of metal "B" is 20. Which of them will be more reactive? Write the chemical reaction of dilute HCl with metal "A".

(3 marks)

Ans. Metal 'A' is more reactive than metal 'B'.

Atomic number of metal 'A' is 11, hence it is Na.

$$2Na + 2HCl \longrightarrow 2NaCl_{(aq)} + H_{2(g)}$$

(21) How does a metal react with a nonmetal?

Ans. By oxidation of a metal, cations are formed, on the other hand by reduction of a nonmetal, anions are formed. The ionic compound is formed due to the metal losing electrons while the nonmetal accepts the electrons. The ionic compound of sodium chloride is formed as sodium loses one electron while chlorine accepts one electron.

$$Na \rightarrow Na^+ + e^-$$

$$Cl + e^- \rightarrow Cl^-$$

$$Na + Cl \rightarrow NaCl \quad \text{Sodium chloride}$$

Similarly Mg and K form ionic compounds $MgCl_2$ and KCl.

(22) How do nonmetals react with oxygen?

Ans. Nonmetals combine with oxygen to form acidic oxides. In some cases, neutral oxides are formed.

$$C_{(s)} + O_{2(g)} \xrightarrow{\text{Complete Combustion}} \underset{\text{Carbon dioxide}}{CO_{2(g)}} \text{ (Acidic)}$$

$$S_{(s)} + O_{2(g)} \xrightarrow{\text{Combustion}} \underset{\text{Sulphur dioxide}}{SO_{2(g)}} \text{ (Acidic)}$$

$$2C_{(s)} + O_{2(g)} \xrightarrow{\text{Partial Combustion}} \underset{\text{Carbon monoxide}}{2CO} \text{ (Neutral)}$$

(23) How do nonmetals react with water?

Ans. Nonmetals do not react with water, (exception : halogen). Chlorine dissolves in water giving hypochlorous acid.

$$Cl_{2(g)} + H_2O_{(l)} \longrightarrow \underset{\text{Hypochlorous acid}}{HOCl_{(aq)}} + HCl_{(aq)}$$

(24) How do nonmetals react with dilute acids?

Ans. Nonmetals do not react with dilute acid, (exception : halogen). Chlorine reacts with dil. hydrobromic acid to form bromine and HCl.

$$\underset{\text{Chlorine}}{Cl_{2(g)}} + 2HBr_{(aq)} \longrightarrow 2HCl_{(aq)} + \underset{\text{Bromine}}{Br_{2(aq)}}$$

(25) How do nonmetals react with hydrogen?

Ans. Nonmetals react with hydrogen under certain conditions (such as proper temperature, pressure, catalyst, etc.)

$$\underset{\text{Nitrogen}}{N_{2(g)}} + 3H_{2(g)} \longrightarrow \underset{\text{Ammonia}}{2NH_3}$$

$$\underset{\text{Sulphur}}{S} + H_{2(g)} \longrightarrow \underset{\text{Hydrogen sulphide}}{H_2S}$$

(26) In the reaction between chlorine and HBr a transformation of HBr into Br_2 takes place. Can this transformation be called oxidation? What is the oxidant that brings about this oxidation?

(Use your brain power!) (Textbook page 98)

Ans. The conversion of HBr to Br_2 is an oxidation process. In the above reaction, Cl_2 in the oxidant.

(27) What is meant by an ionic compound?

Ans. The compound formed from two units, namely cation and anion is called an ionic compound.

(28) What is meant by an ionic bond?

Ans. The cation and anion being oppositely charged, there is an electrostatic force of attraction between them, this force of attraction between cation and anion is called the ionic bond.

(29) State the general properties of ionic compounds.

Ans. (1) Ionic compounds are solids and hard due to strong electrostatic force of attraction between oppositely charged ions. (2) They are generally brittle. When pressure is applied they break into pieces. (3) They have high melting and boiling points, due to intermolecular force of attraction is high in ionic compounds. (4) They are soluble in water and insoluble in solvents such as kerosene and petrol. (5) Ionic compounds cannot conduct electricity when in solid state, they are electrically neutral. They conduct electricity in the molten state and also in an aqueous solution.

(30) Explain the following terms :

Ans. *(1) **Minerals :** The naturally occurring compounds of metals along with other impurities are known as minerals.

Examples : Rocks are composed of mixtures of minerals. Talc and granite are minerals.

*(2) **Gangue :** Ores contain metal compounds with some of the impurities like soil, sand, rocky material, etc. These impurities are called gangue.

*(3) **Ores :** The minerals from which metals are extracted profitably and conveniently are called ores. **Examples :** Bauxite ($Al_2O_3 \cdot H_2O$), Cinnabar (HgS).

*(4) **Metallurgy :** The process used for extraction of metals in their pure form from their ores, then metals are further purified by different methods of purification. All the process is called metallurgy.

(5) **Concentration of ores :** The process of separating gangue from the other ores is called concentration of ores.

(6) **Roasting :** The process of heating an ore to a high temperature in excess of air and converting it into its oxide is called roasting.

Examples : ZnS (zinc blend), PbS (Galena)

$$ZnS \xrightarrow[\text{oxidation}]{O_2 \text{ (heat)}} ZnO$$

(7) **Calcination :** The process of heating an ore in a limited supply of air and converting it into its oxide is called calcination.

Example : Zinc carbonate ($ZnCO_3$)

$$ZnCO_3 \longrightarrow ZnO + CO_2 \uparrow$$

(8) **Refining :** The metal obtained by chemical reduction contains impurities. The process of electrolysis method is used to obtain pure metals from impure metals is known as refining.

(31) State two methods of concentration of ores in which the heavy particles of ores can be separated from the light gangue particles by the gravitational method.

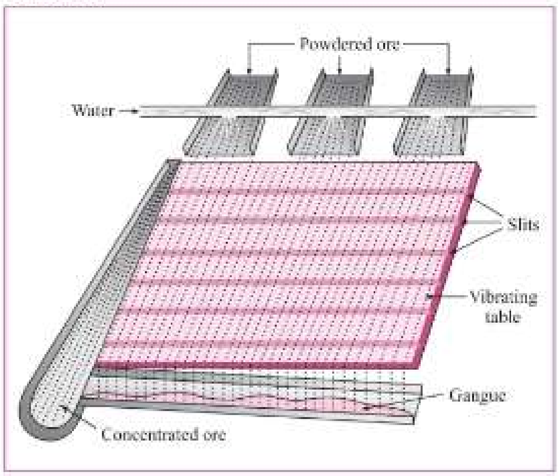
Ans. (1) Wilfley table method and (2) Hydraulic separation method are two methods of concentration of ores in which the heavy particles of ores can be separated from the light gangue particles by the gravitational method.

(32) What are the different methods used for removing gangue from ores? *OR* **Write the five methods of concentration of ores.**

Ans. (1) Wilfley table method (2) Hydraulic separation method (3) Magnetic separation method (4) Froth floatation method (5) Leaching method.

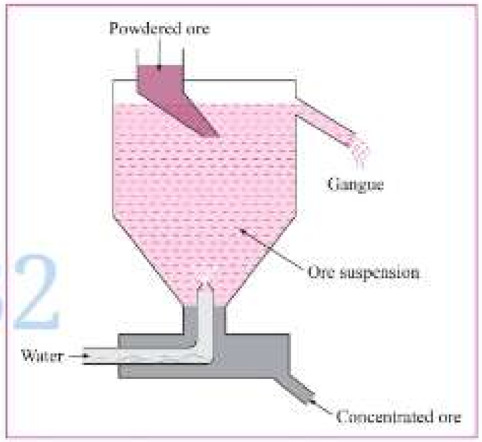
(33) Write short notes on : (1) Wilfley table method (2) Hydraulic separation method (3) Magnetic separation method (4) Froth floatation method (5) Leaching method.

Ans. (1) Wilfley table method : (Separation based on gravitation) This method of separation uses the Wilfley table, it is made by fixing narrow and thin wooden wedges/blocks on inclined surface with low slope. The table is kept continuously vibrating.



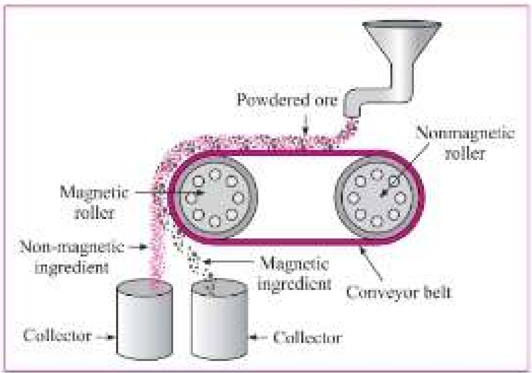
Lumps of the ore is made powdered ore by using ball mill. This powdered ore is poured on the table and a stream of water is simultaneously released from the upper side. This result in the lighter gangue particles getting carried away along with the flowing water, while the heavier particles in which proportion of minerals is more and proportion of gangue particles is less, are blocked by the wooden wedges and is collected through the slits between them.

(2) Hydraulic separation method : The hydraulic separation method is based on the working of a mill. This is a tapering vessel similar to that used in a grinding mill. It opens in a tank-like a container that is tapering on the lower side. The tank has an outlet for water on the upper side and a water inlet on the lower side.



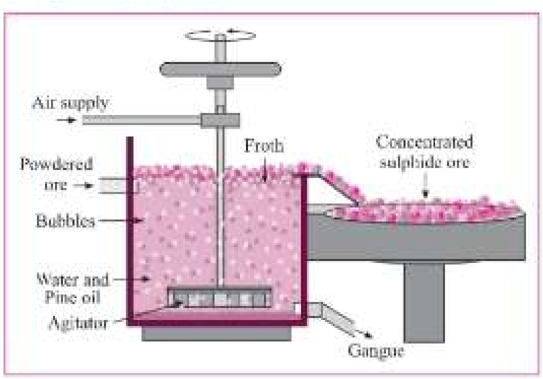
Finely ground ore is added to the tank. A fast stream of water is released in the tank from the lower side. The lighter gangue particles flow out along with the water stream from the outlet on the upper side of the tank and are collected separately, simultaneously the heavy particles of the ore are collected at the bottom from the lower side of the tank. This method is based on the law of gravitation, wherein particles of the same size are separated by their weight with the help of water.

(3) Magnetic separation method : Electromagnetic machine is used in this method. The main parts of this machine are two types of iron rollers and the conveyor belt continuously moving around them. One of the rollers is nonmagnetic while the other is electromagnetic. The conveyor belt moving around the rollers is made up of leather or brass (nonmagnetic). The powdered ore is poured at that end of the conveyor belt which is on the side of the nonmagnetic roller. Two collector vessels are placed below the magnetic roller. The particles of the nonmagnetic part in the ore are not attracted towards the magnetic roller. Therefore, they are carried out further along the belt and fall in the collector vessel which is away from the magnetic roller. Simultaneously the particles of the magnetic ingredients of the ore stick to the magnetic roller and therefore fall in the collector vessel near the belt.



In this way the magnetic and nonmagnetic particles in the ore are separated because of their magnetic nature. For example, cassiterite is a tin ore. It contains mainly the nonmagnetic ingredient stannic oxide (SnO_2) and the magnetic ingredient ferrous tungstate ($FeWO_4$). These are separated by the electromagnetic method.

(4) Froth floatation method : The froth floatation method is based on the two opposite properties, hydrophilic and hydrophobic, of the particles. The metal sulphides particles get wet mainly with oil due to their hydrophobic property. The gangue particles get wet with water due to the hydrophilic property.



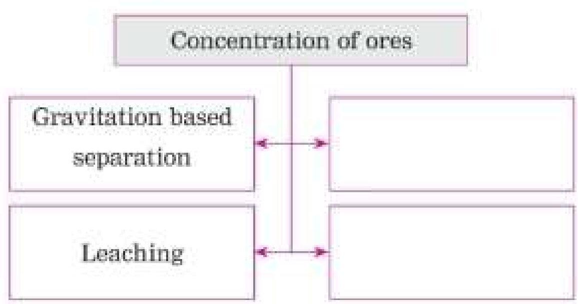
In this method the finely ground mineral is put into a big tank containing a lot of water. The finely powdered ore and vegetable oil such as pine oil, eucalyptus oil are mixed with water for formation of froth. The pressurised air is blown through the mixture. There is a agitator rotating around its axis in the centre of the floatation tank. The agitator is used as per the requirement. Bubbles are formed due to the blown air. A foam is formed from oil, water and air bubbles together, due to the agitating. This foam rises to the surface of the water and floats. Hence this method is called froth floatation. Sulphide minerals float with the foam on water as they get and can be removed. The gangue particles are wetted by water, settles down at the bottom. This method is used for concentration of zinc blend (ZnS) and copper pyrite ($CuFeS_2$).

(5) Leaching : Leaching is the first step in the extraction of the metals like aluminium, gold and silver from their ores. In this method the ore is soaked in a particular solution for long time. The ore dissolves in that solution due to specific chemical reaction. The gangue, however, does not react and therefore does not dissolve in that solution. It can be separated easily. For example, concentration of bauxite, the aluminium ore, is done by leaching method. Bauxite is soaked in aqueous NaOH or aqueous Na_2CO_3 which dissolves the main ingredient alumina in it. This means that bauxite is leached by sodium hydroxide.

(34) Draw a neat labelled diagram of the arrangement of the equipment used in (1) Wilfley table method (2) Hydraulic separation method (3) Magnetic separation method (4) Froth floatation method.

Ans. *For reference see the diagram to Q. 9 (33) (1 to 4).*

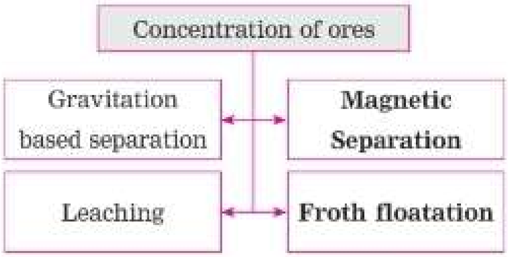
(35) Complete the following flow chart and answer the questions below :



(i) In which method pine oil is used?

(ii) Explain that method of concentration in brief.

Ans.



(i) Pine oil is used in froth floatation method.

(ii) The finely powdered ore and vegetable oil such as pine oil, eucalyptus oil are mixed with water for formation of froth. The pressurised air is blown through the mixture. The agitator is used as per the requirement. Bubbles are formed due to the blown air. A foam is formed from oil, water and air bubbles together, due to the agitating. This foam rises to the surface of the water and floats. Hence this method is called froth floatation. Sulphide minerals float with the foam on water as they get and can be removed. The gangue particles are wetted by water, settles down at the bottom. This method is used for concentration of zinc blend (ZnS) and copper pyrite ($CuFeS_2$).

(36) A tapping vessel opens in a tank like container that is tapering on the lower side. The tank has an outlet for water on the upper side and a water inlet on the lower side. Finely ground ore is released in the tank. A forceful jet of water is introduced in the tank from lower side and gangue particles and pure ore are separated by this method.

(i) The above description is of which gravitation separation method?

(ii) Draw labelled diagram of this method.

(March '19)

Ans. (i) Hydraulic separation method.

(ii) *For reference see the diagram to Q. 9 (33) (2).*

(37) How are sodium, magnesium and potassium obtained from their molten chloride salts?

Ans. The metals sodium, calcium and magnesium are obtained by electrolysis of their molten chloride salts. In this process metal is deposited on the cathode while chlorine gas is liberated at the anode.

(38) Write the electrode reaction for electrolysis of molten magnesium chloride and calcium chloride.

(Use your brain power!) (Textbook page 103)

Ans.

(1) **Magnesium chloride ($MgCl_2$) :**

$MgCl_2 \rightarrow Mg^{2+} + 2Cl^-$

At the cathode : $Mg^{2+} + 2e^- \rightarrow Mg$

At the anode : $2Cl^- \rightarrow Cl_2 + 2e^-$

(2) **Calcium chloride ($CaCl_2$) :**

At the cathode : $Ca^{2+} + 2e^- \rightarrow Ca$

At the anode : $2Cl^- \rightarrow Cl_2 + 2e^-$

(39) Name the main ore of aluminium.

Ans. Bauxite ($Al_2O_3 \cdot H_2O$) is the main ore of aluminium.

(40) What is bauxite ? What are the main impurities found in this ore ?

Ans. Bauxite ($Al_2O_3 \cdot H_2O$) is a hydrated aluminium oxide. It contains 30% to 70% Al_2O_3. The main impurities present in it are iron oxide (Fe_2O_3) and sand (SiO_2).

(41) From which ore is aluminium extracted ? What are the stages in its extraction (give only names) ?

Ans. Aluminium is extracted from bauxite ($Al_2O_3 \cdot nH_2O$). **Stages in the extraction :** (i) Concentration of ore, i.e., conversion of bauxite into alumina. (ii) Electrolytic reduction of alumina.

(42) Describe Bayer's process for concentration of bauxite.

Ans. (1) Bayer's process is used to obtain pure aluminium oxide from bauxite.

(2) Bauxite is then concentrated by chemical separation. Bauxite contains impurities like iron oxide (Fe_2O_3) and silica (SiO_2).

(3) Bauxite ore is powdered and heated with sodium hydroxide under high pressure for 2 to 8 hours at 140 °C in the digester. The aluminium oxide being amphoteric in nature present in bauxite reacts with sodium hydroxide to form water soluble sodium aluminate. This means that bauxite leached by sodium hydroxide. Silica reacts with sodium hydroxide to form soluble sodium silicate. The basic iron oxide (Fe_2O_3) in the gangue remains unaffected. It is separated by filtration.

$$\underset{\text{(From impure bauxite ore)}}{Al_2O_{3(s)}} + 2NaOH_{(aq)} \rightarrow \underset{\text{Sodium aluminate}}{2NaAlO_{2(aq)}} + H_2O_{(l)}$$

$$\underset{\text{silica}}{SiO_2} + 2NaOH_{(aq)} \rightarrow \underset{\text{Sodium silicate}}{Na_2SiO_3} + H_2O$$

(4) The filtrate containing sodium aluminate and sodium silicate is stirred with water and then cooling to 50° C. It is hydrolysed to give precipitate of aluminium hydroxide.

$$NaAlO_{2(aq)} + 2H_2O_{(l)} \longrightarrow \underset{\text{Aluminium hydroxide}}{Al(OH)_{3(s)}} \downarrow + NaOH_{(aq)}$$

(5) Aluminium hydroxide is then filtered, washed with water, dried and then calcinated by heating at 1000 °C to get pure aluminium oxide.

$$2Al(OH)_{3(s)} \xrightarrow[1000\,^\circ C]{heat} Al_2O_{3(s)} + 3H_2O_{(g)}$$

(43) Describe Hall's process for concentration of bauxite.

Ans. In Hall's process the ore is powdered and then it is leached by heating with aqueous sodium carbonate in the digester to form water soluble sodium aluminate. Then the insoluble impurities are filtered out. The filtrate is warmed and neutralised by passing carbon dioxide gas through it. This result in precipitation of aluminium hydroxide.

$$Al_2O_3{\cdot}2H_2O_{(s)} + Na_2CO_{3(aq)} \longrightarrow \underset{\text{Sodium aluminate}}{2NaAlO_{2(aq)}} + CO_2\uparrow + 2H_2O_{(l)}$$

$$2NaAlO_{2(aq)} + 3H_2O + CO_{2(g)} \longrightarrow \underset{\text{Aluminium hydroxide}}{2Al(OH)_3\downarrow} + Na_2CO_3$$

The precipitate of $Al(OH)_3$ obtained in this processes is filtered, washed, dried and then calcinated by heating at 1000 °C to obtain alumina.

$$2Al(OH)_3 \xrightarrow{1000\,^\circ C} \underset{\text{Alumina}}{Al_2O_3} + 3H_2O$$

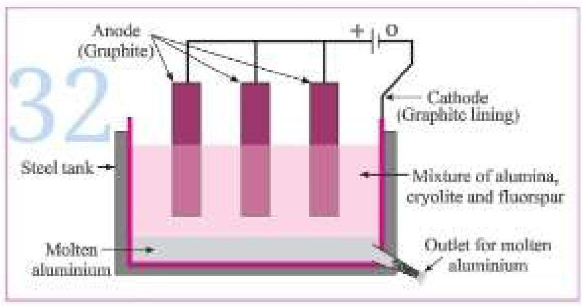
(44) Describe the process of preparation of aluminium by the electrolysis of alumina.

OR

Draw and label the diagram of electrolysis of alumina and explain the electrolytic reduction of alumina.

Ans. Electrolytic reduction of alumina :

(1) The electrolytic cell consists of a rectangular steel tank lined from inside with graphite.



(2) The carbon lining (graphite) acts as a cathode. The anode consists of graphite rods suspended in the molten electrolyte.

(3) Alumina has very high melting point (> 2000 °C). The electrolysis of alumina is carried out at a low temperature by dissolving it in molten cryolite (Na_3AlF_6). The solution of alumina in cryolite and small amount of fluorspar (CaF_2) is added in the mixture to lower its melting point up to 1000 °C.

(4) On passing an electric current, alumina is electrolysed.

(5) Molten aluminium is collected at the cathode, while oxygen gas is evolved at the anode.

The electrode reactions are shown below :

$Al_2O_3 \rightarrow 2Al^{3+} + 3O^{2-}$

Anode reaction : $2O^{2-} \rightarrow O_{2(g)} + 4e^-$

Cathode reaction : $Al^{3+} + 3e^- \rightarrow Al$

The molten aluminium is heavier than the electrolyte. Therefore, it sinks to the bottom of the electrolyte and is removed from time to time. About 99% pure aluminium is obtained by this process.

The oxygen gas liberated reacts with carbon anode and forms carbon dioxide. As the anode gets oxidised during the electrolysis of alumina, it has to be replaced from time to time.

***(45) Draw a neat labelled diagram of electrolytic reduction of alumina.** *OR*

Identify the process given in the following passage and draw neat labelled diagram showing the process.

Electrolysis of molten mixture of alumina (melting point > 2000 °C) is done in a steel tank. The tank has a graphite lining on the inner side. This lining does the work of a cathode. A set of graphite rods dipped in the molten electrolyte works as anode. Cryolite (Na_3AlF_6) and fluorspar (CaF_2) are added in the mixture to lower its melting point up to 1000 °C.

(Board's Model Activity Sheet) (3 marks)

Ans. *For reference see the diagram to Q. 9 (44).*

(46) In the extraction of aluminium :

(i) Name the process of concentration of bauxite.

Ans. The process of concentration of bauxite is known as Bayer's process.

(ii) Write the cathode reaction in electrolytic reduction of alumina.

Ans. At the cathode : $Al^{3+} + 3e^- \longrightarrow Al.$

(iii) Write the function and formula of cryolite in the extraction of aluminium.

Ans. Cryolite is added to the molten mixture of alumina to reduce the melting point to about 1000 °C.

The formula of cryolite is (Na_3AlF_6) or $AlF_3 \cdot 3NaF$.

(iv) Write an equation for the action of heat on aluminium hydroxide.

Ans. $\underset{\text{Aluminium hydroxide}}{2Al(OH)_3} \xrightarrow[1000\,^{\circ}C]{\text{heat}} \underset{\text{Alumina}}{Al_2O_3} + \underset{\text{Water}}{3H_2O}.$

(v) Draw the diagram of extraction of aluminium.

Ans. *For reference, see Fig. Q. 9 (44).*

(vi) Write the anode reaction in electrolytic reduction of alumina.

Ans. $Al_2O_3 \rightarrow 2Al^{3+} + 3O^{2-}$

At Anode $2O^{2-} \rightarrow O_{2(g)} + 4e^-$

(vii) Write the cathode reaction in electrolytic reduction of alumina.

Ans. $Al_2O_3 \longrightarrow 2Al^{3+} + 3O^{2-}$

Cathode : $Al^{3+} + 3e^- \longrightarrow Al_{(l)}$

(47) Observe the following diagram and answer the questions. ***(Nov. '20)***

For reference see the diagram to Q. 9 (44).

(a) Write the anode reaction.

(b) Write the cathode reaction.

(c) What is the purpose of mixing cryolite and fluorspar with alumina in the electrolytic reduction of alumina.

Ans. (a) Anode reaction :

$2O^{2-} \rightarrow O_2 + 4e^-$ (Oxidation)

(b) Cathode reaction :

$Al^{3+} + 3e^- \rightarrow Al$ (Reduction)

(c) Cryolite and fluorspar is added to the molten mixture of alumina to lower its melting point up to 1000 °C

• Can you tell? (Textbook page 104)

(1) What are the moderately reactive metals?

Ans. In the middle of the reactivity series, metals such as iron, zinc, lead, copper are moderately reactive.

(2) In which form to the moderately reactive metals occur in nature?

Ans. The moderately reactive metals which occur in nature are in the form of their sulphide salts or carbonate salts.

(48) What happens when aluminium ore is heated with caustic soda ? Write the balanced chemical equation for the same.

Ans. When aluminium ore is heated with caustic soda solution under high pressure for 2 to 8 hours and at 140 °C to 150 °C, aluminium oxide from aluminium ore, being amphoteric in nature, dissolves in caustic soda solution to form sodium aluminate.

$$\underset{\text{aluminium oxide}}{Al_2O_3} + \underset{\text{sodium hydroxide}}{2NaOH} \longrightarrow \underset{\text{sodium aluminate}}{2NaAlO_2} + H_2O$$

(49) How is zinc extracted from its ore zinc sulphide or zinc carbonate ?

Ans. The crude zinc sulphide ore is heated strongly in excess of air. Zinc sulphide is converted into zinc oxide. This process is known as roasting.

$$\underset{\text{Zinc sulphide}}{2ZnS_{(s)}} + 3O_{2(g)} \longrightarrow \underset{\text{Zinc oxide}}{2ZnO_{(s)}} + \underset{\text{Sulphur dioxide}}{2SO_{2(g)}}$$

OR

The crude zinc carbonate ore is heated strongly in limited supply of air. Zinc carbonate is converted into zinc oxide. This process is known as calcination.

$$\underset{\text{Zinc carbonate}}{ZnCO_{3(s)}} \longrightarrow \underset{\text{Zinc oxide}}{ZnO_{(s)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}}$$

The zinc oxide is reduced to zinc by using a reducing agent such as carbon.

$$\underset{\text{Zinc oxide}}{ZnO_{(s)}} + \underset{\text{Carbon}}{C_{(s)}} \longrightarrow \underset{\text{Zinc}}{Zn_{(s)}} + \underset{\text{Carbon monoxide}}{CO_{(g)}}$$

(50) $3MnO_2 + 4Al \longrightarrow 3\ Mn + 2Al_2O_3 + \text{heat}$. Identify the substances undergone oxidation and reduction reactions. (Textbook page 105)

Ans. MnO_2 is reduced to Mn.

Al is oxidised to Al_2O_3

(51) How is copper extracted from its sulphide ore ?

Ans. Copper is found as cuprous sulphide (Cu_2S) in nature. When Cu_2S is heated in air, copper is obtained.

$$\underset{\text{Cuprous sulphide}}{2Cu_2S_{(s)}} + 3O_{2(g)} \xrightarrow{\text{heat}} \underset{\text{Cuprous oxide}}{2Cu_2O_{(s)}} + 2SO_{2(g)}$$

$$2Cu_2O + Cu_2S \xrightarrow{\text{heat}} 6Cu_{(s)} + SO_{2(g)}$$

(52) How is mercury extracted from cinnabar? *OR*

Extraction of mercury from its ore cinnabar and write the corresponding chemical reaction.

Ans. Cinnabar is an ore of mercury. When cinnabar is heated (roasted), it is converted into mercuric oxide (HgO). Mercuric oxide is then reduced to mercury on further heating.

$$\underset{\text{Cinnabar}}{2HgS_{(s)}} + 3O_{2(g)} \xrightarrow{\text{heat}} 2HgO_{(s)} + 2SO_{2(g)}$$

$$\underset{\text{Mercuric oxide}}{2HgO_{(s)}} \xrightarrow{\text{heat}} \underset{\text{Mercury}}{2Hg} + \underset{\text{Oxygen}}{O_{2(g)}}$$

(53) Show the steps involved in the extraction of moderately reactive metals from their sulphide ores.

Ans. Moderately reactive elements are present as sulphides or carbonates in nature.

Extraction of moderately reactive metal from their sulphide ore

↓ Heating at high temperature in excess air (Roasting)

Metal oxide

↓ Reduction

Metal

↓ Refining

Pure metal

(54) In the reactivity series of metals, some metals are misplaced. Rearrange these metals in the decreasing order of their reactivity.

Most reactive ⟶ **Less reactive**

Zn	Na	K	Mg	Ca	Al	Hg	Fe	Pb	Cu	Ag

Ans.

Most reactive ⟶ **Less reactive**

K	Na	Ca	Mg	Al	Zn	Fe	Pb	Cu	Hg	Ag

(55) Complete the table, if a metal reacts with the reagent then mark ✓ and if not then ✗.

Metal	Ferrous sulphate	Silver nitrate	Copper sulphate	Zinc sulphate
Cu				
Al				

Ans.

Metal	Ferrous sulphate	Silver nitrate	Copper sulphate	Zinc sulphate
Cu	✗	✓	✗	✗
Al	✓	✓	✓	✓

(56) Explain the term corrosion with a suitable example. *OR*

What is corrosion ?

Ans. The process in which a metal is destroyed gradually by the action of air, moisture or a chemical (like an acid) on its surface is called corrosion.

OR

Corrosion is degradation of a material due to reaction with its environment.

The major problem of corrosion occurs with iron, as it is used as a structural material in construction, bridges, ship building.

Iron gets covered by reddish brown flakes when exposed to atmosphere. This is an example of corrosion.

(57) Explain the different methods to prevent corrosion of metals.

Ans. (1) Corrosion of a metal can be prevented if the contact between metal and air is cut off.

(2) Corrosion of a metal is prevented by coating with something which does not allow moisture and oxygen to react with it.

(3) A layer of oil or paint or grease is applied on the surface of a metal to prevent corrosion. The rusting or corrosion of iron can be prevented by this method.

(4) Corrosion is also prevented by coating a corrosive metal with a noncorrosive metal. Galvanising, tinning, electroplating, anodising and alloying are the different methods in which a metal is coated with a noncorrosive metal to prevent corrosion.

(58) Write three methods of preventing rusting of iron.

Ans. (1) The rusting of iron can be prevented by painting, oiling, greasing or varnishing its surface.

(2) Galvanisation is another method of protecting iron from rusting by coating iron with a thin layer of zinc.

(3) Corrosion of iron is prevented by coating iron with noncorrosive substance like carbon. This process is termed as alloying.

(59) Why do silver articles turn blackish while copper vessels turn greenish on keeping in air for long time?

(Think about it) (Textbook page 106)

Ans. (1) Silver articles turn blackish on exposure to air for a long time. This is because of silver sulphide (Ag_2S) layer formed on the silver articles by the reaction of silver with hydrogen sulphide. (2) Carbon dioxide in moist air reacts with copper vessel. Copper loses its lustre due to formation of greenish layer of copper carbonate ($CuCO_3$) on its surface.

(60) Why do pure gold and platinum always glitter? (Think about it) (Textbook page 106)

Ans. Gold and platinum are noble metals as they do not react with moisture, O_2 and CO_2 from air also acids and alkalis, therefore, pure gold and platinum always glitter.

(61) Which measures would you suggest to stop the corrosion of metallic articles or not allow the corrosion to start?

(Can you tell?) (Textbook page 106)

Ans. Various types of methods are used to protect metals from corrosion. Almost in all the methods, special attention is paid so that iron does not rust. It is possible to lower the rate of the process of rusting of iron. Corrosion of metals can be stopped by detaching the air from metals. Some methods are as follows :

(1) To fix a layer of some substance on the metal surface so that the contact of the metal with moisture and oxygen in the air is prevented and no reaction would occur between them.

(2) To prevent corrosion of metals by applying a layer of paint, oil, grease or varnish on their surface. For example, corrosion of iron can be prevented by this method.

(62) What is done so to prevent rusting of iron windows and iron doors of your house?

(Can you tell?) (Textbook page 106)

Ans. To prevent rusting of iron windows and iron doors in the house, they are painted so that they do not rust.

(63) Can we permanently prevent the rusting of an iron article by applying a layer of paint on its surface?

(Use your brain power!) (Textbook page 107)

Ans. The method of painting is alright for sometime. We cannot protect the articles permanently from rusting by painting them.

(64) Why do new iron sheets appear shiny ?

(Textbook page 107)

Ans. The new iron sheets appear shiny because a layer of noncorrosionable metal is fixed on the surface of corrosionable metal.

(65) What is meant by an alloy ? Give two examples with chemical composition.

Ans. The homogeneous mixture formed by mixing a metal with other metals or nonmetals in certain proportion is called an alloy.

Examples :

(1) Bronze : Bronze is an alloy formed from 90% copper and 10% tin. Bronze statues stay well in sun and rain.

(2) Stainless steel : Stainless steel alloy is made from 74% iron, 18% chromium and 8% carbon. This alloy does not get stained with air or water and does not rust.

(66) Write short notes on the following :

(1) Galvanizing.

Ans. (1) The process of coating a thin layer of zinc on iron or steel is called galvanization.

(2) In this method corrosion of zinc occurs first because zinc is more electropositive than iron. After a few years zinc layer goes away and the iron layer gets exposed and starts rusting.

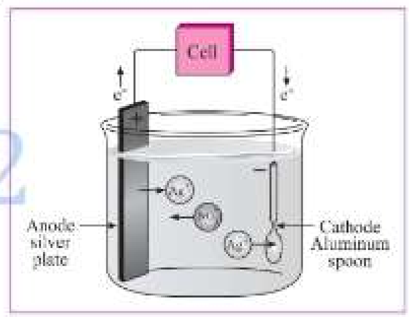
(3) In galvanization an iron object is dipped into molten zinc. A thin layer of zinc is formed all over the iron object. **Examples :** Shiny iron nails, pin, iron pipes.

(2) Tinning.

Ans. (1) The process of coating a thin layer of tin (molten tin) on copper or brass is called tinning. Cooking vessels made of copper and brass get a greenish coating due to corrosion. The greenish substance is copper carbonate and it is poisonous. If butter milk or curry is placed in such a vessel it gets spoiled. Therefore, these vessels are coated with tin to prevent corrosion.

(3) Electroplating.

Ans.



The process in which a less reactive metal is coated on a more reactive metal by electrolysis is called electroplating.

Examples : Silver-plated spoon, gold-plated jewellery.

(1) Which process will you study with the help of above material and solutions.

Ans. With the help of above material and solutions, electroplating process is studied.

(2) Define the process.

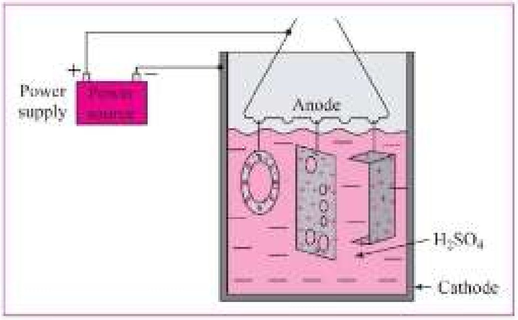
Ans. The process in which less reactive metal is coated on a more reactive metals by electrolysis is called electroplating.

(3) Write the anode and cathode reactions.

Ans. At anode : $Ag \longrightarrow Ag^+ + e^-$

At cathode : $Ag^+ + e^- \longrightarrow Ag$

(4) Anodizing.



Ans. The anodizing technique is an application of electrolysis. In this method copper or aluminium article is used as anode and it is coated with a strong film of their oxides by means of electrolysis. This oxide layer is strong and uniform all over the surface. This thin film protects the metals from corrosion. The protection can be further increased by making the oxide layer thicker during the anodization. **Examples :** Kitchen articles such as anodized pressure cooker and anodized pan.

OR

Identify the process shown in the above diagram and explain it in brief. ***(2 marks)***

Ans. *For reference see the answer to Q. 9 (66) (4). The process shown in the diagram is anodization.*

(5) Alloying. ***(2 marks) (March '20)***

Ans. A homogenous mixture of two or more metals or a metal and a nonmetal in a definite proportion is called an alloy. The physical properties of an alloy are different from those of its constituents. Alloys are corrosion resistant. Alloy decreases the intensity of corrosion of metals.

Examples : Brass is made from copper and zinc. 90 % Copper and 10 % tin are used to make an alloy called bronze. Stainless steel is made from 74 % iron, 8 % carbon and 18 % chromium.

(67) In two methods of control of corrosion of aluminium, either a layer of aluminium oxide is formed or a silver plating is done on the surface. State to which electrode the aluminium article is attached in these methods respectively.

(2 marks) (July '19)

Ans. Layer of aluminium oxide : Anode

Silver plating : Cathode

(68) Complete the flow chart :

Steps involved in galvanizing process :

[ ] → Rinsing → Pickling → [ ] → [ ] → Drying → Zinc bath → [ ]

Ans.

Caustic cleaning → Rinsing → Pickling → **Rinsing** → **Flux solution** → Drying → Zinc bath → **Cooling**

(69) What are the various alloys used in daily life ? Where are those used ?

(Textbook page 108)

Ans.

	Various alloys	Uses
1.	Bronze	It is used to prepare : Coins, utensils, medals, statues
2.	Brass	Pipes, condenser tubes, utensils worshipping God.
3.	Stainless steel	Utensils, tools, dairy equipment, boilers.
4.	Steel	Construction of bridges and buildings, cutting tools, blades.
5.	Tungsten steel	High speed cutting tools
6.	Amalgam	Silver amalgam used by dentists
7.	Duralumin	Bodies of aircraft, buses, kitchenwares
8.	Aluminium bronze	Pigment in ink and paint
9.	German silver	Electrical heaters, resistors
10.	Gun metal	Guns, boiler fittings

	Various alloys	Users
11.	Magnelium	Beams of scientific balances, aircraft parts.
12.	Gold with copper or nickel or silver or platinum	Jewellery

(70) What are the properties that the alloy used for minting coins should have?

(Textbook page 108)

Ans. The alloy used for minting coins should have excellent wear resistance and anticorrosion properties.

Q. 10 Distinguish between :

(Two points of distinction)

Metals and Nonmetals.

Ans.

Metals	Nonmetals
1. Metals have a lustre.	1. Nonmetals have no lustre. Exception : Iodine and Diamond.
2. They are generally good conductors of heat and electricity.	2. They are bad conductors of heat and electricity. Exception : Graphite.
3. They are generally solids at room temperature. Exception : Mercury and gallium are liquids.	3. They are generally gases and solids at room temperature. Exception : Bromine is a liquid.
4. Metals form basic oxides.	4. Nonmetals form acidic or neutral oxides.

Q. 11 Give scientific reasons for the following : *(2 marks each)*

***(1) Sodium is always kept in kerosene.** *OR*

Why is sodium stored in kerosene ?

Ans. (1) Sodium reacts so vigorously with atmospheric oxygen that it catches fire if kept in the open.

(2) It does not react with kerosene and sinks in it. Hence, to protect sodium and to prevent accidental fires it is always kept in kerosene.

(2) Calcium floats on water during the reaction with water.

Ans. (1) Calcium reacts with water less vigorously hence the heat evolved is not sufficient for hydrogen to catch fire.

(2) Instead, calcium floats on water because the bubbles of hydrogen gas formed stick to the surface of the metal.

(3) Common salt has high melting and boiling points.

Ans. (1) Common salt is an ionic compound. Common salt is a solid and hard due to strong electrostatic attraction between oppositely charged Na^+ and Cl^- ions.

(2) A large amount of energy is required to break the strong intermolecular attraction (strong ionic bond). Hence, common salt has high melting and boiling points.

***(4) Generally the ionic compounds have high melting points.**

Ans. (1) The ionic compounds exist in solid state and are hard due to strong electrostatic force of attraction between oppositely charged ions. (2) The inter molecular force of attraction is high in ionic compounds and large energy is required to overcome it. Therefore, ionic compounds have high melting points.

***(5) Lemon or tamarind is used for cleaning copper vessels turned greenish.**

Ans. (1) Copper undergoes oxidation in air to form black copper oxide. Copper oxide reacts slowly with carbon dioxide in air and gains a green coat. This green substance is copper carbonate.

(2) Lemon and tamarind contain acid. The acid dissolves the green coating of basic copper carbonate present on the surface of a tarnished copper utensil and makes it shiny again.

(6) Metals are good conductors, while non-metals are poor conductors of electricity.

Ans. (1) The electrons in the outermost orbit of atoms of a metal are free to move throughout the metal.

(2) When a potential difference is applied between the ends of a metal wire, the movement of the electrons constitutes an electric current. Hence, metals are good conductors of electricity.

(3) Nonmetals involve covalent bonding and do not have free electrons like metals. Hence, nonmetals are poor conductors of electricity.

(7) Sodium is more reactive than aluminium.

Ans. (1) If the number of electrons in the outermost orbit of an atom of a metal is less, the metal is more reactive.

(2) Sodium has electronic configuration (2, 8, 1) and aluminium has electronic configuration (2, 8, 3). The number of electrons in the outermost orbit of sodium and aluminium atoms are 1 and 3, respectively. Hence, sodium is more reactive than aluminium.

(8) When zinc granules are added to copper sulphate solution, the blue coloured solution turns colourless.

Ans. (1) Zinc is more reactive than copper.

(2) When zinc granules are added to copper sulphate solution, they displace copper from the copper sulphate solution to form zinc sulphate solution. As zinc sulphate is colourless, the blue coloured solution of copper sulphate disappears.

(9) When an iron nail is dipped into a copper solution, a shiny coat of copper is formed on the nail.

Ans. (1) Iron is more reactive than copper.

(2) When an iron nail is dipped into copper sulphate solution, iron displaces copper from the copper sulphate solution. The copper so liberated deposits on the iron nail. As a result, a shiny coat of copper is formed on the nail.

(10) Cryolite (Na_3AlF_6) and fluorspar (CaF_2) are added to the electrolytic mixture containing pure alumina.

Ans. (1) Alumina has very high melting point ($> 2000\ °C$). Cryolite (Na_3AlF_6) and fluorspar (CaF_2) lower the fusion temperature of the mixture containing alumina from 2000 °C to 1000 °C, thereby saving electrical energy.

(2) They increase the conductivity and the mobility of the fused mixture. Hence, cryolite and fluorspar are added to the electrolytic mixture containing pure alumina.

***(11) Pine oil is used in the froth floatation process.**

Ans. (1) In the concentration of an ore by froth floatation process, the ore is mixed with water and pine oil. When air is bubbled through the mixture a froth is formed.

(2) The mineral particles in the ore are preferentially wetted by the oil and float on the top in the froth.

(3) The gangue particles are wetted by water and settle down. Thus the mineral can be separated from the gangue and the ore is concentrated.

(12) Air is bubbled through the mixture in Froth floatation process.

Ans. (1) In the froth floatation process, in a tank water, ore and an oil are mixed. When air is bubbled through the mixture the oil forms froth.

(2) The mineral particles are wetted by the oil and float on the surface.

(3) The gangue particles are wetted by water and settle down. Hence, the ore can be concentrated. Hence, air is bubbled through the mixture in froth floatation process.

***(13) Anodes need to be replaced from time to time during the electrolysis of alumina.**

(3 marks) (July '19)

Ans. (1) During electrolysis of alumina, carbon rods are used as anodes.

(2) During electrolysis of alumina, the oxygen liberated at the carbon anode reacts with graphite rods (carbon anode) and forms carbon dioxide (while aluminium is deposited at cathode).

(3) As the anodes gets oxidised during electrolysis of alumina, they are continuously eroded. Hence, it is necessary to replace anodes from time to time.

(14) Silver amalgam is used for filling dental cavities.

Ans. (1) Silver is a soft metal and wears off on constant usage particularly due to abrasion. Silver amalgam is an alloy of silver with mercury.

(2) It is a hard substance. It is nontoxic. Besides these properties it is a lustrous shining substance. It melts at a comparatively low temperature and can therefore conveniently fill in the cavities. Hence, silver amalgam is used for filling dental cavities.

(15) Copper vessels turn greenish and silver articles turn blackish when kept open in air for a long time. ***(Nov. '20)***

Ans. (1) Copper undergoes oxidation in air to form black copper oxide. Carbon dioxide in air reacts with copper oxide. Thus, copper vessel loses its lusture due to formation of greenish layer of copper carbonate ($CuCO_3$) on its surface.

(2) The layer of silver sulphide (Ag_2S) formed by the reaction of silver with hydrogen sulphide in air due to which silver articles turn blackish.

Q. 12 Explain the following reactions with the help of balanced equations :

(1) Out of sodium and sulphur which is a metal? Explain its reaction with oxygen.

(March '19)

Ans. Sodium is a metal. Sodium reacts with oxygen in air at room temperature to form sodium oxide.

$$\underset{\text{Sodium}}{4Na} + \underset{\text{Oxygen}}{O_2} \longrightarrow \underset{\text{Sodium oxide}}{2Na_2O}$$

(2) Magnesium burns in air.

Ans. When magnesium burns in air, it combines with oxygen, emitting intense light and heat to form magnesium oxide.

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

(3) Copper reacts with air.

Ans. Copper tarnishes in moist air and forms black coloured oxide when strongly heated.

$$\underset{\text{Copper}}{2Cu} + \underset{\text{Oxygen}}{O_2} \xrightarrow{\text{heat}} \underset{\text{Copper oxide}}{2CuO}$$

***(4) Aluminium is exposed to air.**

Ans. When aluminium is exposed to air, it develops a thin oxide layer of aluminium.

$$\underset{\text{Aluminium}}{4Al} + \underset{\text{Oxygen}}{3O_2} \xrightarrow{\text{heat}} \underset{\text{Aluminium oxide}}{2Al_2O_3}$$

(5) Sodium reacts with water.

Ans. When sodium reacts with water, it evolves hydrogen which immediately catches fire producing a lot of heat.

$$\underset{\text{Sodium}}{2Na} + 2H_2O \longrightarrow \underset{\text{Sodium hydroxide}}{2NaOH} + H_2 + \text{Heat}$$

(6) Calcium reacts with water.

Ans. Calcium reacts with water less vigorously to form hydrogen gas and calcium hydroxide. In this reaction, the heat evolved is not sufficient for hydrogen to catch fire.

$$\underset{\text{Calcium}}{Ca} + 2H_2O \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Hydrogen}}{H_{2(g)}}$$

(7) Steam is passed over aluminium.

Ans. When steam is passed over aluminium, hydrogen gas and aluminium oxide are formed.

$$\underset{\text{Aluminium}}{2Al_{(s)}} + \underset{\text{Steam}}{3H_2O} \longrightarrow \underset{\text{Aluminium oxide}}{Al_2O_{3\,(s)}} + \underset{\text{Hydrogen}}{3H_{2(g)}}$$

(8) Steam is passed over iron.

Ans. When steam is passed over iron, iron (III) oxide and hydrogen gas are formed.

$$\underset{\text{Iron}}{3Fe_{(s)}} + \underset{\text{Steam}}{4H_2O} \longrightarrow \underset{\text{Iron (III) oxide}}{Fe_2O_4} + 4H_{2(g)}$$

(9) Magnesium reacts with dil. hydrochloric acid.

Ans. When magnesium reacts with dil. hydrochloric acid, magnesium chloride is formed and hydrogen gas is evolved.

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

(10) Aluminium is treated with dil. hydrochloric acid.

Ans. When aluminium is treated with dil. hydrochloric acid, aluminium chloride and hydrogen gas are formed.

$$2Al_{(s)} + 6HCl_{(l)} \longrightarrow 2AlCl_{3(l)} + 3H_{2(g)}$$

Aluminium metal, Aluminium chloride, Hydrogen

(11) Zinc reacts with dil. hydrochloric acid.

Ans. When zinc reacts with dil. hydrochloric acid, zinc chloride and hydrogen gas are formed.

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_{2(g)}$$

Zinc, Zinc chloride, Hydrogen

(12) Iron is treated with dil. hydrochloric acid.

Ans. When iron reacts with dil. hydrochloric acid, ferrous chloride and hydrogen gas is formed.

$$Fe_{(s)} + 2HCl \longrightarrow FeCl_{2(aq)} + H_{2(g)}$$

Iron, Ferrous chloride, Hydrogen

(13) Copper is reacted with conc. nitric acid.

Ans. When copper is reacted with conc. nitric acid, copper nitrate and reddish brown nitrogen dioxide are formed.

$$Cu_{(s)} + 4HNO_{3(aq)} \longrightarrow Cu(NO_3)_{2(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}$$

Copper, (conc.), Copper nitrate, Nitrogen dioxide

(14) Copper is reacted with dil. nitric acid.

Ans. When copper is reacted with dil. nitric acid, copper nitrate and nitric oxide are formed.

$$Cu_{(s)} + 8HNO_{3(aq)} \rightarrow 3Cu(NO_3)_{2(aq)} + 2NO_{(g)} + 4H_2O_{(l)}$$

(dil.), Copper nitrate, Nitric oxide

***(15) Iron filings are dropped in aqueous solution of copper sulphate.**

Ans. When iron filings are dropped in copper sulphate solution, more reactive iron displaces copper from copper sulphate solution. The iron filings get coated with reddish brown copper metal and the blue colour of copper sulphate fades gradually and ferrous sulphate is formed.

$$Fe_{(s)} + CuSO_{4(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$$

Blue, Colourless, Copper

(16) Sodium metal is reacted chlorine gas.

Ans. When sodium metal is reacted with chlorine, sodium chloride an ionic compound is formed.

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

Sodium, Chlorine, Sodium chloride (Ionic compound)

(17) Sulphur burns in air.

Ans. When sulphur burns in air, it combines with oxygen to form acidic sulphur dioxide.

$$S_{(s)} + O_{2(g)} \xrightarrow{heat} SO_{2\,(g)}$$

Sulphur, Sulphur dioxide

(18) Chlorine dissolves in water.

Ans. When chlorine dissolves in water, hypochlorous acid is formed.

$$Cl_{2(g)} + H_2O_{(l)} \longrightarrow HOCl_{(aq)} + HCl_{(aq)}$$

Chlorine, Hypochlorous acid

(19) Chlorine is treated with hydrobromic acid.

Ans. When chlorine is treated with hydrobromic acid, chlorine displaces bromine from hydrobromic acid.

$$Cl_{2(g)} + 2HBr_{(aq)} \longrightarrow 2HCl_{(aq)} + Br_{2(aq)}$$

(20) Hydrogen gas is passed over boiling sulphur.

Ans. When hydrogen gas is passed over boiling sulphur, sulphur combines with hydrogen to form hydrogen sulphide which has rotten egg smell.

$$H_{2(g)} + S_{(l)} \xrightarrow{\text{high temp.}} H_2S \uparrow$$

(boiling), Hydrogen gas

(21) Sodium aluminate is treated with water.

Ans. When sodium aluminate is treated with water, it is hydrolysed to give a precipitate of aluminium hydroxide.

$$NaAlO_2 + 2H_2O_{(l)} \longrightarrow NaOH_{(aq)} + Al(OH)_3 \downarrow$$

Sodium aluminate, Aluminium hydroxide

(22) Dry aluminium hydroxide is ignited at 1000 °C.

Ans. When dry aluminium hydroxide is ignited at 1000 °C, alumina (Al_2O_3) is formed.

$$2Al(OH)_3 \xrightarrow[1000\,^\circ C]{heat} Al_2O_3 + 3H_2O$$

Aluminium hydroxide, Alumina, Steam

(23) Zinc sulphide is heated strongly in excess of air.

Ans. When zinc sulphide is heated strongly in excess of air, it forms zinc oxide and sulphur dioxide gas.

$$\underset{\text{Zinc sulphide}}{2ZnS_{(s)}} + \underset{\text{Oxygen}}{3O_{2(g)}} \xrightarrow{\text{heat}} \underset{\text{Zinc oxide}}{2ZnO_{(s)}} + \underset{\text{Sulphur dioxide}}{2SO_{2(g)}}$$

(24) Zinc carbonate is heated strongly in a limited supply of air.

Ans. When zinc carbonate is heated strongly in a limited supply of air, it gives zinc oxide and carbon dioxide.

$$\underset{\text{Zinc carbonate}}{ZnCO_{3(s)}} \xrightarrow{\text{heat}} \underset{\text{Zinc oxide}}{ZnO_{(s)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}}$$

(25) Zinc oxide is treated with carbon.

Ans. When zinc oxide is treated with carbon, it is reduced to zinc. In this reaction, carbon acts as reducing agent.

$$\underset{\text{Zinc oxide}}{ZnO} + \underset{\text{Carbon}}{C} \longrightarrow \underset{\text{Zinc}}{Zn} + \underset{\text{Carbon monoxide}}{CO}$$

(26) Manganese dioxide is heated with aluminium.

Ans. When manganese dioxide is heated with aluminium, manganese dioxide is reduced to manganese and large amount of heat is evolved.

$$\underset{\text{Manganese dioxide}}{3MnO_2} + \underset{\text{Aluminium}}{4Al} \longrightarrow \underset{\text{Manganese}}{3Mn} + \underset{\text{Alumina}}{2Al_2O_3} + \text{heat}$$

***(27) Iron (III) oxide (ferrous oxide) is heated with aluminium.**

Ans. When iron (III) oxide (ferrous oxide) is heated with aluminium, it gives aluminium oxide and iron. This reaction is highly exothermic and it is known as thermit reaction.

$$\underset{\text{Iron (III) oxide}}{3Fe_3O_2} + \underset{\text{Aluminium}}{4Al} \longrightarrow \underset{\text{Iron}}{9Fe} + \underset{\text{Alumina}}{2Al_2O_3} + \text{heat}$$

(28) Cinnabar is heated in air.

Ans. When cinnabar is heated in air, it forms mercuric oxide and sulphur dioxide.

$$\underset{\text{Cinnabar}}{2HgS_{(g)}} + 3O_{2(g)} \xrightarrow{\text{heat}} \underset{\text{Mercuric oxide}}{2HgO_{(s)}} + \underset{\text{Sulphur dioxide}}{2SO_{2(g)}}$$

(29) Cuprous sulphide is heated in air.

Ans. When cuprous sulphide is heated in air, cuprous oxide is formed. Cuprous oxide is reduced to copper in the presence of ore.

$$\underset{\text{Cuprous sulphide}}{2Cu_2S} + \underset{\text{Oxygen}}{3O_2} \xrightarrow{\text{heat}} \underset{\text{Cuprous oxide}}{2Cu_2O} + \underset{\text{Sulphur dioxide}}{2SO_{2(g)}\uparrow}$$

$$\underset{\text{Cuprous oxide}}{2Cu_2O} + \underset{\text{Cuprous sulphide}}{Cu_2S} \xrightarrow{\text{heat}} \underset{\text{Copper}}{6Cu} + \underset{\text{Sulphur dioxide}}{SO_{2(g)}\uparrow}$$

***(30) Electrolysis of alumina is done.**

Ans. During electrolysis of alumina, aluminium is deposited at the cathode. Molten aluminium being heavier than the electrolyte, is collected at the bottom of the tank. Oxygen gas is liberated at the anode.

Anode reaction : $2O^{--} \rightarrow O_2 + 4e^-$ (Oxidation)

Cathode reaction : $Al^{3+} + 3e^- \rightarrow Al_{(l)}$ (Reduction)

***(31) Zinc oxide is dissolved in dilute hydrochloric acid,**

Ans. Zinc oxide is dissolved in dilute hydrochloric acid, zinc chloride and water are formed.

$$\underset{\text{Zinc oxide (basic oxide)}}{ZnO_{(s)}} + 2HCl_{(l)} \longrightarrow \underset{\text{Zinc chloride}}{ZnCl_{2(aq)}} + H_2O_{(l)}$$

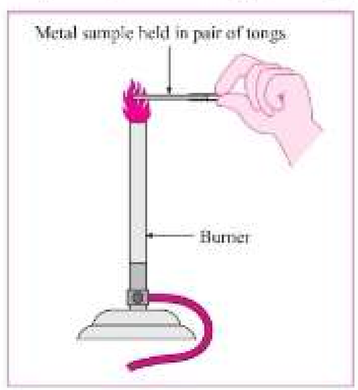
• **Activity 1 (Textbook page 94)**

Apparatus : Pair of tongs or spatula, knife, burner, etc.

Chemicals : Samples of aluminium, copper, iron, lead, magnesium, zinc and sodium, etc.

(**Note :** Use sodium carefully, in presence of teacher)

Procedure : Hold the sample of each of the above metals at the top of the flame of a burner with the help of a pair of tongs, or a spatula.



(1) Which metal catches fire readily?

Ans. Sodium metal catches fire easily.

(2) How does the surface of the metal appear on catching fire?

Ans. The surface of the metal appears blackish on catching fire.

(3) What is the colour of the flame while the metal is burning on the flame?

Ans. When metal burns in the flame, the flame turns blue.

• Activity 2 (Textbook page 95)

Reactions of metals with water

Apparatus : Beakers

Chemicals : Samples of various metals (Important notice : Sodium metal should not be taken), water.

(**Note :** Use sodium carefully, in presence of teacher)

Procedure : Drop a piece of each of the metal in separate beakers filled with cold water.

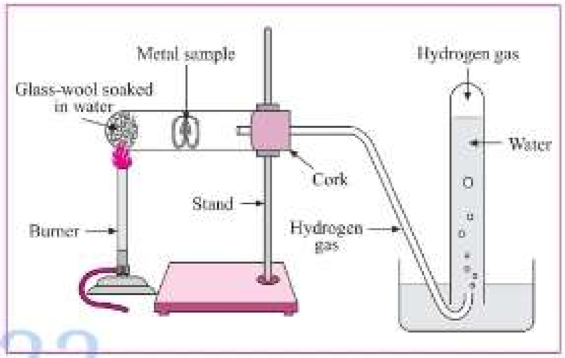
(1) Which metal reacts with water?

Ans. Sodium, potassium and calcium react with cold water.

(2) Which metal floats on water? Why?

Ans. Calcium floats on water, because H_2 gas released in the reaction of calcium and water, collects on the surface of the metal in the form of bubbles.

Prepare a table with reference to the above procedure and note your observations in it.



Conclusion :

Metal	Cold water	Hot water	Steam	Reaction	Product / Gas
Sodium	✓	✗	✗	Rapid and vigorously	Sodium hydroxide + Hydrogen
Potassium	✓	✗	✗	Rapid and vigorously	Potassium hydroxide + Hydrogen
Calcium	✓			Slow and less vigorously	Calcium hydroxide + Hydrogen
Aluminium	✗	✗	✓	—	Aluminium oxide + Hydrogen
Iron	✗	✗	✓	—	Iron oxide + Hydrogen
Zinc	✗	✗	✓	—	Zinc oxide + Hydrogen

Aluminium, iron and zinc do not react with cold or hot water, but these react with steam to form their oxides.

• Test whether the metals gold, silver and copper react with water and think over the finding. (Textbook page 95)

Ans. Gold, silver and copper metals do not react with cold water, hot water and steam as these metals are less reactive.

• **Activity 3 (Textbook page 96)**

Reaction of metals with salts of other metals.

Apparatus : Copper wire, iron nail, beaker or big test tube, etc.

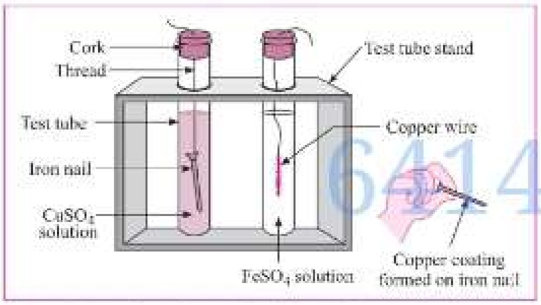
Chemicals : Aqueous solutions of ferrous sulphate and copper sulphate.

Procedure :

(1) Take a clean copper wire and a clean iron nail.

(2) Dip the copper wire in ferrous sulphate solution and the iron nail in copper sulphate solution.

(3) Keep on observing continually at a fixed interval of time.



Reaction of metals with solution of salts of other metals

(1) Which reaction will you study with the help of above material and solutions? Draw the diagram of the experiment arrangement.

Ans. With the help of given material and solutions, displacement reaction is studied. *Refer the given diagram. (Activity 3)*

(2) In which test tube do you find that a reaction has taken place?

Ans. The reaction takes place in a test tube containing iron nail in a solution of copper sulphate.

(3) How did you recognize that a reaction has taken place?

Ans. Blue coloured copper sulphate turns colourless.

(4) What is the type of the reaction?

Ans. In the given activity, iron has displaced copper from copper sulphate. It means that metallic iron is more reactive than metallic copper. Therefore, this reaction is displacement reaction.

$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

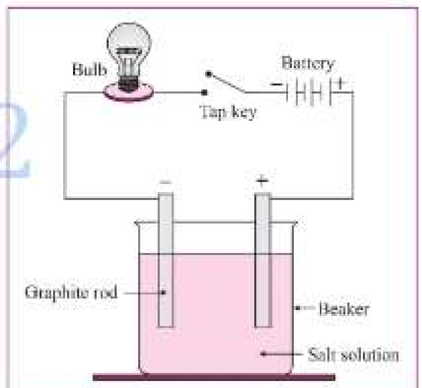
No reaction takes place with copper wire in a solution of ferrous sulphate.

• **Activity 4 (Textbook page 98 and 99)**

Ionic compounds and their properties :

Apparatus : metal spatula, burner, carbon electrodes, beaker, cell, lamp, press key, electrical wires, etc.

Chemicals : Samples of sodium chloride, potassium iodide and barium chloride, water.



Testing the conductivity of salt solution

Procedure : Observe the above samples. Place sample of one of the above salts on the spatula and heat it on flame of the burner. Repeat the procedure using the other salts. As shown in the figure, assemble an electrolytic cell by using a beaker and connecting the carbon electrodes to the positive and negative terminals of the cell. Dip the electrodes in solution of any one of the salts. You see the lamp to glow. Check then with all the other salts as well.

Ans. (1) At room temperature sodium chloride, potassium iodide and barium chloride salts are solids. When these salts are heated, they do not melt easily it means they have high melting point. Therefore, these salts are ionic compounds.

To confirm the properties of ionic compounds : The electrodes are placed in the solution of NaCl. An electric circuit is set up by including a battery, a bulb and a tap key. When the key is pressed, the electric bulb glows. This shows NaCl solution allows the electric current to pass through it. In other words, NaCl solution conducts electricity. Similarly solutions of potassium iodide and barium chloride also conduct electricity.

The bulb glows. The intensity of glow depends upon the various factors such as the concentration of the solution, and the battery voltage.

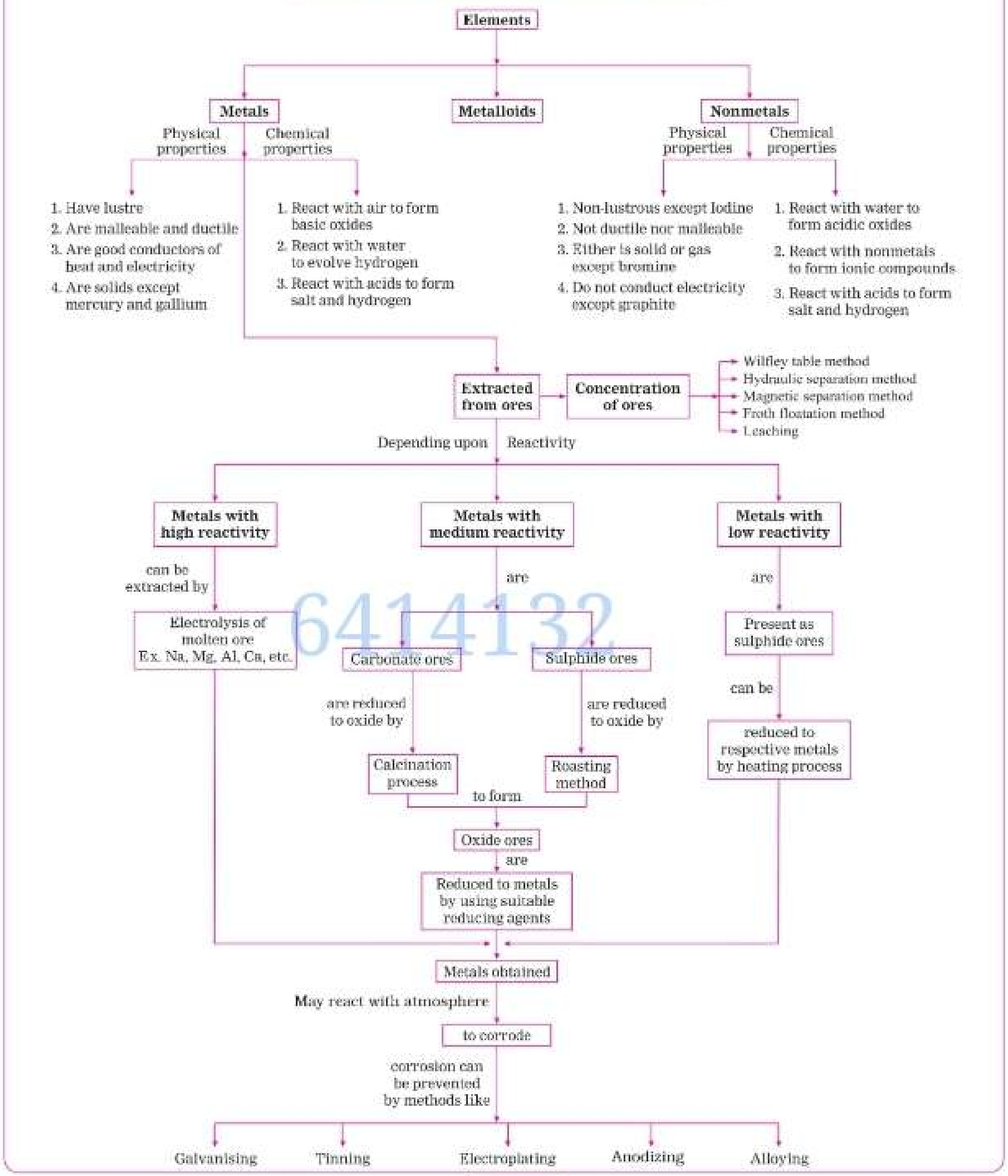
PROJECT

(1) Visit the museum to see the coins, metal vessels and various metal articles from ancient times and write detailed information. Write the steps in the procedure that can be done in the laboratory for giving glitter to these. Seek guidance from your teacher.

(2) Which metals are used in day to day life? What are its uses?

(3) Which nonmetals are used in day to day life? What are its uses?

MEMORY MAP / CONCEPT MAP



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9 CARBON COMPOUNDS

CHAPTER OUTLINE

IMPORTANT POINTS

• Can you recall? (Textbook page 110)

(1) What are the types of compounds?

Ans. Organic and inorganic compounds are the two important types of compounds.

(2) Objects in everyday use such as foodstuff, fibres, paper, medicines, wood, fuels are made of various compounds. Which constituent elements are common in these compounds?

Ans. The constituent elements common in these compounds are carbon (C), hydrogen (H) and oxygen (O).

(3) To which group in the periodic table does the element carbon belongs? Write down the electronic configuration of carbon and deduce the valency of carbon.

Ans. The element carbon belongs to group 14 and its electronic configuration is 2,4. The valency of carbon is 4.

9.1 Bonds in carbon compounds :

1. **Properties of carbon compounds :** (1) Carbon compounds have low melting and boiling points. (2) These compounds are bad conductors of heat and electricity. (3) The chemical bonds in carbon compounds do not produce ions.

• Can you tell? (Textbook page 110)

(1) What is meant by a chemical bond?

Ans. The force of attraction which holds the atoms together in a molecule is called a chemical bond.

(2) What is the number of chemical bonds that an atom of an element forms called?

Ans. The number of chemical bonds that an atom of an element forms is called catenation power.

(3) What are the two important types of chemical bonds?

Ans. Ionic bonds and covalent bonds are the two important types of chemical bonds.

2. **Bonds in carbon compounds :**

Carbon atom	Electronic configuration	Number of electrons in the Valence shell	Nearby noble gas and the electronic configuration	
			He	Ne
$_6C$	2,4	4	2	2,8

Carbon has 4 valence electrons and to attain the configuration of neon by sharing four valence electrons of other atoms. The shared electrons are accommodated in the overlapping region of valence shells of both the atoms. As a result, both the atoms attain a noble gas configuration without generating any net charge on them, which means that atoms remain electrically neutral. Atoms attain stability due to these factors. Therefore this route is adopted by carbon atom to attain a noble gas configuration.

The chemical bond formed by sharing of two valence electrons between the two atoms is called covalent bond.

A covalent bond is clearly represented by drawing an electron–dot structure. In this method a circle is drawn around the atomic symbol and each of the valence electrons is indicated by a dot or a cross. The covalent bond formed between the atoms is indicated by showing the circles around the atomic symbols crossing each other. The shared electrons are shown in the overlapping regions of the two circles by dot or cross. The electron–dot structure is also drawn without showing the circle. One covalent bond constitutes one pair of shared electrons. A covalent bond is also represented by a small line joining the symbols of the two atoms. The line structure is also called structural formula.

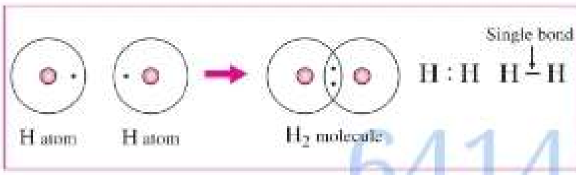


Fig. 9.1 : Electron dot structure and line structure of hydrogen molecule

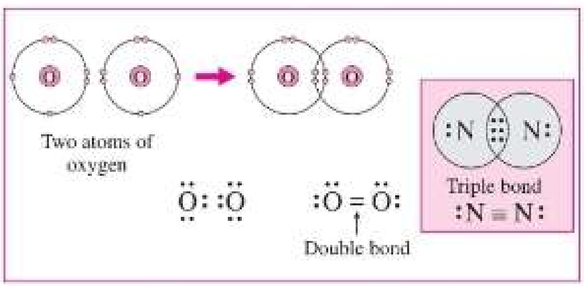


Fig. 9.2 : Double bond – oxygen molecule and triple bond – nitrogen molecule

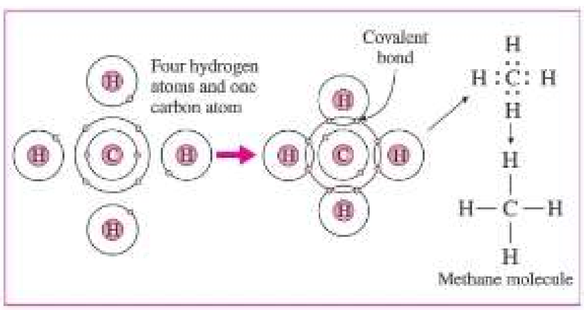


Fig. 9.3 : Electron-dot structure and line structure of methane molecule

9.2 Carbon : A versatile element :

1. Carbon : A versatile element :

In short, the entire living kingdom is made from carbon. Carbon is the basic ingredient of our body. Millions of molecules ranging from the small and simple methane molecule to the extremely big D.N.A. molecule are made from carbon. The molecular masses of carbon compounds range up to 10^{12}.

Carbon Compound	Molecular mass
Methane CH_4 (The smallest carbon compound)	16
Cooking gas ($C_3H_8 + C_4H_{10}$)	44/58
Benzene (C_6H_6)	78
Camphor ($C_{10}H_{16}O$)	152
Penicillin ($C_{16}H_{18}N_2O_4S$)	334
Sugar ($C_{12}H_{22}O_{11}$)	342
Sodium dodecyl benzene sulphate (a detergent)	347
Fat	~ 700
Starch	~ 10^3
Cellulose	~ 10^5
Protein	~ 10^5
Polyethylene	~ 10^6
D.N.A.	~ 10^{12}

Carbon compounds and molecular masses

2. Characteristics of carbon :

(1) Carbon has a unique ability to form strong covalent bonds with other carbon atoms; this results in formation of big molecules. This property of carbon is called catenation power.

(2) One, two or three covalent bonds can bond together two carbon atoms. These bonds are called single covalent bond, double covalent bond and triple covalent bond respectively. Example : ethane ($CH_3–CH_3$), ethene ($CH_2 = CH_2$) and ethyne ($CH \equiv CH$) which contain two carbon atoms.

(3) Carbon being tetravalent, one carbon atom can form bonds with four other atoms (carbon or any other). This results in formation of many compounds. These compound possess different properties as per the atoms to which carbon is bonded. For example, five different compounds are formed using one carbon atom and two monovalent elements hydrogen and chlorine : CH_4, CH_3Cl, CH_2Cl_2, $CHCl_3$, CCl_4. Similarly carbon atoms form covalent bonds with atoms of elements like O, N, S halogen and P to form different types of carbon compounds in large number.

(4) Isomerism is one more characteristic of carbon compound which is responsible for large number of carbon compounds.

9.3 Hydrocarbons, functional groups and homologous series :

1. Saturated hydrocarbon : In hydrocarbon, the four valencies of carbon atom are satisfied only by the single bonds, such compounds are called saturated hydrocarbons. e.g. Ethane (C_2H_6), Propane (C_3H_8).

2. Unsaturated hydrocarbon : The carbon compounds having a double bond or triple bond between two carbon atoms are called unsaturated hydrocarbons.

The unsaturated hydrocarbons containing a carbon-carbon double bond are called alkenes. e.g. Ethene ($CH_2 = CH_2$), Propene ($CH_3 - CH = CH_2$)

The unsaturated hydrocarbons containing a carbon−carbon triple bond are called alkynes. e.g. Ethyne ($CH \equiv CH$)

• Do you know? (Textbook page 116)

In the course of millions of years the reserves of crude oil were formed from the dead organisms buried under the sea floor. This crude oil and natural gas are now recovered from the oil wells. The natural gas is mainly methane. The crude oil is a complex mixture of thousands of different compounds. It mainly contains various hydrocarbons. Various useful components such as CNG, LPG, petrol (gasoline), rockel, diesel, engine oil, lubricant, etc. are obtained by separating crude oil using fractional distillation.

3. Structural Isomerism : Butane is represented by two different compounds, as their structural formulae are different. These two different structural formulae have the same molecular formula, i.e. C_4H_{10}.

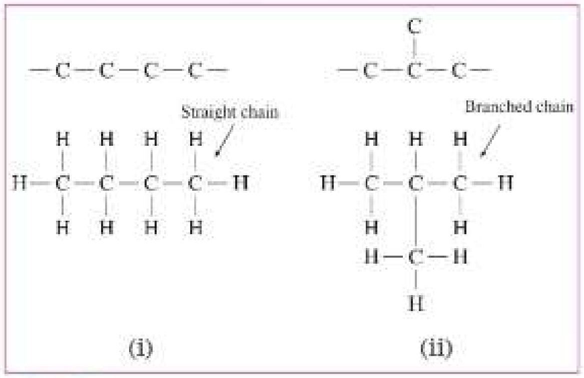


Fig. 9.4 : Two structural formulae for C_4H_{10}

The closed chain of carbon atoms are present in some carbon compounds, wherein, rings of carbon atoms form. For example, the molecular formula of cyclohexane is C_6H_{12} and its structural formula contains a ring of six carbon atoms.

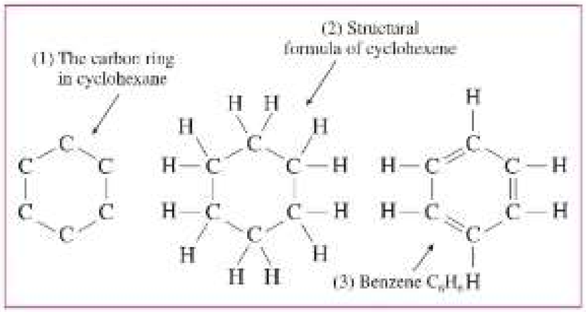


Fig. 9.5 : Ring Structure of Cyclohexane

Benzene is a cyclic unsaturated hydrocarbon. There are three alternate double bonds in the six membered ring structure of benzene. The compounds having this characteristic unit in their structure are called aromatic compounds.

4. **Functional group :** The compound acquire specific chemical properties due to these hetero atoms or the groups of atoms that contain hetero atoms, irrespective of the length and nature of the carbon chain in that compound. Therefore, these hetero atoms or the groups of atoms containing hetero atoms are called functional groups.

5. **Homologous series :** The length of the carbon chains in carbon compounds is different, their chemical properties are very much similar due to the presence of the same functional group in them. The series of compounds formed by joining the same functional group in place of a particular hydrogen atom on the chains having sequentially increasing length is called homologous series. Two adjacent members of the series differ by only one $-CH_2-$ (methylene) unit and their mass differ by 14 units.

6. **Characteristics of Homologous series :**

(1) In homologous series while going in an increasing order of the length of carbon chain (a) one methylene unit ($-CH_2-$) gets added (b) molecular mass increases by 14 u (c) number of carbon atoms increases by one.

(2) Chemical properties of members of a homologous series show similarity due to the presence of the same functional group in them.

(3) Each member of the homologous series can be represented by the same general molecular formula.

(4) While going in an increasing order of the length there is gradation in the physical properties, i.e. the boiling and melting points.

9.4 Nomenclature of carbon compounds :

- **IUPAC nomenclature system :** International Union for Pure and Applied Chemistry (IUPAC) put forth a nomenclature system based on the structure of the compounds, and it was accepted all over the world. There are three units in the IUPAC name of any carbon compound : parent, suffix and prefix.

IUPAC name :

(1) CH_3-CH_2-OH

(i) Parent name : Ethane

(ii) Suffix : $-OH$ (ol) (functional group)

(iii) Parent suffix : Ethanol

IUPAC name : Ethanol.

(2) $CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_2-CH_2-CH_3$

(i) Parent name : Pentane

(ii) Suffix : $-OH$ (ol) (functional group)

(iii) Assign numbering : 2

$$\overset{1}{C}H_3-\underset{\displaystyle OH}{\underset{|}{\overset{2}{C}H}}-\overset{3}{C}H_2-\overset{4}{C}H_2-\overset{5}{C}H_3$$

(iv) Parent suffix : Pentan–2–ol

IUPAC name : Pentan–2–ol.

• Can you tell? (Textbook page 123)

(1) Which is the component of biogas that makes it useful as fuel?

Ans. Methane is the component of biogas that makes it useful as fuel.

(2) Which product is formed by the combustion of elemental carbon?

Ans. Carbon dioxide is formed by the combustion of elemental carbon.

(3) Is the biogas combustion reaction endothermic or exothermic?

Ans. The biogas combustion is exothermic reaction.

9.5 Chemical properties of carbon compounds :

1. Properties of carbon compounds :

(1) **Combustion :** Methane undergoes combustion in the presence of oxygen to emit heat and light to form carbon dioxide and water.

$$\underset{\text{Methane}}{CH_4} + 2O_2 \rightarrow CO_2 + 2H_2O + \text{heat and light}$$

$$\underset{\text{Ethanol}}{CH_3-CH_2-OH} + 3O_2 \rightarrow 2CO_2 + 3H_2O + \text{heat and light}$$

(2) **Oxidation :** Ethanol gets oxidised in the presence of alkaline potassium permanganate to form ethanoic acid.

$$\underset{\text{ethanol}}{CH_3-CH_2-OH} \xrightarrow[\text{alk.}KMnO_4]{(O)} \underset{\text{ethanoic acid}}{CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-OH}$$

(3) **Addition reaction :** Vegetable oil (unsaturated compound) undergoes addition reaction with hydrogen in the presence of nickel catalyst to form vanaspati ghee (saturated compound).

$$\underset{\substack{\text{Unsaturated}\\\text{compound}\\\text{(Vegetable oil)}}}{-\overset{|}{C}=\overset{|}{C}-} \xrightarrow[Pt/Ni]{H_2} \underset{\substack{\text{Saturated compound}\\\text{(Vanaspati ghee)}}}{-\overset{|}{\underset{H}{\underset{|}{C}}}-\overset{|}{\underset{H}{\underset{|}{C}}}}$$

(4) **Substitution reaction :** The reaction in which the place of one type of atom/group in a reactant is taken by another atom/group of atoms, is called substitution reaction. Chlorination of methane, is a substitution reaction which gives four products.

$$CH_4 + Cl_2 \xrightarrow{\text{Sunlight}} CH_3-Cl + HCl$$
$$CH_3Cl + Cl_2 \xrightarrow{\text{Sunlight}} CH_2Cl_2 + HCl$$
$$CH_2Cl_2 + Cl_2 \xrightarrow{\text{Sunlight}} CHCl_3 + HCl$$
$$CHCl_3 + Cl_2 \xrightarrow{\text{Sunlight}} CCl_4 + HCl$$

(5) **Ethanol :** Ethanol is a colourless liquid at room temperature and its boiling point is 78 °C. Generally ethanol is called alcohol or spirit. Ethanol is soluble in water in all proportions. When aqueous solution of ethanol is tested with litmus paper it is found to be neutral.

Ethanol being good solvent, it is used in medicines such as tincture iodine (solution of iodine and ethanol), cough mixture and also in many tonics.

Methanol (CH_3OH), the lower homologue of ethanol, is poisonous, and intake of its small quantity can affect vision and at times can be lethal. To prevent the misuse of the important commercial solvent ethanol, it is mixed with the poisonous methanol. Such ethanol is called denatured spirit. A blue dye is also added to it, so that it is easily recognised.

2. Chemical properties of ethanol : Reaction with sodium

$$2Na + \underset{\text{Ethanol}}{2CH_3-CH_2-OH} \longrightarrow \underset{\text{(Sodium ethoxide)}}{2CH_3-CH_2-ONa} + H_2\uparrow$$

All the alcohols react with sodium metal to liberate hydrogen gas and form sodium alkoxide salts. When ethanol reacts with sodium metal, hydrogen gas and sodium ethaoxide are formed.

Dehydration reaction : When ethanol is heated at the temperature 170 °C with excess amount of concentrated sulphuric acid, to form ethene, with elimination of water molecule.

$$\underset{\text{Ethanol}}{CH_3-CH_2-OH} \xrightarrow[\text{conc. }H_2SO_4]{170\ °C} \underset{\text{Ethene}}{CH_2=CH_2} + H_2O$$

Here, concentrated sulphuric acid acts as a dehydrating agent.

Ethanoic acid : Ethanoic acid is a colourless liquid with boiling point 118 °C. Ethanoic acid is commonly known as acetic acid. Its aqueous solution is acidic and turns blue limus red. Vinegar, which is used as preservative in pickles, is a 5–8 % aqueous solution of acetic acid. The melting point of pure ethanoic acid is 17 °C. Therefore during winter in cold countries ethanoic acid freezes at room temperature itself and looks like ice. Therefore it is named 'glacial acetic acid'.

Chemical Properties of ethanoic Acid :

(i) Reaction with base :

(a) A reaction with strong base

Ethanoic acid gives neutralization reaction with a strong base sodium hydroxide to form a salt and water.

$$\underset{\substack{\text{(Acid)}\\\text{Ethanoic acid}}}{CH_3-COOH} + \underset{\text{(Base)}}{NaOH} \longrightarrow \underset{\substack{\text{(Salt)}\\\text{Sodium}\\\text{ethanoate}}}{CH_3COONa} + \underset{\text{(Water)}}{H_2O}$$

Ethanoic acid reacts with sodium carbonate to form sodium ethanoate, water and carbon dioxide.

$$2CH_3COOH_{(aq)} + Na_2CO_3 \longrightarrow CH_3COONa_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Ethanoic acid ... Sodium ethanoate

$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Sodium bicarbonate

Esterification reaction : Ethanoic acid reacts with ethanol in presence of an acid catalyst, ethyl ethanoate (ester) is formed. This reaction is known as esterification.

$$CH_3COOH + CH_3 - CH_2 - OH \xrightarrow[\text{catalyst}]{\text{Acid}} CH_3 - COO - CH_2 - CH_3 + H_2O$$

Ethanoic acid ... Ethanol ... Ethyl ethanoate

Esters have sweet odour. Esters are used for making fragrances and flavouring agents.

Saponifaction : When an ester is reacted with the alkali sodium hydroxide, the corresponding alcohol and sodium salt of carboxyclic acid are obtained. This reaction is called saponification reaction, as it is used for preparation of soap from fats.

Ester + Sodium hydroxide → Sodium Carboxylate + Alcohol

When fat is heated with NaOH solution, soap and glycerin are obtained.

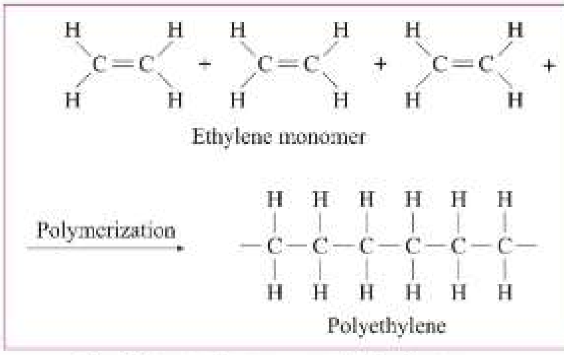
9.6 Macromolecules and polymers :

- **Macromolecules and polymers :**

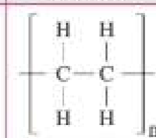
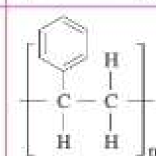
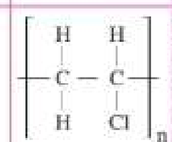
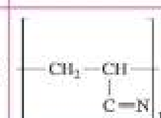
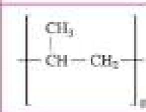
Macromolecules : The giant carbon molecules formed from hundreds of thousands of atoms are called macromolecules. Natural macromolecules : Polysaccharides, proteins and nucleic acid and rubber, etc.

Manmade macromolecules : Elastomers, plastic, nylon, etc.

Polymers : A macromolecule formed by regular repetition of a small unit is called polymer. The small unit that repeats regularly to form a polymer is called monomer. The reaction by which monomer molecules are converted into a polymer is called polymerization.



Various polymers and their uses :

Name of polymer	Constituent monomer	Structural formula of the polymer	Uses
Polyethlene	Ethylene $CH_2=CH_2$		Carry bags, sports wear
Polystyrene	Styrene $C_6H_5-CH=CH_2$		Thermo-coal articles
Polyvinyl chloride (PVC)	Vinyl chloride $Cl-CH=CH_2$		P.V.C. pipes, doormats, tubes and bags in hospital kits.
Polyacrylo nitrile	Acrylo nitrile $CH_2=CH-C\equiv N$		Winter clothing, blankets
Teflon	Tetrafluoro ethylene $CF_2=CF_2$		Nonstick cookware
Poly-propylene	Propylene $CH_3-CH=CH_2$		Injection syringe, Furniture

The polymers in the above examples are formed by repetition of single monomer. These are called homopolymers. The other type of polymers are formed from two or more monomers. They are called copolymers. For example, PET is poly ethylene terephthalate. The structures of polymers are linear as in the above examples or they are branched and cross linked as well. Polymers acquire various properties as per the nature of the monomers and the type of structure.

Some natural polymers and their occurrence :

Polymer	Name of the monomer	Occurrence
Polysaccharide	Glucose	Starch
Cellulose	Glucose	Wood (cell walls of plant cells)
Proteins	alpha amino acids	Muscles, hair, enzymes, skin, egg
D.N.A.	Nucleotide (base-deoxyribose-phosphate)	Chromosomes of animals
R.N.A.	Nucleotide (base-ribose-phosphate)	Chromosomes of plants
Rubber	Isoprene $CH_2 = \underset{\underset{CH_3}{\vert}}{C} - CH = CH_2$	Latex of rubber tree

QUESTIONS & ANSWERS

Q. 1 Fill in the blanks and rewrite the completed statements :

(1) The organic compounds having double or triple bonds in them are termed as ....

(2) The general formula of alkane is ....

(3) The compounds of homologous series have the same ...... group.

(4) A double bond is formed between carbon atoms by ...... pairs of electrons.

(5) The compounds having different structural formulae having the same molecular formula is called ....

(6) The functional group of ether is ....

(7) The general formula of alkene is ....

(8) The bond between two atoms of nitrogen is a ...... bond.

(9) Benzene ring is made up of ...... carbon atoms.

(10) Due to ...... , vegetable oil is converted into vanaspati ghee.

(11) ...... control the heredity at molecular level.

(12) The regular repetition of a small unit is called ....

(13) The structural formula of polypropylene is ....

(14) The monomers of proteins are ....

(15) The monomer of cellulose is ....

(16) ...... have sweet odour.

Ans.

(1) The organic compounds having double or triple bonds in them are termed as unsaturated hydrocarbons.

(2) The general formula of alkane is $C_nH_{2n} + 2$.

(3) The compounds of homologous series have the same functional group.

(4) A double bond is formed between carbon atoms by two pairs of electrons.

(5) The compounds having different structural formulae having the same molecular formula is called structural isomerism.

(6) The functional group of ether is $-O-$.

(7) The general formula of alkene is C_nH_{2n}.

(8) The bond between two atoms of nitrogen is a triple bond.

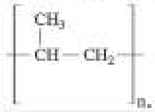
(9) Benzene ring is made up of six carbon atoms.

(10) Due to hydrogenation, vegetable oil is converted into vanaspati ghee.

(11) Nucleic acids control the heredity at molecular level.

(12) The regular repetition of a small unit is called polymer.

(13) The structural formula of polypropylene is



(14) The monomers of proteins are alpha amino acids.

(15) The monomer of cellulose is glucose.

(16) Esters have sweet odour.

Q. 2 Choose the correct alternative and write it along with its allotted alphabet : *(1 mark each)*

(1) The property of direct bonding between atoms of the same element to form a chain is called ......

(a) catenation *(b) isomerism*

(c) dehydration *(d) polymerization*

(2) The molecular weight of two adjacent members in homologous series of an alkane differ by...... units.

(a) 16 *(b) 20* *(c) 14* *(d) 12*

(3) Consecutive members of a homologous series differ by ...... group.

(a) $-CH$ *(b)* $-CH_2$ *(c)* $-CH_3$ *(d)* $-CH_4$

(4) ...... is used to prepare carbon black.

(a) Methane *(b) Ethene*

(c) Propane *(d) Butane*

(5) ...... is the general formula of alkene.

(a) C_nH_{2n} *(b)* C_nH_{2n+2} *(c)* C_nH_{2n-2} *(d)* C_nH_{n-2}

(6) The reaction of methane with chlorine in the presence of sunlight is called ......

(a) pyrolysis

(b) an elimination reaction

(c) a substitution reaction

(d) an addition reaction

(7) The general formula for alkynes is ......

(a) C_nH_{2n} *(b)* C_nH_{2n+2}

(c) C_nH_{2n-2} *(d)* C_nH_{2n-1}

(8) The reaction of ...... with ethanol is a fast reaction.

(a) calcium *(b) magnesium*

(c) sodium *(d) aluminium*

(9) Ethylene has ...... bond between two carbon atoms.

(a) a single *(b) a double*

(c) a triple *(d) an ionic*

(10) The saturated hydrocarbons are those in which carbon atom are linked by ......

(a) a single bond *(b) a double bond*

(c) a triple bond *(d) an ionic bond*

(11) C_7H_{16} is ......

(a) hexane *(b) octane*

(c) methane *(d) heptane*

(12) $-\overset{\overset{\displaystyle O}{\|}}{C}-OH$ is called ......

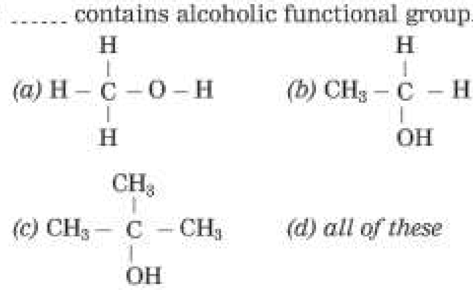
(a) carboxylic acid group *(b) aldehyde group*

(c) ketonic group *(d) alcohol group*

(13) The possible isomers for C_5H_{12} are ......

(a) 2 *(b) 4* *(c) 1* *(d) 3*

(14) ...... contains alcoholic functional group.



(d) all of these

(15) Oxygen molecule has ...... bond between two oxygen atoms.

(a) a double *(b) a single*

(c) a triple *(d) an ionic*

(16) Some acetic acid is treated with solid $NaHCO_3$. The resulting solution will be ......

(a) colourless *(b) blue* *(c) green* *(d) yellow*

(17) Ethanoic acid has a ...... odour.

(a) rotten eggs *(b) pungent*

(c) mild *(d) vinegar-like*

(18) Acetic acid ......

(a) turns red litmus blue

(b) has pungent odour

(c) is red in colour

(d) is odourless

(19) When acetic acid reacts with sodium metal ...... gas is formed.

(a) oxygen *(b) hydrogen*

(c) chlorine *(d) nitrogen*

(20) The molecular formula of acetic acid (ethanoic acid) is ......

(a) HCOOH *(b)* CH_3COOH

(c) C_2H_5COOH *(d)* C_3H_7COOH

(21) When sodium bicarbonate solution is added to dilute acetic acid ......

(a) a gas is evolved

(b) a solid settles at the bottom

(c) the mixture becomes warm

(d) the colour of the mixture becomes yellow

(22) 2 ml of ethanoic acid was taken in each of test tubes *A*, *B*, *C* and 2 ml, 4 ml, 6 ml of water was added respectively to them. A clear solution is obtained in ......

(a) test tube A *(b) test tube B*

(c) test tube C *(d) all the test tubes*

(23) In the presence of acid catalyst, ethanoic acid reacts with ethanol and .... ester is produced.

(a) ethanol *(b) ethanoic*

(c) ethyl ethanoate *(d) ethyl ethanol*

(24) The following structural formula belongs to which carbon compound?

(a) Camphor

(b) Benzene

(c) Starch

(d) Glucose

(25) What type of reaction is shown below?

$CH_4 + Cl_2 \xrightarrow{\text{Sunlight}} CH_3 - Cl + HCl$

(a) Addition *(b) Substitution*

(c) Decomposition *(d) Reduction*

(26) The carbon compound is used in daily life is ....

(a) edible oil *(b) salt*

(c) carbon dioxide *(d) baking soda*

(March '19)

(27) The melting point of pure ethanoic acid is ....

(a) 17 °C *(b) 19°C* *(c) 15°C* *(d) 27°C*

(Nov. '20)

Ans.

(1) (a) catenation
(2) (c) 14
(3) (b) $-CH_2$
(4) (a) Methane
(5) (a) C_nH_{2n}
(6) (c) a substitution reaction
(7) (c) C_nH_{2n-2}
(8) (c) sodium
(9) (b) a double
(10) (a) a single bond
(11) (d) heptane
(12) (a) carboxylic acid group
(13) (d) 3
(14) (d) all of these
(15) (a) a double
(16) (a) colourless
(17) (d) vinegar-like
(18) (b) has pungent odour
(19) (b) hydrogen
(20) (b) CH_3COOH
(21) (a) a gas is evolved
(22) (d) all the test tubes
(23) (c) ethyl ethanoate
(24) (b) Benzene
(25) (b) Substitution
(26) (a) edible oil
(27) (a) 17 °C

Q. 3 State whether the following statements are *true* or *false*. (If a statement is false, correct it and rewrite it.) : ***(1 mark each)***

(1) Generally the melting and boiling points of carbon compounds are high.

(2) Till now the number of known carbon compounds is about 10 million.

(3) Unsaturated hydrocarbons are less reactive than saturated hydrocarbons.

(4) Benzene is an aromatic compound.

(5) The carbon-carbon double and triple bonds are also recognised as functional groups.

(6) The general formula of alkyne is C_nH_2n.

(7) Naphthalene burns with a yellow flame.

(8) When vegetable oil and tincture iodine react, the colour of iodine does not change.

(9) Saturated fats are healthy.

(10) Aqueous solution of ethanol is found to be neutral.

(11) Denatured ethanol is used as industrial solvent.

(12) Vinegar is a 12–15 % aqueous solution of acetic acid.

(13) The functional group of ethanoic acid is a carboxylic group.

(14) Sodium hydroxide is used in the preparation of soap from fats and oils.

(15) Rubber is a manmade macromolecule.

(16) Polyvinyl chloride is used in the manufacture of P.V.C. pipes and bags.

(17) Polyethylene is a homopolymer.

(18) The chemical bonds in carbon compounds do not produce ions.

Ans.

(1) **False.** (Generally the melting and boiling points of carbon compounds are low.)

(2) **True.**

(3) **False.** (Unsaturated hydrocarbons are more reactive than saturated hydrocarbons.)

(4) **True.** (5) **True.**

(6) **False.** (The general formula of alkyne is C_nH_{2n-2}.)

(7) **True.**

(8) **False.** (When vegetable oil and tincture iodine react, the colour of iodine changes.)

(9) **False.** (Saturated fats are harmful to health.)

(10) **True.** (11) **True.**

(12) **False.** (Vinegar is a 5–8 % aqueous solution of acetic acid.)

(13) **True.** (14) **True.**

(15) **False.** (Rubber is a natural macromolecule.)

(16) **True.** (17) **True.** (18) **True.**

Q. 4 Find the odd one out : ***(1 mark each)***

(1) Propane, methane, ethene, pentane

(2) Methane, butane, benzene, sodium chloride

(3) CH_4, C_2H_6, C_3H_8, $CaCO_3$

(4) C_2H_2, C_3H_8, C_2H_6, CH_4

(5) C_2H_4, C_4H_{10}, C_3H_8, CH_4

(6) Polyethylene, Polysaccharide, Polystyrene, Polypropylene

(7) $-NH_2$, $-COOH$, $-SO_4$, $-Br$

(8) Methane, Ethane, Propene, Propane, Butane

Ans.

(1) **Ethene.** (Others are saturated hydrocarbons.)

(2) **Sodium chloride.** (Others are organic compounds.)

(3) **$CaCO_3$.** (Others are organic compounds.)

(4) **C_2H_2.** (Others are saturated hydrocarbons.)

(5) **C_2H_4.** (Others are saturated hydrocarbons.)

(6) **Polysaccharide** (Others are manmade polymers.)

(7) **$-SO_4$** (Others are functional groups.)

(8) **Propene** (Others are members of homologous series of alkanes.)

Q. 5 Complete the correlation :

(1) Alkene : $C = C$: : Alkyne : .... ***(March '20)***

(2) Methane : Saturated hydrocarbon : : Propene ....

Ans. (1) $C \equiv C$ (2) Unsaturated hydrocarbon.

Q. 6 Match the columns :

(1) Column I	Column II	
(1) CH_4	(a) $CH_2 = CH_2$	(b) C_nH_{2n-2}
(2) Ethane	(c) Methane	(d) C_2H_6

Ans. (1) CH_4 – Methane
(2) Ethane – C_2H_6.

(2) Column I	Column II
(1) Aromatic hydrocarbon	(a) Propyne
	(b) Benzene
(2) Alkane	(c) Saturated hydrocarbon
	(d) C_nH_{2n}

Ans. (1) Aromatic hydrocarbon – Benzene
(2) Alkane – Saturated hydrocarbon.

(3) Column I	Column II	
(1) Cyclohexane	(a) CH_3COOH	(b) CH_3Cl
(2) Methanol	(c) CH_3OH	(d) C_6H_{12}

Ans. (1) Cyclohexane – C_6H_{12}
(2) Methanol – CH_3OH.

(4) Column I	Column II
(1) – OH	(a) Amine
(2) – COOH	(b) Aldehyde
	(c) Alcohol
	(d) Carboxylic acid

Ans. (1) (– OH) – Alcohol
(2) (– COOH) – Carboxylic acid.

(5) Column I	Column II	
(1) Ethyne	(a) C_2H_6	(b) C_2H_2
(2) Ethene	(c) C_3H_6	(d) C_2H_4

Ans. (1) Ethyne – C_2H_2 (2) Ethene – C_2H_4.

(6) Column I	Column II
(1) Cellulose	(a) P.V.C. pipes, bags
(2) R.N.A.	(b) Blankets
	(c) Wood
	(d) Chromosomes of plants

Ans. (1) Cellulose – Wood
(2) R.N.A. – Chromosomes of plants.

(7) Column 'A'	Column 'B'
(1) C_2H_6	(a) Unsaturated hydrocarbon
(2) C_2H_2	(b) Molecular formula of an alcohol
(3) CH_4O	(c) Saturated hydrocarbon
(4) C_3H_6	(d) Triple bond

Note : In examination match the column question will have 2 components in Column 'A' with 4 alternatives in Column 'B'.

Ans. (1) C_2H_6 – Saturated hydrocarbon
(2) C_2H_2 – Triple bond
(3) CH_4O – Molecular formula of an alcohol
(4) C_3H_8 – Triple bond.

(8) Column I	Column II *(July '19)*
(1) Ethanol	(a) Hydrogen peroxide
(2) Methane	(b) Tincture iodine
	(c) Biogas
	(d) Non-stick vessels

Ans. (1) Ethanol – Tincture iodine
(2) Methane – Biogas.

Q. 7 Complete the following flowchart and write the general formula of alkane :

(1)

$\boxed{CH_4} \rightarrow \boxed{\text{..............}} \rightarrow \boxed{C_3H_8} \rightarrow \boxed{\text{..............}} \rightarrow \boxed{C_5H_{12}}$

(2 marks) (July '19)

Ans.

$\boxed{CH_4} \rightarrow \boxed{\mathbf{C_2H_6}} \rightarrow \boxed{C_3H_8} \rightarrow \boxed{\mathbf{C_4H_{10}}} \rightarrow \boxed{C_5H_{12}}$

General formula of alkane : C_nH_{2n+2}.

(2)

C_2H_2 → .... → .... →

C_5H_8 → .... → ....

Ans.

C_2H_2 → $\mathbf{C_3H_4}$ → $\mathbf{C_4H_6}$ →

C_5H_8 → $\mathbf{C_6H_{10}}$ → $\mathbf{C_7H_{12}}$

General formula of alkyne : C_nH_{2n-2}.

Q. 8 Consider the relation between Column I and II. Fill in Column IV to match Column III.

Column I	Column II	Column III	Column IV
(1) Ethylene	Polyethylene	Tetrafluoroethylene	....
(2) Poly-propylene	Propylene	Polystyrene	....
(3) Poly-saccharide	Glucose	Proteins	....
(4) Rubber	Isoprene	D.N.A.	....
(5) Wood	Cellulose	Chromosomes of plants	....

Ans. (1) Teflon (2) Styrene (3) Alpha aminoacid (4) Nucleotide (5) R.N.A.

Q. 9 Define.

(1) Alkane : In hydrocarbon, the four valencies of carbon atom are satisfied only by the single bonds, such compounds are called alkane.

Example : Methane (CH_4), Ethane (C_2H_6)

(2) Alkene : The unsaturated hydrocarbons containing a carbon–carbon double bond are called alkenes.

Example : Ethene ($CH_2 = CH_2$)

(3) Alkyne : The unsaturated hydrocarbons containing a carbon–carbon triple bond are called alkynes.

Example : Ethyne C_2H_2 ($CH \equiv CH$).

(4) Addition reaction : When a carbon compound combines with another compound to form a product that contains all the atoms in both the reactants; it is called an addition reaction.

$$\text{Vegetable oil} + H_{2(g)} \xrightarrow[\text{catalyst}]{\text{Ni}} \text{Vanaspati ghee}$$

(5) Substitution reaction : The reaction in which the place of one type of atom/group in a reactant is taken by another atom/group of atoms, is called substitution reaction.

$$CH_4 + Cl_2 \xrightarrow{\text{Sunlight}} CH_3Cl + HCl$$

$$CH_3Cl + Cl_2 \xrightarrow{\text{Sunlight}} CH_2Cl_2 + HCl$$

$$CH_2Cl_2 + Cl_2 \xrightarrow{\text{Sunlight}} CHCl_3 + HCl$$

(6) Esterification : A carboxylic acid reacts with an alcohol in presence of an acid catalyst, an ester is formed. The reaction is known as esterification.

$$\underset{\text{Acid}}{CH_3-COOH} + \underset{\text{alcohol}}{CH_3-CH_2-OH} \xrightarrow[\text{catalyst}]{\text{Acid}} \underset{\text{Ester}}{CH_3COOC_2H_5} + H_2O$$

(7) Saponification : When an ester reacts with the alkali, i.e. sodium hydroxide, the corresponding alcohol and sodium salt of carboxylic acid are obtained. This reaction is called saponification reaction. It is used in the preparation of soap.

Ester + Sodium hydroxide → Sodium salt of carboxylic acid + Alcohol.

(8) Polymerization : The reaction by which monomer molecules are converted into a polymer is called polymerization.

$$\underset{\text{Monomer}}{nCH_2 = CH_2} \xrightarrow{\text{Polymerization}} \underset{\text{Polymer}}{(CH_2-CH_2)_n}$$

Q. 10 Name the following :

(1) The higher homologue of hexane.

Ans. Keptane.

(2) The number of double bonds in benzene.

Ans. Three.

(3) The functional group in ether and halogen.

Ans. Functional groups :

Ether : – O –

Halogen : – X (– Cl, – Br, – I).

(4) Polymer of tetrafluoroethylene.

Ans. Teflon.

(5) The monomer of polysaccharide.

Ans. Glucose.

(6) The Polymer of nucleotide.

Ans. D.N.A./R.N.A.

(7) The Monomer of rubber.

Ans. Isoprene.

(8) Two oxidising compounds.

Ans. Potassium permanganate, Potassium dichromate.

(9) IUPAC name of sodium acetate.

Ans. Sodium ethanoate.

(10) The main component of natural gas.

Ans. Methane.

(11) Two isomers of butane.

Ans. n-butane and i-butane.

(12) A nomenclature system based on the structure of the compounds and it was accepted all over the world.

Ans. International Union of Pure and Applied Chemistry (IUPAC).

(13) Two carbon compounds used in day-to-day life. ***(1 mark) (March '20)***

Ans. (1) Cooking gas (2) Sugar (3) Ethanol (4) Methane.

Q. 11 Identify the type of the following reaction of carbon compounds.

(1) $CH_3-CH_2-CH_2-OH + (O) \rightarrow CH_3-CH_2-COOH$

(2) $CH_3-CH_2-CH_3 + O_2 \rightarrow 3CO_2 + 4H_2O$

(3) $CH_3-CH=CH-CH_3 + Br_2 \rightarrow CH_3-CHBr-CHBr-CH_3$

(4) $CH_3-CH_3 + Cl_2 \rightarrow CH_3-CH_2-Cl + HCl$

(5) $CH_3-CH_2-CH_2-CH_2-OH \rightarrow CH_3-CH_2-CH=CH_2 + H_2O$

(6) $CH_3-CH_2-COOH + NaOH \rightarrow CH_3-CH_2-COONa^+ + H_2O$

(7) $CH_3-COOH + CH_3-OH \rightarrow CH_3-COO-CH_3 + H_2O$

Ans.

(1) $CH_3-CH_2-CH_2-OH \xrightarrow[\text{alk.KMnO}_4]{(O)} CH_3CH_2-COOH$

Chemical reaction : Oxidation reaction

(2) $CH_3-CH_2-CH_3 + O_2 \xrightarrow{\text{heat}} 3CO_2 + 4H_2O$

Chemical reaction : Combustion

(3) $CH_3-CH=CH-CH_3 + Br_2 \rightarrow \underset{}{CH_3}-\underset{\displaystyle Br}{\underset{|}{CH}}-\underset{\displaystyle Br}{\underset{|}{CH}}-CH_3$

Chemical reaction : Addition reaction

(4) $CH_3-CH_3 + Cl_2 \xrightarrow{\text{Sunlight}} CH_3-CH_2-Cl + HCl$

Chemical reaction : Substitution reaction

(5) $CH_3-CH_2-CH_2-CH_2-OH \xrightarrow[\Delta]{\text{Con.}H_2SO_4} CH_3-CH_2-CH=CH_2 + H_2O$

Chemical reaction : Dehydration reaction

(6) $CH_3-CH_2-COOH + NaOH \rightarrow CH_3-CH_2-COO^-Na^+ + H_2O$

Chemical reaction : Neutralization

(7) $CH_3-COOH + CH_3-OH \xrightarrow[\text{catalyst}]{\text{acid}} CH_3-COO-CH_3 + H_2O$

Chemical reaction : Esterification

Q. 12 Answer the following questions.

(1) What is meant by a covalent bond? *OR*

***Explain the term covalent bond with example :**

Ans. The chemical bond formed by sharing of two valence electrons between the two atoms is called covalent bond.

Example : *For reference, see the answers to Q. 12 (2) and (3).*

(2) How is hydrogen molecule formed?

Ans.

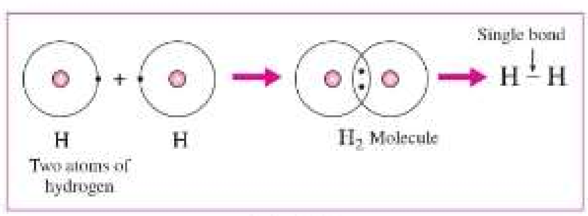


Fig. 9.6

The atomic number of hydrogen is 1, its atom contains 1 electron in K shell. It requires one more electron to complete the K shell and attain the configuration of helium (He). To meet this requirement two hydrogen atoms share their electrons with each other to form H_2 molecule. One covalent bond, i.e. a single bond is formed between two hydrogen atoms by sharing of two electrons.

(3) Describe the formation of oxygen molecule (O_2).

Ans.

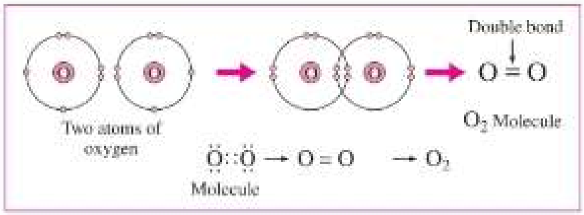


Fig. 9.7

(1) The atomic number of oxygen is 8. The electronic configuration of oxygen is (2, 6). Oxygen has 6 electrons in the outermost shell.

(2) It requires 2 electrons to complete the L shell and attain the configuration of neon (Ne).

(3) Each oxygen atom shares its valence electron with the valence electron of another oxygen atom to give two shared pairs of electrons which results in the formation of oxygen molecule.

(4) Thus, two electron pairs are shared between two oxygen atoms, forming double covalent bond (=).

(4) Describe the formation of nitrogen molecule.

Ans.

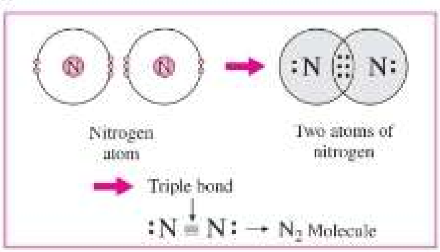


Fig. 9.8

(1) The atomic number of nitrogen is 7.

The electronic configuration of nitrogen is (2, 5). Nitrogen has 5 electrons in the outermost shell.

(2) It requires three more electrons to complete the L shell and attain the configuration of neon (Ne).

$$:N\,⋮⋮\,N: \longrightarrow :N \equiv N: \longrightarrow N_2$$
(triple bond)

(3) Two nitrogen atoms come close together and share three pairs of electrons with each other, resulting in the formation of a triple bond.

(4) Thus, two nitrogen atoms are bound with a triple bond (≡) to form a nitrogen molecule.

(5) How is the methane molecule formed?

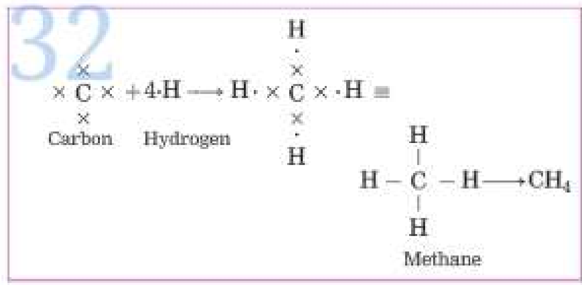
Ans. (1) The electronic configuration of carbon is (2, 4). Carbon has four electrons in the outermost shell, hence it is tetravalent.

(2) The electronic configuration of hydrogen is 1, hence it is monovalent.

(3) Carbon needs four electrons to complete the L shell and attain the configuration of neon (Ne).

(4) Four atoms of hydrogen share 1 electron each with 4 electrons of carbon.

(5) A single covalent bond is formed by sharing of two electrons.



Thus, the methane molecule contains four single bonds between the carbon and hydrogen atoms.

***(6) What causes the existence of very large number of carbon compound ?**

Ans. (1) Carbon has a unique ability to form strong covalent bonds with other carbon atoms; this results in formation of big molecules. This property of carbon is called catenation power. The carbon compounds contain open chains or closed chains of carbon atoms. An open chain can be a straight chain or a branched chain. A closed chain is a ring structure. The covalent bond between two carbon atoms is strong and therefore stable. Carbon is bestowed with catenation power due to the strong and stable covalent bonds.

(2) One, two or three covalent bonds can bond together two carbon atoms. These bonds are called single covalent bond, double covalent bond and triple covalent bond respectively. Due to the ability of carbon atoms to form multiple bonds as well as single bonds, the number of carbon compounds increases. For example, there are three compounds, namely, ethane (CH_3-CH_3), ethene ($CH_2=CH_2$) and ethyne ($CH \equiv CH$) which contain two carbon atoms.

(3) Carbon being tetravalent, one carbon atom can form bonds with four other atoms (carbon or any other). This results in formation of many compounds. These compounds possess different properties as per the atoms to which carbon is bonded. For example, five different compounds are formed using one carbon atom and two monovalent elements hydrogen and chlorine : CH_4, CH_3Cl, CH_2Cl_2, $CHCl_3$, CCl_4. Similarly carbon atoms form covalent bonds with atoms of elements like O, N, S, halogen and P to form different types of carbon compounds in large number.

(4) Isomerism is one more characteristic of carbon compound which is responsible for large number of carbon compounds.

(7) What is meant by catenation power?

Ans. Carbon has a unique ability to form strong covalent bonds with other carbon atoms, this result in formation of big molecules. This property of carbon is called catenation power.

(8) State the various compounds and its formulae formed by a single atom of carbon with monovalent hydrogen and chlorine.

Ans.

Compounds	Names
CH_4	Methane
CH_3Cl	Methyl chloride
CH_2Cl_2	Methylene dichloride
$CHCl_3$	Methylene trichloride
CCl_4	Carbon tetrachloride

(9) What are hydrocarbons ? *OR*

Define : Hydrocarbons. ***(1 mark) (March '20)***

Give one example.

Ans. The compounds containing only carbon and hydrogen are called hydrocarbons. These compounds are known as organic compounds. E.g. Methane, Ethane.

(10) Name the types of hydrocarbons.

(1 mark) (March '20)

Ans. Hydrocarbons are of two types :

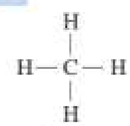
(1) Saturated hydrocarbon

(2) Unsaturated hydrocarbon.

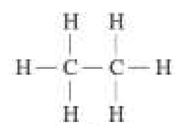
(11) What are saturated hydrocarbons? Give examples. *OR*

***Explain the term saturated hydrocarbon with example.**

Ans. In hydrocarbon, the four valencies of carbon atom are satisfied only by the single bonds, such compounds are called saturated hydrocarbons. Methane molecule contains only one carbon atom. In methane, four hydrogen atoms are bonded to carbon atom by four covalent bonds.



Methane



Ethane

(12) What are unsaturated hydrocarbons? Give example.

Ans. The carbon compounds having a double bond or triple bond between two carbon atoms are called unsaturated hydrocarbons.

The unsaturated hydrocarbons containing a carbon–carbon double bond are called alkenes.

e.g. Ethene ($CH_2=CH_2$), Propene ($CH_3-CH=CH_2$).

The unsaturated hydrocarbons containing a carbon–carbon triple bond are called alkynes e.g. Ethyne ($CH \equiv CH$).

(13) State the general formula of alkane.

Ans. The general formula of an alkane is C_nH_{2n+2}.

(14) Give two examples of alkanes.

Ans. Methane (CH_4) and ethane (C_2H_6) are alkanes.

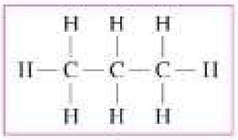
(15) Give two examples of alkenes.

Ans. Ethene ($CH_2 = CH_2$) and propene ($CH_3 - CH = CH_2$) are alkenes.

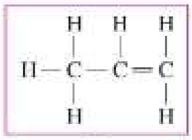
(16) Give two examples of alkynes.

Ans. Ethyne ($HC \equiv CH$) and propyne ($CH_3 - C \equiv CH$) are alkynes.

(17) Observe the straight chain hydrocarbons given below and answer the following questions :



A



B

(i) Which of the straight chain compounds from A and B is saturated and unsaturated straight chains?

(ii) Name these straight chains.

(iii) Write their chemical formulae and number of $-CH_2$ units.

Ans. (i) A is a saturated hydrocarbon, B is an unsaturated hydrocarbon.

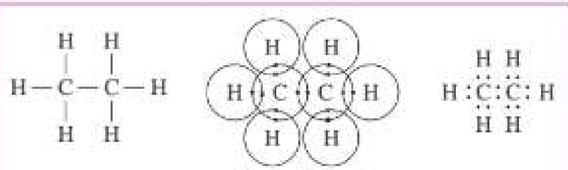
(ii) A = Propane, B = Propene

(iii) The chemical formula of A = C_3H_8 and number of $-CH_2$ units are 3.

The chemical formula of B = C_3H_6 and number of $-CH_2$ unit is 1.

(18) Draw electron-dot and line structure of an ethane molecule.

Ans. The molecular formula of ethane is C_2H_6.



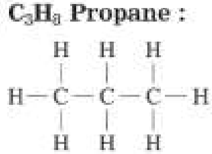
Electron dot structure

***(19) Draw structural formulae of compounds from their molecular formula given below : (1) C_3H_8 *(Nov.'20)* (2) C_4H_{10} (3) C_3H_4**

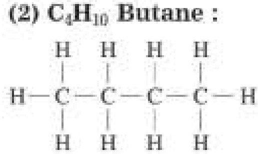
(1 mark) (Board's Model Activity Sheet)

Ans. Structural formulae :

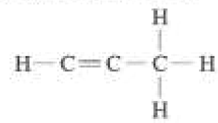
(1) C_3H_8 Propane :



(2) C_4H_{10} Butane :



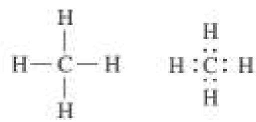
(3) C_3H_4 Propyne :



***(20) Draw the electron-dot structure of the following molecules (without showing circles) (1) Methane *(Nov.' 20)* (2) Ethene (3) Methanol (4) Water**

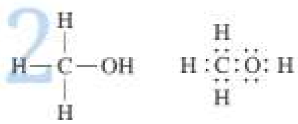
Ans.

(1) **Methane :** Molecular formula : CH_4



(2) **Ethene :** Molecular formula : $H_2C = CH_2$

(3) **Methanol :** Molecular formula : H_3C-OH

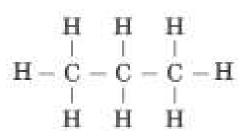


(4) **Water :** Molecular formula : H_2O

$H-\ddot{\underset{\cdot\cdot}{O}}-H \qquad H:\ddot{\underset{\cdot\cdot}{O}}:H$

(21) The molecular formula of propane is C_3H_8. From this draw its structural formula.

Ans. The structural formula of propane :



(22) The molecular formula of ethyne is C_2H_2. From this draw its structural formula and electron-dot structure.

(Use your brain Power!) **(Textbook page 115)**

Ans. Ethyne : Molecular formula : C_2H_2

$H-C \equiv C-H \qquad H:C \vdots\vdots C:H$

(23) How many bonds have to be there in between the two carbon atoms in ethyne so as to satisfy their tetra valency?

(Use your brain power!) **(Textbook page 115)**

Ans. To satisfy their tetravalency, three double bonds have to be there in between two carbon atoms in ethyne.

(24) Draw the electron-dot structure of cyclohexane.

(Use your brain power!) (Textbook page 116)

Ans. Cyclohexane : Molecular formula : C_6H_{12}

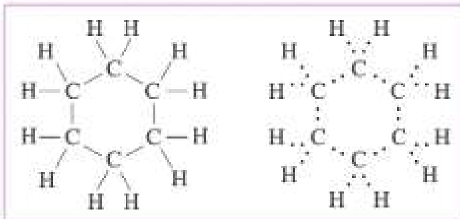


Fig. 9.9 : Cyclohexane

(25) Draw the structure and carbon skeleton for cyclohexane.

Ans.

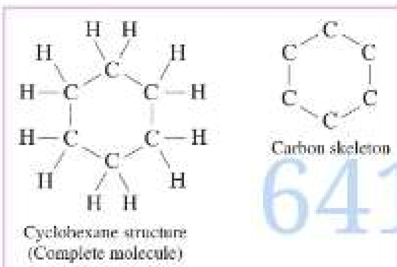


Fig. 9.10

(26) How many covalent bonds are there in a molecule of cyclohexane ?

Ans. A molecule of cyclohexane contains 18 covalent bonds.

(27) Classify into saturated and unsaturated hydrocarbons : (1) Methane (2) Ethene (3) Ethane (4) Ethyne (5) Propene (6) Propyne (7) Butane (8) Cyclohexene (9) Cyclopentane (10) Heptane.

Ans. (i) **Saturated hydrocarbons :** (1) Methane (2) Ethane (3) Butane (4) Cyclopentane (5) Heptane.

(ii) **Unsaturated hydrocarbons :** (1) Ethene (2) Ethyne (3) Propene (4) Propyne (5) Cyclohexene.

(28) Classify into alkanes, alkenes and alkynes : (1) Ethane (2) Ethene (3) Methane (4) Propene (5) Ethyne (6) Propyne (7) Butane (8) Pentane.

Ans. Alkanes : (1) Ethane (2) Methane (3) Butane (4) Pentane

Alkenes : (1) Ethene (2) Propene

Alkynes : (1) Ethyne (2) Propyne

(29) Classify into straight chain carbon compounds, branched chain carbon compounds and ring carbon compounds :

(1) Propene (2) Butane (3) Iso-butane (4) Cyclopentane (5) Benzene (6) Isobutylene.

Ans. Straight chain carbon compounds : (1) Propene (2) Butane.

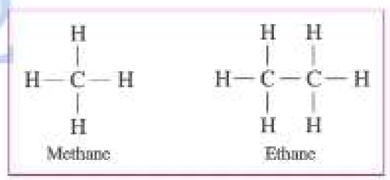
Branched chain carbon compounds : (1) Iso-butane (2) Isobutylene.

Ring carbon compounds : (1) Cyclopentane (2) Benzene.

***(30) Explain the term alkane with example.**

Ans. In hydrocarbon, the four valencies of carbon atom are satisfied only by the single bonds, such compounds are called alkane.

Example : In methane, four hydrogen atoms are bonded to carbon atom by four single covalent bonds.



(31) Draw chain and ring structures of organic compound having six carbon atoms in it.

Ans. Chain structures of an organic compound having six carbon atoms :

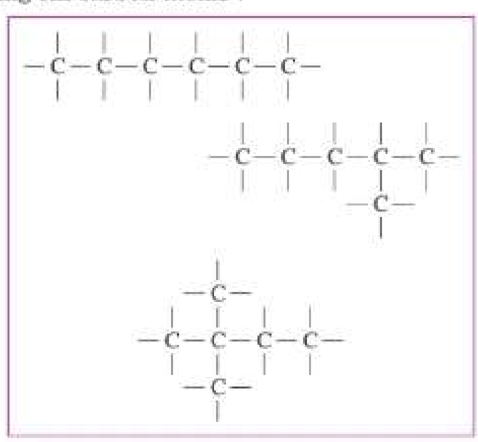
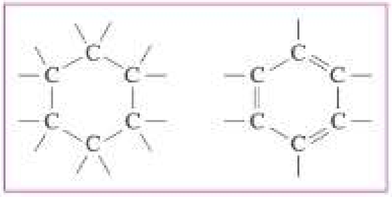


Fig. 9.11

Ring structures of an organic compound having six carbon atoms :



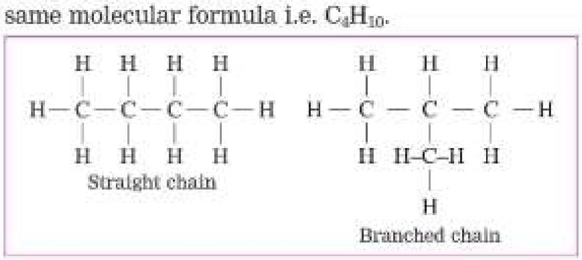
(32) Explain the structure of benzene.

Ans. The molecular formula of benzene is C_6H_6. It is a cyclic unsaturated hydrocarbon. Benzene ring is made of six carbon atoms. In benzene, each carbon atom is linked to two other carbon atoms, on one side by a single bond and on the other side by a double bond, i.e. three alternate single bonds and double bonds in the six membered ring structure of benzene. The compound having this characteristic unit in their structure are called aromatic compounds.

***(33) Explain the term structural isomerism with example.**

Ans. The phenomenon in which compounds having different structural formulae have the same molecular formula is called structural isomerism.

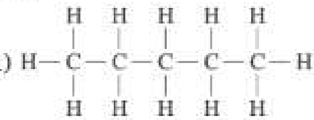
Butane is represented by two different compounds as their structural formulae are different. The first compound is a straight chain compound and the second compound is a branched chain compound. These two different structural formulae have the same molecular formula i.e. C_4H_{10}.

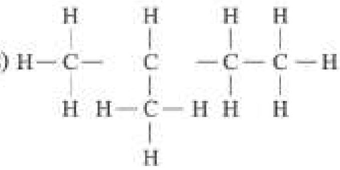


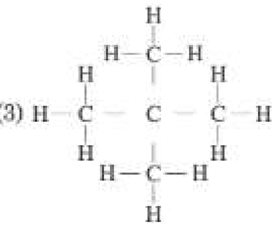
Two structural isomers of butane (C_4H_{10})

(34) Draw the structures of isomers of pentane (C_5H_{12}).

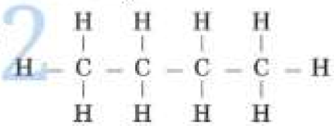
Ans.

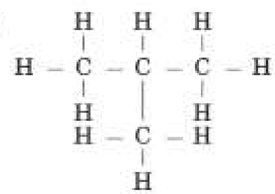
(1)  n-pentane

(2)  i-pentane

(3)  neopentane

(35) Recognize the carbon chain type for each of the following :

(1) 

(2) 

Ans. *For reference see the answer to Q. 12 (33).*

(36) What is meant by functional group? Give examples. *OR* **Explain the term functional group with example.**

Ans. The compound acquire specific chemical properties due to these hetero atoms or the groups of atoms that contain hetero atoms, irrespective of length and nature of the carbon chain in that compound. Therefore these hetero atoms or groups of atoms containing hetero atoms are called the functional groups.

Example : Methyl alcohol, acetic acid.

In methane (CH_4), when one hydrogen atom is replaced by an – OH group, methyl alcohol (CH_3OH), is formed. The – OH is known as the alcoholic functional group.

Similarly, from methane (CH_4) when one hydrogen atom is replaced by – COOH group, acetic acid (CH_3COOH) is formed. The – COOH group is known as the carboxylic acid functional group.

(37) Which functional groups are present in aldehyde and ketone ?

Ans. The functional group – CHO is present in aldehyde and the functional group

$-\overset{\overset{\displaystyle O}{\|}}{C}-$ is present in ketone.

(38) Which functional group is present in CH_3-O-CH_3?

Ans. –O– functional group is present in CH_3-O-CH_3 .

***(39) Explain the term hetero atom in a carbon compound with example.**

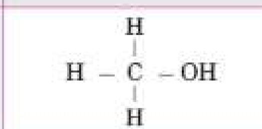
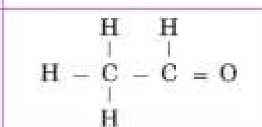
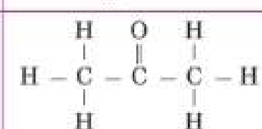
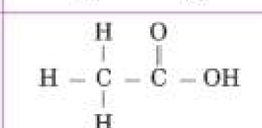
Ans. Carbon compounds are formed by formation of bonds of carbon with other elements such as halogens, oxygen, nitrogen, sulphur. The atoms of these elements substitute one or more hydrogen atoms in the hydrocarbon chain and thereby the tetravalency of carbon is satisfied. The atom of the element which is substitute for hydrogen is referred to as a hetero atom. Sometimes hetero atoms are not alone but exist in the form of certain groups of atoms.

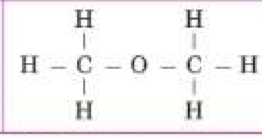
Examples :

Structural formula	Hetero atom
– X (– Cl, Br, – I)	Halogen
– O – H	Oxygen
– O –	Oxygen
$-NH_2$	Nitrogen
$-\overset{\overset{\displaystyle O}{\|}}{C}-$	Oxygen

***(40) Give any four functional groups containing oxygen as the hetero atom in it. Write name and structural formula of one example each.**

Ans.

Functional Group					
Hetero Atom	**Name**	**Structural Formula**	**Condensed Structural Formula**	**Example**	**Name**
Oxygen	1. Alcohol	– O – H	– OH		Methanol
	2. Aldehyde	$-\overset{\overset{\displaystyle O}{\|}}{C}-H$	– CHO		Acetaldehyde
	3. Ketone	$-\overset{\overset{\displaystyle O}{\|}}{C}-$	– CO –		Acetone
	4. Carboxylic	$-\overset{\overset{\displaystyle O}{\|}}{C}-O-H$	– COOH		Acetic acid

Functional Group					
Hetero Atom	Name	Structural Formula	Condensed Structural Formula	Example	Name
	5. Ether	– O –	– O –		Dimethyl ether

*(41) **Give names of three functional groups containing three different hetero atoms. Write name and structural formula of one example each.**

Ans.

Hetero Atom	Name	Structural Formula	Condensed Structural Formula	Example
(1) Halogen, [Chlorine Bromine, Iodine]	Halo	– X(– Cl, – Br, – I)	– X(– Cl, – Br, – I)	CH_3Cl Chloromethane $CH_3 - CH_2 - Br$ Bromoethane
(2) Oxygen	Alcohol	– O – H	– OH	$CH_3 - OH$ Methanol $CH_3 - CH_2 - OH$ Ethanol
(3) Nitrogen	Amine		$-NH_2$	$CH_3 - NH_2$ Methyl amine $CH_3 - CH_2 - NH_2$ Ethylamine

(42) Define functional group and complete the following table :

Ans.

Functional group	Compound	Formula
....	Ethyl alcohol	....
....	Acetaldehyde	....

Ans. The compound acquire specific chemical properties due to these hetero atoms or the groups of atoms that contain hetero atoms, irrespective of length and nature of the carbon chain in that compound. Therefore these hetero atoms or groups of atoms containing hetero atoms are called the functional groups.

Functional group	Compound	Formula
– OH	Ethyl alcohol	C_2H_5OH
– CHO	Acetaldehyde	CH_3CHO

(43) What is meant by homologous series? *OR* **Define homologous series.** ***(Nov. '20)***

Ans. The length of the carbon chains in carbon compounds is different their chemical properties are very much similar due to the presence of the same functional group in them. The series of compounds formed by joining the same functional group in place of a particular hydrogen atom on the chains having sequentially increasing length is called homologous series. Two adjacent members of the series differ by only one $-CH_2-$ (methylene) unit and their mass differ by 14 units.

The homologous series of straight chain alkanes can be represented by the general formula C_nH_{2n+2}. The members of this series are as follows :

Methane – CH_4 Ethane – C_2H_6	– These differ by – CH_2 units
Ethane – C_2H_6 Propane – C_3H_8	– These differ by – CH_2 units
Butane – C_4H_{10} Pentane – C_5H_{12}	– These differ by – CH_2 units

(44) State the four characteristics of homologous series.

Ans. Characteristics of Homologous series :

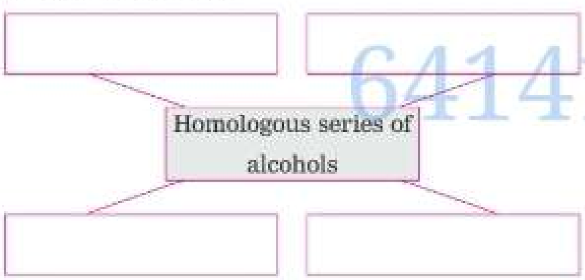
(1) In homologous series while going in an increasing order of the length of carbon chain (a) one methylene unit ($-CH_2-$) gets added (b) molecular mass increases by 14 u (c) number of carbon atoms increases by one.

(2) Chemical properties of members of a homologous series show similarity due to the presence of the same functional group in them.

(3) Each member of the homologous series can be represented by the same general molecular formula.

(4) While going in an increasing order of the length there is gradation in the physical properties i.e. the boiling and melting points.

(45) Write names of first four homologous series of alcohols :



(March '19)

Ans. First four homologous series of alcohols are

(1) Methanol CH_3-OH

(2) Ethanol C_2H_5-OH

(3) Propanol C_3H_7-OH

(4) Butanol C_4H_9-OH

(46) Write the name and molecular formula of a higher homologue of propane.

Ans. Butane (C_4H_{10}) is a higher homologue of propane.

(47) Describe the IUPAC rules of naming organic compounds.

Ans. IUPAC nomenclature system : International Union for Pure and Applied Chemistry (IUPAC) put forth a nomenclature system based on the structure of the compounds and it was accepted all over the world. There are three units in the IUPAC name of any carbon compound : parent, suffix and prefix. These are arranged in the name as follows :

Prefix-parent-suffix :

An IUPAC name is given to a compound on the basis of the name of its parent alkane. The name of the compound is constructed by attaching appropriate suffix and prefix to the name of the parent-alkane. The steps in the IUPAC nomenclature of straight chain compounds are as follows :

Step 1 : Draw the structural formula of the straight chain compound and count the number of carbon atoms in it. The alkane with the same number of carbon atoms is the parent alkane of the concerned compound. Write the name of this alkane. In case the carbon chain of concerned compound contains a double bond, change the ending of the parent name from 'ane' to 'ene'. If the carbon chain in the concerned compound contains a triple bond, change the ending of the parent name from 'ane' to 'yne'.

Sr. No.	Structural formula	Straight chain	Parent name
1.	$CH_3-CH_2-CH_3$	C–C–C	propane
2.	CH_3-CH_2-OH	C–C	ethane
3.	CH_3-CH_2-COOH	C–C–C	propane
4.	$CH_3-CH_2-CH_2-CHO$	C–C–C–C	butane
5.	$CH_3-CH=CH_2$	C–C=C	propene
6.	$CH_3-C\equiv CH$	C–C≡C	propyne

Step 2 : If the structural formula contains a functional group, replace the last letter 'e' from the parent name by the condensed name of the functional group as the suffix. (Exception : The condensed name of the functional group 'halogen' is always attached as the prefix.)

Step 3 : Number the carbon atoms in the carbon chain from one end to the other. Assign the number '1' to carbon in the functional group –CHO or – COOH, if present. Otherwise, the chain can be numbered in two directions. Accept that numbering which gives smaller number to the carbon carrying the functional group. In the final name, a digit (number) and a character (letter) should be separated by a small horizontal line.

(48) Write the IUPAC names of the following structural formulae.

***(a) $CH_3 - CH_2 - CH_2 - CH_3$**

Ans. The number of carbon atoms in the longest chain : 4

Parent alkane : Butane   IUPAC name : *n*-Butane

(b) $CH_3 - CHOH - CH_3$** ***(1 mark)

(Board's Model Activity Sheet; Nov. '20)

Ans. The number of carbon atoms in the longest chain : 3

$$\begin{array}{c} \overset{1}{C}H_3 - \overset{2}{C}H - \overset{3}{C}H_3 \\ \quad | \\ \quad OH \end{array}$$

Parent alkane : Propane

Functional group : – OH (ol)

Assign the number : 2

The carbon atom to which the – OH group is attached is numbered as C_2. If the carbon chain of the compound contains a – OH group then change the ending of the parent name, i.e. 'e' of propane is replaced by 'ol'. (ol stands for alcohol)

Parent suffix : Propan-2-ol

IUPAC name : Propan-2-ol

(c) $CH_3 - CH_2 - COOH$** ***(1 mark)

(Board's Model Activity Sheet; Nov. '20)

Ans. The number of carbon atoms in the longest chain : 3

Parent alkane : Propane

Functional group : – COOH (-oic acid)

If the carbon chain of the compound contains a – COOH group then change the ending of the parent name, i.e. 'e' of propane is replaced by 'oic acid'.

Parent suffix : Propanoic acid

IUPAC name : Propanoic acid

***(d) $CH_3 - CH_2 - NH_2$**

Ans. Number of carbon atoms : 2

Parent alkane : Ethane

Functional group : – NH_2 (amine)

If the carbon chain of the compound contains a – NH_2 group, then change the ending of the parent name, i.e. 'e' of ethane is replaced by 'amine'.

Parent suffix : Ethanamine

IUPAC name : Ethanamine

***(e) $CH_3 - CHO$**

Ans. Number of carbon atoms : 2

Parent alkane : Ethane

Functional group : – CHO (al)

If the carbon chain of the compound contains a – CHO group, then change the ending of the parent name, i.e. 'e' of ethane is replaced by 'al'.

Parent suffix : Ethanal

IUPAC name : Ethanal

(f) $CH_3 - CO - CH_2 - CH_3$** ***(Nov. '20)

Ans. Number of carbon atoms in the longest chain : 4

Parent alkane : Butane

Functional group : – CO – (one)

Assign the number : 2 $\overset{1}{C}H_3 - \overset{2}{C}O - \overset{3}{C}H_2 - \overset{4}{C}H_3$

In the longest chain, the numbering of carbon atom starts from the carbon atom nearest to the function group.

If the carbon chain of the compound contains a (– CO –) group, then change the ending of the parent name, i.e. 'e' of butane is replaced by 'one'.

Parent suffix : Butan-2-one

IUPAC name : Butan-2-one

(g) $CH_3 - CH_2 - CH = CH_2$

Ans. Number of carbon atoms in the longest chain : 4

Parent alkane : Butene

Functional group : double bond

Assign the number : 1 $\overset{4}{C}H_3 - \overset{3}{C}H_2 - \overset{2}{C}H = \overset{1}{C}H_2$

In the longest chain, the numbering of carbon atom starts from the carbon atom nearest to the double bond and the other c-atoms are numbered accordingly.

Parent suffix : But-1-ene

IUPAC name : But-1-ene

(h) $CH_3 - C \equiv C - H$

Ans. Number of carbon atoms in the longest chain : 3

Parent alkane : Propyne

Functional group : triple bond

Parent suffix : Propyne

IUPAC name : Propyne

(i) $CH_3 - \underset{\underset{Cl}{|}}{CH} - CH_2 - CH_2 - CH_3$

Ans. The number of carbon atoms in the longest chain : 5

Parent alkane : Pentane

Prefix functional group : Chloro

Assign the number : 2

$$\overset{1}{CH_3} - \underset{\underset{Cl}{|}}{\overset{2}{CH}} - \overset{3}{CH_2} - \overset{4}{CH_2} - \overset{5}{CH_3}$$

The carbon atom to which the –Cl atom is attached is numbered as C_2 and the other C atoms are numbered accordingly.

Prefix parent : 2-Chloropentane

IUPAC name : 2-Chloropentane

(j) $CH_3 - CH_2 - CH_2 - Br$

Ans. The number of carbon atoms in the longest chain : 3

Parent alkane : Propane

Prefix functional group : Bromo

Assign the number : 1 $\overset{3}{CH_3} - \overset{2}{CH_2} - \overset{1}{CH_2} - Br$

The carbon atom to which the –Br atom is attached is numbered as C_1 and the other C atoms are numbered accordingly.

Prefix parent : 1-Bromopropane

IUPAC name : 1-Bromopropane

(k) $CH_3 - CH_2 - \underset{\underset{OH}{|}}{CH} - CH_3$

Ans. The number of carbon atoms in the longest chain : 4

Parent alkane : Butane

Functional group : –OH (ol)

Assign the number : 2 $\overset{4}{CH_3} - \overset{3}{CH_2} - \underset{\underset{OH}{|}}{\overset{2}{CH}} - \overset{1}{CH_3}$

The carbon atom to which the –OH group is attached is numbered as C_2.

If the carbon chain of the compound contains a –OH group, then change the ending 'e' of the parent name, i.e. 'e' of butane is replaced by 'ol' (ol for alcohol).

Parent suffix : Butan-2-ol

IUPAC name : Butan-2-ol

(l) $CH_3 - \underset{\underset{NH_2}{|}}{CH} - CH_3$

Ans. The number of carbon atoms : 3

Parent alkane : Propane

Functional group : $-NH_2$ (amine)

Assign the number : 2 $\overset{1}{CH_3} - \underset{\underset{NH_2}{|}}{\overset{2}{CH}} - \overset{3}{CH_3}$

If the carbon chain of the compound contains a $-NH_2$ group then change the ending of the parent name, i.e. 'e' of propane is replaced by 'amine'.

Parent suffix : 2-Propanamine

IUPAC name : 2-Propanamine

(m) HCOOH

Ans. The number of carbon atoms : 1

Parent alkane : Methane

Functional group : –COOH (-oic cid)

If the carbon chain of the compound contains a –COOH group, then change the ending of the parent name, i.e. 'e' of methane is replaced by '-oic acid'.

Parent suffix : Methanoic acid

IUPAC name : Methanoic acid

(n) $CH_3 - CH_2 - CH_2 - CHO$

Ans. The number of carbon atoms in the longest chain : 4

Parent alkane : Butane

Functional group : –CHO (al)

Assign the number : 1

Assign the number '1' to carbon in the functional group –CHO. $\overset{4}{CH_3} - \overset{3}{CH_2} - \overset{2}{CH_2} - \overset{1}{CHO}$

If the carbon chain of the compound contains a –CHO group then change the ending of the parent name, i.e. 'e' of the butane is replaced by 'al'.

Parent suffix : Butanal

IUPAC name : Butanal

(o) $CH_3 - CH_2 - \underset{\underset{O}{\|}}{C} - CH_2 - CH_3$

Ans. The number of carbon atoms in the longest chain : 5

Parent alkane : Pentane

Functional group : $-\underset{\underset{O}{\|}}{C}-$ (-one)

Assign the numbering :

$$\overset{1}{C}H_3 - \overset{2}{C}H_2 - \underset{\underset{O}{\|}}{\overset{3}{C}} - \overset{4}{C}H_2 - \overset{5}{C}H_3$$

In the longest chain, the numbering of carbon atom starts from the carbon nearest to the functional group (both the numbering equivalent).

If the carbon chain of compound contains a $\left(-\underset{\underset{O}{\|}}{C}-\right)$ group, then change the ending of the parent name i.e. 'e' of pentane is replaced by 'one'.

Parent suffix : Pentan-3-one

IUPAC name : Pentan-3-one.

(49) What happens when methane is burnt in air? Write the balanced chemical equation for the same.

Ans. When methane burns in air, carbon dioxide and water are formed. The reaction is exothermic with release of large amount of heat and light.

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

(50) Compare : The proportions of carbon atoms in ethanol (C_2H_5OH) and naphthalene ($C_{10}H_8$). **(Textbook page 124)**

Ans. Ethanol contains two carbon atoms while naphthalene contains 10 carbon atoms. Ethanol is a saturated hydrocarbon and naphthalene is an unsaturated hydrocarbon.

(51) What happens when ethanol is burnt in air?

Ans. When ethanol is burnt in air, it burns with a clean blue flame, carbon dioxide and water are formed. In this reaction, release of large amount of heat and light takes place.

$$\underset{\text{Ethanol}}{CH_3 - CH_2 - OH_{(l)}} + 3O_{2(g)} \longrightarrow 2CO_{2(g)} + 3H_2O_{(g)} + \text{Heat and light}$$

(52) What happens when ethanol is treated with alkaline potassium permanganate? Write the balanced chemical equation for the same.

Ans. When ethanol is treated with alkaline potassium permanganate, ethanol gets oxidised by alkaline potassium permanganate to form ethanoic acid.

$$\underset{\text{Ethanol}}{CH_3 - CH_2 - OH} \xrightarrow[\text{Alkaline } KMnO_4]{(O)} \underset{\text{Ethanoic acid}}{CH_3 - \overset{\overset{O}{\|}}{C} - OH}$$

(53) Compare : How is the transformation of ethanol into ethanoic acid on oxidation reaction? **(Textbook page 125)**

Ans. The transformation of ethanol into ethanoic acid is an oxidation process, in which ethanol accepts oxygen.

(54) What happens when vegetable oil is hydrogenated? Write the balanced chemical equation.

Ans. When vegetable oil (unsaturated compound) is hydrogenated in the presence of nickel catalyst, vanaspati ghee (saturated) compound is formed.

$$\underset{\substack{\text{Unsaturated} \\ \text{compound} \\ \text{(vegetable oil)}}}{-\overset{|}{C} = \overset{|}{C}-} \xrightarrow[Pt/Ni]{H_2} \underset{\substack{\text{Saturated} \\ \text{compound} \\ \text{(vanaspati ghee)}}}{-\underset{\underset{H}{|}}{\overset{|}{C}} - \underset{\underset{H}{|}}{\overset{|}{C}}-}$$

(55) What happens when chlorine is treated with methane? *OR* **Describe the action of chlorine on methane.** *OR* **Write a note on chlorination of methane.**

Ans. Methane reacts rapidly with chlorine in the presence of sunlight to form four products. In this reaction, chlorine atoms replace, one by one, all the hydrogen atoms in the methane.

$$\underset{\text{Methane}}{CH_4} - Cl_2 \xrightarrow{\text{Sunlight}} \underset{\text{Methyl chloride}}{CH_3Cl} + HCl$$

$$CH_3 - Cl + Cl_2 \xrightarrow{\text{Sunlight}} \underset{\text{Methylene dichloride}}{CH_2Cl_2} + HCl$$

$$\underset{\text{Methylene dichloride}}{CH_2Cl_2} + Cl_2 \xrightarrow{\text{Sunlight}} \underset{\text{Chloroform}}{CHCl_3} + HCl$$

$$\underset{\text{Chloroform}}{CHCl_3} + Cl_2 \xrightarrow{\text{Sunlight}} \underset{\text{Carbon tetrachloride}}{CCl_4} + HCl$$

The reaction in which the place of one type of atom / group in a reactant is taken by another atom / group of atoms is called substitution reaction. Chlorination of methane is a substitution reaction.

(56) What happens when ethanol is reacted with sodium?

Ans. When ethanol is reacted with sodium at room temperature, sodium ethoxide is formed and hydrogen gas is liberated.

$$\underset{\text{Ethanol}}{2C_2H_5OH} + \underset{\text{Sodium}}{2Na} \longrightarrow \underset{\text{Sodium ethoxide}}{2C_2H_5ONa} + \underset{\text{Hydrogen}}{H_2\uparrow}$$

(57) What happens when ethanol is heated at 170 °C with excess of con. sulphuric acid?

Ans. When ethanol is heated at 170 °C with excess of conc. sulphuric acid, one molecule of water is removed from its molecule to form ethene (unsaturated compound).

$$\underset{\text{Ethanol}}{CH_3 - CH_2 - OH} \xrightarrow[170\ ^\circ C]{\text{Conc. } H_2SO_4} \underset{\text{Ethene}}{CH_2 = CH_2} + \underset{\text{Water}}{H_2O}$$

(58) What happens when ethanoic acid is treated with sodium hydroxide? Write the balanced equation for the same.

Ans. When ethanoic acid is treated with sodium hydroxide, neutralization takes place to form sodium acetate (sodium ethanoate) and water.

$$\underset{\substack{\text{Ethanoic}\\\text{acid}\\\text{(Acid)}}}{CH_3 - COOH} + \underset{\substack{\text{Sodium}\\\text{hydroxide}\\\text{(Base)}}}{NaOH} \longrightarrow \underset{\substack{\text{Sodium}\\\text{ethanoate}\\\text{(Salt)}}}{CH_3 - COONa} + \underset{\substack{\text{water}\\\text{(Water)}}}{H_2O}$$

(59) What happens when ethanoic acid is treated with sodium carbonate?

Ans. When ethanoic acid is treated with sodium carbonate, sodium ethanoate, carbon dioxide and water is formed.

$$\underset{\text{Ethanoic acid}}{2CH_3COOH} + Na_2CO_3 \longrightarrow \underset{\text{Sodium ethanoate}}{2CH_3 - COONa} + H_2O + CO_2\uparrow$$

(60) What happens when ethanoic acid is treated with sodium bicarbonate?

Ans. When ethanoic acid is treated with sodium bicarbonate, sodium ethanoate, water and carbon dioxide is formed.

$$\underset{\text{Ethanoic acid}}{CH_3 - COOH} + NaHCO_3 \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + H_2O + CO_2\uparrow$$

(61) What happens when ethanoic acid is treated with ethanol? Write the balanced equation for the same.

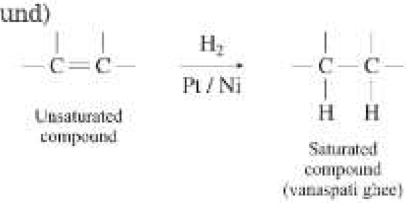
Ans. When ethanoic acid is treated with ethanol in the presence of an acid catalyst, an ester, i.e. ethyl ethanoate is formed.

$$\underset{\substack{\text{Ethanoic}\\\text{acid}}}{CH_3 - COOH} + \underset{\text{Ethanol}}{CH_3 - CH_2 - OH} \xrightarrow[\text{Catalyst}]{\text{Acid}} \underset{\text{Ethyl ethanoate}}{CH_3 - COO - CH_2 - CH_3} + \underset{\text{Water}}{H_2O}$$

***(62) What is a catalyst? Write any one reaction which is brought about by the use of catalyst?**

Ans. Catalyst is a substance, which changes the rate of reaction, without causing any disturbance to it.

Vegetable oil (unsaturated compound) undergoes addition reaction with hydrogen in the presence of nickel catalyst to form vanaspati ghee (saturated compound)



(63) What happens when ethylene gas is heated at high pressure and high temperature in the presence of suitable catalyst?

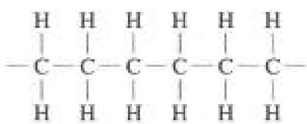
Ans. When ethylene gas is heated at high pressure and high temperature in the presence of suitable catalyst, it polymerizes to form polyethylene or polythene (plastic).

$$\underset{\text{Ethylene}}{nCH_2 = CH_2} \xrightarrow[\text{Catalyst}]{\text{Heat, high pressure}} \underset{\text{Polythene or Polyethylene}}{(CH_2 - CH_2)_n}$$

$(n = 100 \text{ to } 1000)$

$$..... CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 ... \text{ etc.}$$

OR



(64) State the physical properties of ethyl alcohol ethanol.

Ans. (1) Ethanol is a colourless liquid and it is soluble in water in all proportions and has pleasant odour.

(2) The boiling point of ethanol is 78 °C and the freezing point is -114 °C.

(3) It is combustible and burns with a blue flame.

(4) An aqueous solution of ethanol is neutral to litmus paper.

(65) What is meant by denatured alcohol?

Ans. Ethanol is the important commercial solvent. To prevent the misuse of this solvent, it is mixed with the poisonous methanol. Such ethanol is called denatured spirit.

***(66) What is meant by vinegar and gasohol ? What are their uses ?**

Ans. (1) Vinegar is a 5 – 8% aqueous solution of acetic acid. It is used as preservative in pickles. It is used to cook meat. It is used as a salad dressing.

(2) To increase the efficiency of petrol, it is mixed with 10% anhydrous ethanol, such a fuel is called gasohol. It is used as a fuel in cars and other vehicles.

(67) State the uses of ethanol.

Ans. (1) Ethanol is used as an important commercial solvent in industries.

(2) It is used in medicines such as tincture iodine, cough mixture and also in many tonics.

(3) Ethanol is used as a clean fuel.

(68) State the properties of ethanoic acid.

Ans. (1) Ethanoic acid is a colourless liquid with boiling point 118 °C and melting point 17 °C. It has a pungent odour.

(2) Its aqueous solution is acidic and turns blue litmus red.

(3) A 5 – 8% aqueous solution of acetic acid is used as vinegar.

(4) It is a weak acid.

(69) What is meant by glacial acetic acid ?

Ans. The melting point of pure acetic acid is 17 °C. Therefore, during winter in old countries acetic acid freezes at room temperature itself and looks like ice. Therefore it is named glacial acetic acid.

(70) Give two examples of natural macromolecules.

Ans. Examples : Polysaccharide, protein and nucleic acid.

***(71) Give names of three natural polymers. Write the place of their occurrence and names of monomers from which they are formed.**

Ans. (1) Polysaccharide is a natural polymer. It occurs in starch/carbohydrates. It is formed from monomer glucose.

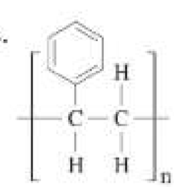
(2) Protein is a natural polymer. It occurs in muscles, hair, enzymes, skin, egg. It is formed from alpha amino acids.

(3) Rubber is a natural polymer. It occurs in latex of rubber tree. It is formed from monomer isoprene.

(72) Write the structure of polystyrene and give its uses.

Structure :

Ans.



Polystyrene is used to make thermocol articles.

(73) Write the name and the structure of monomer of polyacrylonitrile.

Ans. The name and structure of monomer :

Acrylonitrile $CH_2 = CH-CN$

(74) Write the name and the structure of monomer of teflon and its uses.

Ans. The name and structure of monomer :

Tetrafluro ethylene $CF_2 = CF_2$

Teflon is used to make nonstick cookware.

(75) What is meant by homopolymers? *OR*

***Explain the term : Homopolymer.**

Ans. The polymers formed by repetition of single monomer are called homopolymer. e.g. polyethylene $\left(CH_2-CH_2 \right)_n$.

(76) What is meant by copolymers?

Ans. The polymers formed from two or more monomers are called copolymers. **Examples :** Poly ethylene terephthalate.

***(77) Explain the term with example : Monomer**

Ans. The small unit that repeats regularly to form a polymer is called monomer. **Example :** Ethylene.

***(78) Explain the term with example : Oxidants**

Ans. Substance that can give oxygen to other substances are called oxidants. **Examples :** Potassium permanganate or potassium dichromate.

***(79) Explain the term with example : Reduction**

Ans. In a chemical reaction, removal of oxygen from a compound or addition of hydrogen to a compound is called a reduction.

***(80) Write the structural formulae for the following IUPAC names.**

(a) Pent-2-one	**(b) 2-Chlorobutane**
(c) Propan-2-ol	**(d) Methanal**
(e) Butanoic acid	**(f) 1-Bromopropane**
(g) Ethanamine	**(h) Butanone.**

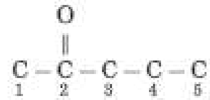
Ans.

(a) Pent-2-one.

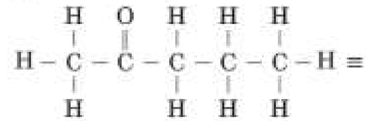
(1) Pent stands for 5 carbon atoms in a chain. Number the carbon atoms in a chain as 1, 2, 3, ...

$\overset{1}{C}-\overset{2}{C}-\overset{3}{C}-\overset{4}{C}-\overset{5}{C}$

(2) 'one' stands for functional group $\left(-\overset{\overset{O}{\|}}{C}-\right)$ ketone. The number assigned for the ketone group is 2. Show the ketone group at C_2.



(3) Now satisfy the valencies of each carbon atom



$CH_3-\overset{\overset{O}{\|}}{C}-CH_2-CH_2-CH_3$

$\mathbf{CH_3-\overset{\overset{O}{\|}}{C}-CH_2-CH_2-CH_3}$

(b) 2-Chlorobutane.

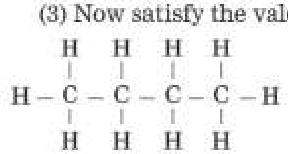
(1) In 2-chlorobutane, butane is parent alkane stands for 4 carbon atoms and number the carbon atoms in a chain as 1, 2, 3 ... .

$\overset{1}{C}-\overset{2}{C}-\overset{3}{C}-\overset{4}{C}-$

(2) Chloro (Halo) is the prefix and the number assigned for prefix (chloro) is 2. Show the chloro atom at C_2

$\overset{1}{C}-\underset{\underset{Cl}{|}}{\overset{2}{C}}-\overset{3}{C}-\overset{4}{C}-$

(3) Now satisfy the valencies of each carbon atom

 $\equiv CH_3-\underset{\underset{Cl}{|}}{CH}-CH_2-CH_3$

$\mathbf{CH_3-\underset{\underset{Cl}{|}}{CH}-CH_2-CH_3}$

(c) Propan-2-ol.

(1) Propan stands for 3 carbon atoms in a chain. Number the carbon atom in a chain as 1, 2, 3.

$-\overset{1}{C}-\overset{2}{C}-\overset{3}{C}-$

(2) '-ol' stands for (– OH) hydroxyl group. The number assigned for the hydroxyl group is 2. Show the – OH group at C_2.

$\underset{1}{C}-\underset{2}{\overset{\overset{OH}{|}}{C}}-\underset{3}{C}$

(3) Now satisfy the valencies of each carbon atom

$$\begin{array}{ccccccc} & & H & & OH & & H & & \\ & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & \\ & & H & & H & & H & & \end{array} \equiv \begin{array}{c} CH_3 - \underset{|}{CH} - CH_3 \\ \quad OH \end{array}$$

$$\mathbf{CH_3 - \underset{\underset{OH}{|}}{CH} - CH_3}$$

(d) Methanal.

(1) Meth – stands for one carbon atom and assigned the number '1' to carbon in the functional group – CHO.

(2) '-al' stands for functional group (– CHO) aldehyde.

(3) Now satisfy the valencies of carbon in – CHO.

$$\underset{\text{(Aldehyde)}}{-\overset{\overset{H}{|}}{C} = O} \longrightarrow \underset{\text{Methanal}}{H - \overset{\overset{H}{|}}{C} = O} \longrightarrow HCHO$$

HCHO

(e) Butanoic acid.

(1) But stands for 4 carbon atoms in a chain. Number the carbon atoms in a chain as 1, 2, 3, ...

$$\overset{4}{C} - \overset{3}{C} - \overset{2}{C} - \overset{1}{C}$$

'-oic acid' stands for functional group – COOH. Assign the number 1 to carbon in the functional group – COOH.

$$\overset{4}{C} - \overset{3}{C} - \overset{2}{C} - \overset{1}{C}OOH$$

Now satisfy the valencies of each carbon atom

$$H - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - COOH \equiv CH_3 - CH_2 - CH_2 - COOH$$

$$\mathbf{CH_3 - CH_2 - CH_2 - COOH}$$

(f) 1-Bromopropane.

(1) In 1-bromopropane, propane is parent alkane stands for 3 carbon atoms and number the carbon atoms in a chain as 1, 2, 3, ...

$$\overset{3}{C} - \overset{2}{C} - \overset{1}{C}$$

(2) Bromo (Halo) is the prefix and the number assigned for prefix (bromo) is 1, show the bromine atom at C_1.

$$\overset{3}{C} - \overset{2}{C} - \overset{1}{C} - Br$$

(3) Now satisfy the valencies of each carbon atom

$$H - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - Br \equiv CH_3 - CH_2 - CH_2 - Br$$

$$\mathbf{CH_3 - CH_2 - CH_2 - Br}$$

(g) Ethanamine.

(1) Eth stands for 2 carbon atoms in a chain and the parent alkane is ethane.

$$- C - C -$$

(2) 'amine' stands for (– NH_2) amino group. Show the amino (– NH_2) at any carbon atom.

$$- C - C - NH_2$$

(3) Now satisfy the valencies of each carbon atom

$$H - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - NH_2 \equiv CH_3 - CH_2 - NH_2$$

$$\mathbf{CH_3 - CH_2 - NH_2}$$

(h) Butanone.

(1) But stands for 4 carbon atoms in a chain and the parent alkane is butane. Number the carbon atoms in a chain 1, 2, 3, ...

$$\overset{1}{C} - \overset{2}{C} - \overset{3}{C} - \overset{4}{C}$$

(2) '-one' stands for functional group $\left(- \overset{\overset{O}{\|}}{C} - \right)$ ketone. The number assigned for the ketone group is 2. Show the ketone group at C_2.

$$\underset{1}{C} - \underset{2}{\overset{\overset{O}{\|}}{C}} - \underset{3}{C} - \underset{4}{C}$$

(3) Now satisfy the valencies of each carbon atom

$$H - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - \overset{\overset{O}{\|}}{C} - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - \overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}} - H \equiv CH_3 - \overset{\overset{O}{\|}}{C} - CH_2 - CH_3$$

$$\mathbf{CH_3 - \overset{\overset{O}{\|}}{C} - CH_2 - CH_3}$$

Q. 13 Use your brain power! Can you tell ?

(1) Atomic number of chlorine is 17. What is the number of electrons in the valence shell of the chlorine ? (Textbook page 112)

Ans. There are seven electrons in the valence shell of the chlorine.

(2) Molecular formula of chlorine is Cl_2. Draw electron-dot and line structure of a chlorine molecule. (Textbook page 112)

Ans. $:\ddot{\underset{..}{Cl}}:\ddot{\underset{..}{Cl}}: \longrightarrow :\ddot{\underset{..}{Cl}}-\ddot{\underset{..}{Cl}}: \longrightarrow Cl-Cl$

Fig. 9.12

(3) The molecular formula of water is H_2O. Draw electron-dot and line structures for triatomic molecule. (Use dots for electron of oxygen atom and crosses for electrons of hydrogen atoms.) (Textbook page 112)

Ans.

$H \times\cdot \ddot{\underset{..}{O}} \cdot\times H$

Fig. 9.13

(4) The molecular formula of ammonia is NH_3. Draw electron-dot and line structures for ammonia molecule. (Textbook page 112)

Ans. $H:\ddot{\underset{H}{\underset{..}{N}}}:H \longrightarrow H-\ddot{\underset{H}{\underset{|}{N}}}-H$

Fig. 9.14

(5) The molecular formula of carbon dioxide is CO_2. Draw the electron-dot structure (without showing circle) and line structure for CO_2. (Textbook page 112)

Ans.

$:\ddot{O}::C::\ddot{O}: \longrightarrow \underset{..}{\ddot{O}}=C=\underset{..}{\ddot{O}}$

Fig. 9.15

(6) With which bond C atom in CO_2 is bonded to each of the O atoms ? (Textbook page 112)

Ans. In CO_2, carbon atom is bonded to each of the O atoms by double bond.

(7) The molecular formula of sulphur is S_8 in which eight sulphur atoms are bonded to each other to form one ring. Draw electron-dot structure for S_8 without showing the circles.

(Textbook page 112)

Ans.

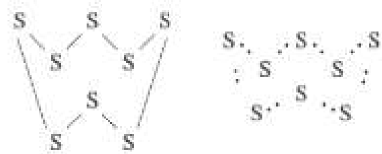


Fig. 9.16

The above S_8 molecule of sulphur has crown shaped structure. One molecule of sulpur is made up of eight atoms of sulphur.

(8) Hydrogen peroxide decomposes of its own by the following reaction :

$$2H-O-O-H \longrightarrow 2H-O-H + O_2$$

From this, what will be your inference about the strength O – O covalent bond ?

Tell from the above example whether oxygen has catenation power or not.

(Textbook page 113)

Ans. In hydrogen peroxide (H_2O_2), the O – O covalent bond is not strong as oxygen has no catenation power.

Homologous Series of Alkenes

Name	Molecular formula	Condensed Structural formula	Number of carbon atoms	Number of $-CH_2-$ units	Boiling point °C
Ethene	C_2H_4	$CH_2=CH_2$	2	0	– 102
Propene	C_3H_6	$CH_3-CH=CH_2$	3	1	– 48
1-Butene	C_4H_8	$CH_3-CH_2-CH=CH_2$	...	...	– 6.5
1-Pentene	C_5H_{10}	$CH_3-CH_2-CH_2-CH=CH_2$	...	...	30

(9) The above table shows the homologous series of alkenes. Inspect the molecular formulae of the members of this series. Do you find any relationship, in the number of carbon atoms and the number of hydrogen atoms in the molecular formulae ? (Textbook page 120)

Ans. In the above homologous series, if we observe the molecular formulae of alkenes then the number of carbon atoms are half the number of hydrogen atoms.

(10) If the number of carbon atoms in the molecular formulae of alkenes is denoted by 'n', what will be the number of hydrogen atoms ?

Ans. If the number of carbon atoms in the molecular formulae of alkenes is denoted by 'n' then the number of hydrogen atoms would be $2n$.

(11) What would be the general formula for the molecular formulae of the members of the homologous series of alkanes ? What would be the value of 'n' for the first member of this series ? (Textbook page 120)

Ans. The general formula for the homologous series of alkane is C_nH_{2n+2} . The value of 'n' for the first member of homologous series is 1.

$$C_nH_{2n+2} = C_1H_{2\times 1} + 2 = \underset{\text{Methane}}{CH_4}$$

(12) The general molecular formula for the homologous series of alkynes is C_nH_{2n-2}. Write down the individual molecular formulae of the first, second and third members by substituting the values 2, 3 and 4 respectively for 'n' in this formula. (Textbook page 120)

Ans. The general molecular formula for the homologous series of alkynes is C_nH_{2n-2}

$n = 2$ $C_2H_{2\times 2-2} = C_2H_2$ Ethyne

$n = 3$ $C_3H_{2\times 3-2} = C_3H_4$ Propyne

$n = 4$ $C_4H_{2\times 4-2} = C_4H_6$ Butyne

(13) Write down structural formulae of the first four members of the various homologous series formed by making use of the functional groups. (Textbook page 120)

Ans.

Functional group Halo – X (Cl, Br, – I)	Functional group Aldehyde – CHO	Functional group Carboxylic acid – COOH	Functional group Amine – NH_2
CH_3Cl Chloromethane	HCHO Methanal	HCOOH Methanoic acid	CH_3NH_2 Methanamine
$CH_3 - CH_2 - Cl$ Chloroethane	CH_3CHO Ethanal	CH_3COOH Ethanoic acid	$CH_3CH_2NH_2$ Ethanamine
$CH_3 - CH_2 - CH_2 - Cl$ 1-Chloropropane	CH_3CH_2CHO Propanal	CH_3CH_2COOH Propanoic acid	$CH_3CH_2CH_2NH_2$ Propanamine
$CH_3 - CH_2 - CH_2 - CH_2 - Cl$ 1-Chlorobutane	$CH_3CH_2CH_2CHO$ Butanal	$CH_3CH_2CH_2COOH$ Butanoic acid	$CH_3CH_2CH_2CH_2NH_2$ Butanamine

(14) General formula of the homologous series of alkanes is C_nH_{2n+2}. Write down the molecular formula of the 8th and 12th member using this. (Textbook page 120)

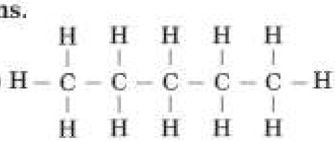
Ans. General formula of alkanes is C_nH_{2n+2}

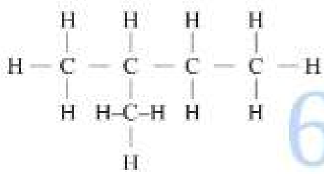
$n = 8$ $C_8H_{2 \times 8 + 2} = C_8H_{18}$ Octane

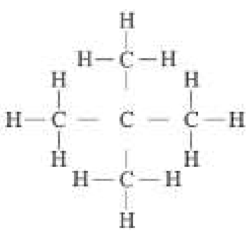
$n = 12$ $C_{12}H_{2 \times 12 + 2} = C_{12}H_{26}$ Dodecane

(15) Draw three structural formulae having molecular formula C_5H_{12}. Give the names *n*-pentane, *i*-pentane and neo-pentane to the above structural formulae. (Textbook page 121)

Ans.

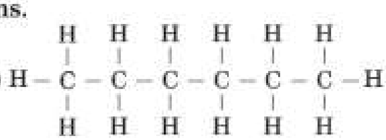
(1)  *n*-Pentane

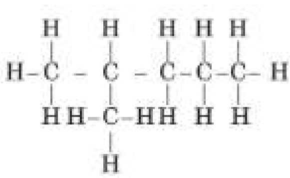
(2)  *i*-pentane

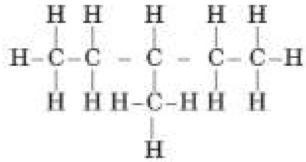
(3)  neo-pentane

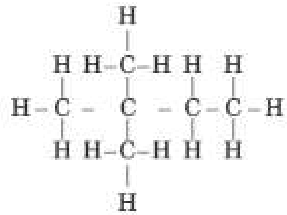
(16) Draw all possible structural formulae having molecular formula C_6H_{14}. Give names to all the isomers. (Textbook page 121)

Ans.

(1)  *n*-hexane

(2)  *i*-hexane

 *i*-hexane

(3)  neo-hexane

(17) Propane (C_3H_8) is one of the combustible components of L.P.G. Write down the reaction of propane (C_3H_8).

Ans.

$$\underset{\text{Propane}}{C_3H_{8(g)}} + 5O_{2(g)} \xrightarrow{\text{Combustion}} \underset{\substack{\text{Carbon}\\\text{dioxide}}}{3CO_{2(g)}} + 4H_2O_{(g)} + \text{Heat}$$

(18) Light a bunsen burner. Open and close the air hole at the bottom of the burner by means of the movable ring around it. When do you get yellow sooty flame? When do you get blue flame? (Try This! Textbook page 124)

Ans. When the air hole at the bottom of the burner is open, sufficient oxygen is mixed gaseous fuel for complete combustion and a clean blue flame is obtained. When the air hole is partially blocked by means of the movable ring around it, the air supply is limited which results in incomplete combustion. Hence, yellow sooty flame is produced.

(19) The names of four fatty acids separated from vegetable oils are given in the table. Identify the number of carbon – carbon double bonds from their structure and molecular formula from the below fatty acids which one when reacts with iodine will make the colour of iodine disappear. (Textbook page 125)

Ans.

Name	Molecular Formula	Number of C=C double bonds	Will it decolourise I_2?
Stearic acid	$C_{17}H_{35}COOH$	....	~~yes~~/ no
Oleic acid	$C_{17}H_{33}COOH$	One double bond	yes/ ~~no~~
Plamitic acid	$C_{15}H_{31}COOH$	....	~~yes~~/ no
Linoleic acid	$C_{17}H_{31}COOH$	Two double bonds	yes/ ~~no~~

(20) In the chlorination, substitution reaction of propane two isomeric products containing one chlorine atom are obtained. Draw their structural formulae and give their IUPAC names. (Textbook page 126)

Ans. $\underset{\text{Propane}}{CH_3 - CH_2 - CH_3} \xrightarrow{Cl_2}$

$$CH_3 - CH_2 - CH_2 - Cl + CH_3 - \underset{\underset{Cl}{|}}{CH} - CH_3$$

$CH_3 - CH_2 - CH_2 - Cl$ 1-Chloropropane

$CH_3 - \underset{\underset{Cl}{|}}{CH} - CH_3$ 2-Chloropropane

(21) Explain by writing a reaction, what will happen when pieces of sodium metal are put in *n*-propyl alcohol. (Textbook page 128)

Ans. *n*-Propyl alcohol reacts with pieces of sodium metal, sodium propoxide and hydrogen gas are obtained.

$$\underset{n\text{-propyl alcohol}}{2CH_3 - CH_2 - CH_2 - OH} + 2Na \longrightarrow \underset{\text{Sodium propoxide}}{2CH_3 - CH_2 - CH_2 - ONa} + H_2 \uparrow$$

(22) Explain by writing a reaction, which product will be formed on heating *n*-butyl alcohol with concentrated sulphuric acid. (Textbook page 128)

Ans. When *n*-butyl alcohol is heated with concentrated sulphuric acid, one molecule of water is removed from its molecule to form 1-butene.

$$\underset{n\text{-butyl alcohol}}{CH_3 - CH_2 - CH_2 - CH_2 - OH} \xrightarrow[\Delta]{\text{conc. } H_2SO_4} \underset{\text{1-butene}}{CH_3 - CH_2 - CH = CH_2} + H_2O$$

(23) Which one of ethanoic acid and hydrochloric acid is stronger? (Textbook page 129)

Ans. Hydrochloric acid is stronger acid.

(24) Which indicator paper out of blue litmus paper and pH paper is useful to distinguish between ethanoic acid and hydrochloric acid ? (Textbook page 129)

Ans. pH paper is useful to distinguish between ethanoic acid and hydrochloric acid.

(25) Explain why does the lime water turns milky in the reaction of acetic acid with sodium carbonate. (Textbook page 130)

Ans. In the reaction of acetic acid with sodium carbonate, carbon dioxide gas is evolved which turns lime water milky resulting in the formation of insoluble calcium carbonate.

$$\underset{\text{Acetic acid}}{2CH_3COOH} + \underset{\text{Sodium carbonate}}{Na_2CO_3} \longrightarrow \underset{\text{Sodium acetate}}{2CH_3COONa} + H_2O + CO_2 \uparrow$$

$$\underset{\text{Lime water}}{Ca(OH)_2} + \underset{\text{Carbon dioxide}}{CO_{2(g)}} \longrightarrow \underset{\text{Calcium carbonate (milky)}}{CaCO_3} \downarrow + H_2O$$

(26) Explain the reaction that would take place when a piece of sodium metal is dropped in ethanoic acid. (Textbook page 130)

Ans. When a piece of sodium metal is dropped in ethanoic acid, sodium acetate and hydrogen gas is formed.

$$\underset{\text{Ethanoic acid}}{2CH_3COOH} + \underset{\text{Sodium}}{2Na} \longrightarrow \underset{\text{Sodium ethanoate}}{2CH_3COONa} + H_2 \uparrow$$

(27) Two test tubes contain two colourless liquids ethanol and ethanoic acid. Explain by writing reaction which chemical test you would perform to tell which substance is present in which test tube. (Textbook page 130)

Ans. Ethanol does not react with sodium bicarbonate, while ethanoic acid reacts with sodium bicarbonate to form carbon dioxide gas.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + NaHCO_3 \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + H_2O + CO_2 \uparrow$$

(28) When fat is heated with sodium hydroxide solution, soap and glycerin are formed. Which functional groups might be present in fat and glycerin ? What do you think ?

(Textbook page 131)

Ans. The functional group carboxylic acid (– COOH) is present in fat whereas the functional group hydroxyl group (– OH) is present in glycerin.

(29) What are the chemical names of the nutrients that we get from the foodstuff, namely, cereals, pulses and meat ?

(Textbook page 131)

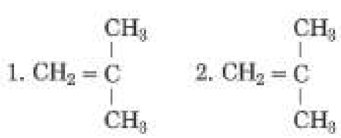
Ans. The nutrients that we get from the foodstuff, namely cereals, pulses and meat are alpha amino acids.

(30) What are the chemical substances that make cloth, furniture and elastic objects ?

(Textbook page 131)

Ans. The chemical substances that make cloth, furniture and elastic objects are cellulose and rubber.

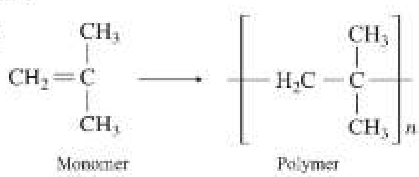
(31) Structural formulae of some monomers are given below. Write the structural formula of the homopolymer formed from them.



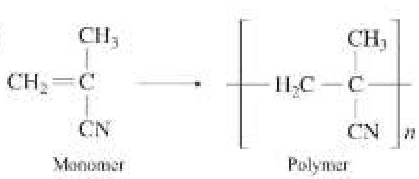
(Textbook page 133)

Ans.

1.

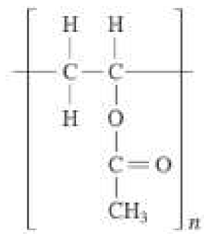


2.



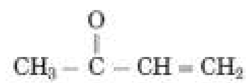
(32) From the given structural formula of polyvinyl acetate, that is used in paints and glues, deduce the name and structural formula of the corresponding monomer.

(Textbook page 133)



polyvinyl acetate (polymer)

Ans.



(monomer)

Q. 14 Write short notes :

(1) Catenation Power.

Ans. (1) Carbon has a unique ability to form strong covalent bonds with other carbon atoms; this results in formation of big molecules. This property of carbon is called catenation power.

(2) Carbon shows catenation. Two or more carbon atoms can share their valence electrons and bond with each other. Thus, carbon chains can be straight or branched or closed chain ring structure forming large molecules. The covalent bond between two carbon atoms is strong and therefore stable. Carbon is bestowed with catenation power due to the strong and stable covalent bonds.

(3) Hence, carbon atoms can form an unlimited number of compounds.

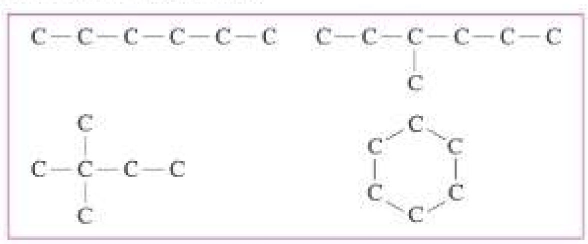


Fig. 9.17 : Chain structures of organic compound

(2) Characteristics of Carbon.

Ans. *Refer to the answer to Q. 12 (6).*

(3) Functional group.

Ans. (1) The compound acquire specific chemical properties due to these hetero atoms or the groups of atoms that contain hetero atoms, irrespective of the length and nature of the carbon chain in that compound. Therefore these hetero atoms or the groups of atoms containing hetero atoms are called functional groups.

All organic compounds are derivatives of hydrocarbons. The derivatives are formed by replacing one or more H-atom/atoms of hydrocarbon by some other hetero atom or groups of atoms containing hetero atoms. After replacement, a new compound is formed which has properties different from the parent hydrocarbon.

Examples : For methane, if one hydrogen atom is replaced by an $-OH$ group, then a compound is methyl alcohol (CH_3OH). The $-OH$ group is known as the alcoholic functional group.

Functional group is organic compound :

1. Alcohol : $-OH$ (hydroxy group)

2. Aldehyde : $\begin{array}{c} H \\ | \\ -C=O \end{array}$

3. Ketones : $\begin{array}{c} O \\ \| \\ -C- \end{array}$

4. Carboxylic acid : $-COOH$

(4) Homologous series.

Ans. *Refer to the answer to Q. 12 (43) and (44).*

(5) Polymerization.

Ans. (1) The reaction by which monomer molecules are converted into a polymer is called polymerization. A macromolecule formed by regular repetition of a small unit is called polymer. The small unit that repeats regularly to form a polymer is called monomer. The important method of polymerization is to make a polymer by joining alkene type of monomers.

(2) When ethylene gas is heated at high pressure and high temperature in the presence of suitable catalyst, it polymerizes to form polyethylene or polythene (plastic).

$$\underset{\text{Ethylene}}{nCH_2=CH_2} \xrightarrow[\text{High pressure}]{\text{Heat}} \underset{\text{Polyethylene or Polythene}}{-\!\!(CH_2-CH_2)\!\!-_n}$$

$$\ldots\ldots\ CH_2-CH_2-CH_2-CH_2-CH_2-\ \ldots\ldots \text{ etc.}$$

(3) The polymer polystyrene is used to make thermocoal articles. The polymer polyvinyl chloride is used to make P.V.C. pipes, doormats, etc. The polymer teflon is used to make nonstick cookware. The polymer polypropylene is used to make injection syringe, furniture, etc.

Q. 15 Give scientific reasons : *(2 marks each)*

(1) Carbon atoms are capable of forming an unlimited number of compounds.

Ans. (1) Carbon has the property of catenation. Two or more carbon atoms can share some of their valence electrons to form (single, double and triple) bonds.

(2) The straight chains or branched chains or rings may have different shapes and sizes. This results in formation of many compounds. Isomerism is one more characteristic of carbon compounds which is responsible for large number of carbon compounds. Hence, carbon atoms are capable of forming an unlimited number of compounds.

(2) Ethylene is an unsaturated hydrocarbon.

Ans. (1) Ethylene ($CH_2=CH_2$) contains a double bond between carbon atoms.

(2) Thus, the valencies of the two carbon atoms are not fully satisfied by single covalent bonds. Hence, ethylene is an unsaturated hydrocarbon.

(3) Naphthalene burns with a yellow flame.

Ans. (1) Naphthalene is an unsaturated compound. In unsaturated hydrocarbon the proportion of carbon is larger than that of saturated hydrocarbon. As a result, some unburnt carbon particles are also formed during combustion of unsaturated compounds.

(2) In the flame, these unburnt hot carbon particles emit yellow light and therefore the flame

appears yellow. Hence, naphthalene burns with a yellow flame.

(4) The colour of iodine disappears in the reaction between vegetable oil and iodine.

Ans. (1) Vegetable oils (unsaturated compound) contains a multiple bond as their functional group. They undergo addition reaction to form a saturated compound as the product.

(2) The addition reaction of vegetable oil with iodine takes place instantaneously at room temperature. The colour of iodine disappears in this reaction. This iodine test indicates the presence of a multiple bond in vegetable oil.

(5) The hydrogenation of vegetable oil in the presence of nickel catalyst forms vanaspati ghee.

Ans. (1) The molecules of vegetable oil contain long and unsaturated carbon chains. These unsaturated hydrocarbons contain a multiple bond as their functional group. They undergo addition reaction to form a saturated compound as the product.

(2) When vegetable oil (unsaturated compound) is hydrogenated in the presence of nickel catalyst, the addition reaction takes place, vanaspati ghee (saturated compound) is formed.

Q. 16 Distinguish between the following :

Saturated hydrocarbons and Unsaturated hydrocarbons :

Ans.

Saturated hydrocarbons	Unsaturated hydrocarbons
1. In saturated hydrocarbons, the carbon atoms are linked to each other only by single covalent bonds.	1. In unsaturated hydrocarbons, the valencies of carbon atoms are not fully satisfied by single covalent bonds.
2. They contain only a single bond.	2. They contain carbon to carbon double or triple bonds.
3. They are chemically less reactive.	3. They are chemically more reactive.
4. Substitution reaction is a characteristic property of these hydrocarbons.	4. Addition reaction is a characteristic property of these hydrocarbons.
5. Their general formula is C_nH_{2n+2}.	5. Their general formula is C_nH_{2n} or C_nH_{2n-2}.

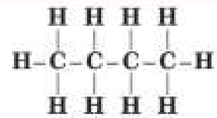
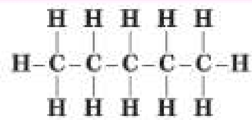
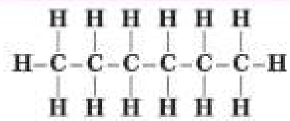
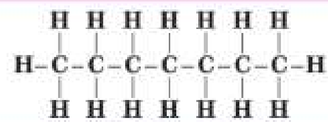
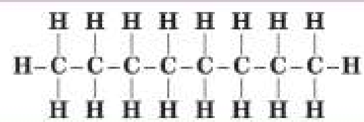
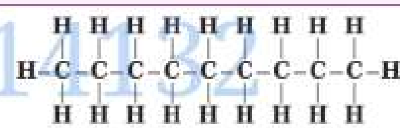
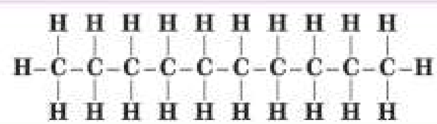
Q. 17 Complete the tables :

(1) Complete the following table by writing their Structural formulae and Molecular formulae.

(Textbook page 116)

Ans. *(Answer is given directly in bold letters.)*

Straight chain of Carbon atoms	Structural formula	Molecular formula	Name
C	$\begin{array}{c} H \\ \vert \\ H-C-H \\ \vert \\ H \end{array}$	CH_4	Methane
C – C	$\begin{array}{c} \mathbf{H\ \ H} \\ \vert\ \ \vert \\ \mathbf{H-C-C-H} \\ \vert\ \ \vert \\ \mathbf{H\ \ H} \end{array}$	$\mathbf{C_2H_6}$	Ethane
C – C – C	$\begin{array}{c} \mathbf{H\ \ H\ \ H} \\ \vert\ \ \vert\ \ \vert \\ \mathbf{H-C-C-C-H} \\ \vert\ \ \vert\ \ \vert \\ \mathbf{H\ \ H\ \ H} \end{array}$	$\mathbf{C_3H_8}$	Propane

Straight chain of Carbon atoms	Structural formula	Molecular formula	Name
C – C – C – C		**C_4H_{10}**	Butane
C – C – C – C – C		**C_5H_{12}**	Pentane
C – C – C – C – C – C		**C_6H_{14}**	Hexane
C – C – C – C – C – C – C		**C_7H_{16}**	Heptane
C – C – C – C – C – C – C – C		**C_8H_{18}**	Octane
C – C – C – C – C – C – C – C – C		**C_9H_{20}**	Nonane
C – C – C – C – C – C – C – C – C – C		**$C_{10}H_{22}$**	Decane

(2) Fill in the gaps in the table : (Textbook page 119)

Ans. *(Answer is given directly in bold letters.)*

(a) Homologous series of Alkanes

Name	Molecular formula	Condensed Structural Formula	Number of carbon atoms	Number of $-CH_2-$ Units	Boiling Point °C
Methane	CH_4	CH_4	1	1	– 162
Ethane	C_2H_6	$CH_3 - CH_3$	2	2	– 88.5
Propane	C_3H_8	$CH_3 - CH_2 - CH_3$	3	3	– 42
Butane	C_4H_{10}	$CH_3 - CH_2 - CH_2 - CH_3$	**4**	**4**	0
Pentane	C_5H_{12}	$CH_3 - CH_2 - CH_2 - CH_2 - CH_3$	**5**	**5**	36
Hexane	C_6H_{14}	$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$	**6**	**6**	69

(b) Homologous series of Alcohol

Name	Molecular formula	Condensed Structural Formula	Number of carbon atoms	Number of $-CH_2-$ Units	Boiling Point °C
Methanol	CH_4O	CH_3OH	1	1	63
Ethanol	C_2H_6O	CH_3-CH_2OH	2	2	78
Propanol	C_3H_8O	$CH_3-CH_2-CH_2-OH$	3	3	97
Butanol	$C_4H_{10}O$	$CH_3-CH_2-CH_2-CH_2-OH$	4	4	118

(c) Homologous series of Alkenes

Name	Molecular formula	Condensed Structural Formula	Number of carbon atoms	Number of $-CH_2-$ Units	Boiling Point °C
Ethyne	C_2H_4	$H_2C=CH_2$	2	0	-102
Propane	C_3H_6	$CH_3-CH=CH_2$	3	1	-48
1-Butene	C_4H_8	$CH_3-CH_2-CH=CH_2$	4	2	-6.5
1-Pentane	C_5H_{10}	$CH_3-CH_2-CH_2-CH=CH_2$	5	3	$+30$

(3) Complete the table by writing the IUPAC names in the third column. (Textbook page 123)

Ans. *(Answer is directly given with underline.)*

Common name	Structural formula	IUPAC name
ethylene	$CH_2=CH_2$	Ethene
acetylene	$HC\equiv CH$	Ethyne
acetic acid	CH_3-COOH	Ethanoic acid
methyl alcohol	CH_3-OH	Methanol
ethyl alcohol	CH_3-CH_2-OH	Ethanol
acetaldehyde	CH_3-CHO	Ethanal
acetone	$CH_3-CO-CH_3$	Propan-2-one
ethyl methyl ketone	$CH_3-CO-CH_2-CH_3$	Butan-2-one
ethyl amine	$CH_3-CH_2-NH_2$	Ethanamine
n-propyl chloride	$CH_3-CH_2-CH_2-Cl$	1-Chloropropane

(4) Complete the following table : ***(3 Marks) (March '20)***

Ans. *(Answer is given directly in bold letters.)*

Straight chain of Carbon Compounds	Structural formula	Molecular formula	Name
C	$\begin{array}{c}H\\ \vert\\ H-C-H\\ \vert\\ H\end{array}$	CH_4	Methane

Straight chain of Carbon Compounds	Structural formula	Molecular formula	Name
C – C	$\begin{array}{cccc} & H & H & \\ & \vert & \vert & \\ H- & C- & C- & H \\ & \vert & \vert & \\ & H & H & \end{array}$	C_2H_6	Ethane
C – C – C	$\begin{array}{ccccc} & H & H & H & \\ & \vert & \vert & \vert & \\ H- & C- & C- & C- & H \\ & \vert & \vert & \vert & \\ & H & H & H & \end{array}$	C_3H_8	**Propane**
C – C – C – C	$\begin{array}{cccccc} & H & H & H & H & \\ & \vert & \vert & \vert & \vert & \\ H- & C- & C- & C- & C- & H \\ & \vert & \vert & \vert & \vert & \\ & H & H & H & H & \end{array}$	C_4H_{10}	**Butane**

(5) Complete the following table : ***(March '19)***

Ans. *(Answer is directly given with underline.)*

Common name	Structural formula	IUPAC name
Ethylene	$CH_2 = CH_2$	Ethene
Acetic acid	CH_3COOH	Ethanoic acid
Methyl alcohol	CH_3OH	Methanol

• Use your brain power! (Textbook page 119)

(1) By how many $-CH_2-$ (methylene) units do the formulae of the first two members of homologous series of alkanes, methane (CH_4) and ethane (C_2H_6) differ ? Similarly, by how many $-CH_2-$ units do the neighbouring members ethane (C_2H_6) and propane (C_3H_8) differ from each other ?

Ans. The first two members of homologous series of alkanes, methane (CH_4) and ethane (C_2H_6) differed by one $-CH_2-$ unit. Similarly, ethane (C_2H_6) and propane (C_3H_8) differed by – **(2) How many methylene units are extra in the formula of the fourth member than the third member of the homologous series of alcohols ?**

Ans. There is only one methylene unit extra in the formula of the fourth member and the third member of the homologous series of alcohols.

CH_2 – unit.

(3) How many methylene units are less in the formula of the second member than the third member of the homologous series of alkenes ?

Ans. There is only one methylene unit less in the formula of the second member of and the third member of the homologous series of alkenes.

• Activity 1 (Textbook page 124)

Apparatus : Bunsen burner, copper gauze, metal plate, etc.

Chemicals : Ethanol, acetic acid, naphthalene.

Procedure : Place one of the above chemicals (3-4 drops or a pinch) on a clean copper gauze at room temperature, hold it on a blue flame of the Bunsen burner and observe. Is smoke / soot seen to form due to combustion ? Hold the metal plate on the flame when the substance is undergoing combustion. Does any deposit get collected on the plate ? Which colour ? Repeat the same procedure using other chemicals from the above list.

Inference : Ethanol and acetic acid are saturated hydrocarbons. These saturated hydrocarbons burn with a clean blue flame, while naphthalene is an unsaturated compound and it burns with a yellow flame and releases black smoke. Due to this black smoke a deposit of black soot gets collected on the metal plate.

• Activity 2 (Textbook page 124)

Apparatus : Test tube, Bunsen burner, measuring cylinder, dropper, etc.

Chemicals : Ethanol, dilute solution of sodium carbonate, dilute solution of potassium permanganate.

Procedure : Take 2–3 ml ethanol in a test tube, add 5 ml sodium carbonate solution to it and warm the mixture by holding the test tube on the burner for a while. Do dropwise addition of a dilute solution of potassium permanganate to this warm mixture with stirring. Does the typical pink colour of potassium permanganate stay as it is on addition ? Does the pink colour stop vanishing and stays on after some time of the addition process ?

Inference : In a warm mixture of ethanol and dilute solution of sodium carbonate, a drop of dilute solution of potassium permanganate is added drop by drop, with constant stirring. The pink colour disappears in the beginning, this is because potassium permanganate is used up in oxidation process. At certain point of the addition, oxidation of entire ethanol in the test tube is complete.

If the addition of potassium permanganate is continued beyond this point, it is not used up and becomes excess. This pink colour of this excess potassium permanganate does not vanish it remains as it is.

• Activity 3 (Textbook page 125)

Apparatus : Test tubes, droppers, etc.

Chemicals : Tincture iodine, bromine water, liquefied vanaspati ghee, various vegetable oils (peanut, safflower, sunflower, olive, etc.).

Procedure : (1) Bromine water when diluted, the colour of bromine becomes faint (lighter). This colour should be taken as reference point. (2) Take 4 ml of oil in a test tube and add 4 to 5 drops of bromine water in it. Shake the test tube. Now it is compared with reference point, it is concluded that the colour of bromine water disappears that means bromine water reacts with vegetable oil. (3) Now take vanaspati ghee add 4 to 5 drops of bromine water and shake the test tube.

Inference : This reaction is an addition reaction. Vegetable oil contains a carbon-carbon multiple bond as their functional group. Unsaturated compounds undergo addition reaction to form a saturated compound as the product. The addition reaction of an unsaturated compound with bromine takes place instantaneously at room temperature. The colour change can be seen by the eyes. Therefore, this reaction is considered as a test for detection of a multiple bond in a carbon compound. In the above activity, the colour of bromine disappears in the reaction. However, there is no colour change with vanaspati ghee. Because vanaspati ghee is a saturated compound it does not contain carbon-carbon multiple bond.

• Which of the following hydrocarbons undergo addition reactions :

C_2H_6, C_3H_8, C_2H_4, C_3H_6 ?

Ans. C_2H_4 (ethene) and C_3H_6 (propene) undergo addition reactions.

• Activity 4 (Textbook page 127)

Apparatus : Big test tube, delivery tube fitted in a rubber cork, knife, candle, etc.

Chemicals : Sodium metal, ethanol, magnesium ribbon, etc.

Procedure : Take 10 ml ethanol in a big test tube. Cut sodium metal into 2–3 pieces of a serial grain size. Put the sodium pieces into the ethanol in the test tube and fix the gas delivery tube to the test tube. Take a burning candle near the outlet of the gas delivery tube and observe.

(1) Which is the combustible gas coming out of the gas delivery tube ?

(2) Why do the sodium pieces appear to dance on the surface of ethanol ?

(3) Repeat the above procedure using magnesium ribbon instead of sodium.

(4) Do you see gas bubble released from the piece of magnesium ribbon ?

(5) Does magnesium metal react with ethanol ?

Ans. (1) The combustible gas coming out of the gas delivery tube is hydrogen.

(2) Sodium reacts with ethanol less vigorously. The sodium pieces appear to dance on the surface of ethanol because the bubbles of hydrogen gas formed stick to the surface of the metal.

(3) The bubbles of hydrogen gas do not form from magnesium ribbon.

(4) There is no release of gas bubbles from the piece of magnesium ribbon.

(5) Magnesium metal does not react with ethanol.

• Activity 5 (Textbook page 128)

Apparatus : Glazed tile, glass rods, pH paper, blue litmus paper.

Chemicals : Dilute ethanoic acid, dilute hydrochloric acid.

Procedure : Place two strips of blue litmus paper on a glazed tile. Put one drop dilute ethanoic acid with the help of another glass rod on the other strip. Note the colour change that take place in the litmus strip. Repeat the same procedure using strip of pH paper. Note all the observations in the following table.

Sub-stance	Colour change in blue litmus paper	Corre-sponding pH (Scratch the unwanted)	Colour change seen on the pH paper	Corre-sponding pH
Ethanoic acid	Red	< 7/		6 to 6.5
Hydro-chloric	Red	< 7/		5 to 6

• Activity 6 (Textbook page 129)

Apparatus : Big test tube, small test tube, bent gas delivery tube, rubber cork, thistle funnel, stand, etc.

Chemicals : Acetic acid, sodium carbonate powder, freshly prepared lime water.

Procedure : Arrange the apparatus as shown in figure. Place sodium carbonate powder in the big test tube. Pour 10 ml acetic acid through the thistle funnel. Observe the changes taking place in the two test tubes.

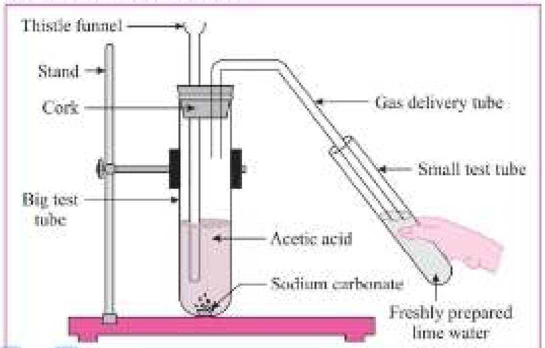


Fig. 9.18

(1) Which gas does come out as effervescence in the big test tube?

Ans. Carbon dioxide comes out as effervescence in the big test tube.

(2) Why are bubbles seen in the small test tube?

Ans. The bubbles seen in the small test tube is due to CO_2, which is formed in the reaction of sodium carbonate and acetic acid.

(3) What is the colour change in the lime water? Write the related equation.

Ans. The lime water turns milky.

Reaction :

$$\underset{\text{lime water}}{Ca(OH)_2} + CO_{2g} \rightarrow \underset{\substack{\text{Calcium carbonate} \\ \text{(milky)}}}{CaCO_3} \downarrow + H_2O$$

The reaction of acetic acid and sodium carbonate is given above :

Answer the following questions.

Ans. For reference see the questions and answers (See activity 6). ***(3 marks)***

• Activity 7 (Textbook page 130)

Apparatus : Test tube, beakers, burner, etc.

Chemicals : Glacial ethanoic acid, ethanol concentrated sulphuric acid, etc.

Procedure : Take 1 ml ethanol and 1 ml glacial ethanoic acid in a test tube. Add a few drops of concentrated sulphuric acid in it. Keep this test tube in the beaker containing hot water (hot water bath) for five minutes. Then take 20–30 ml water in another beaker, and pour the above reaction mixture in it and smell it.

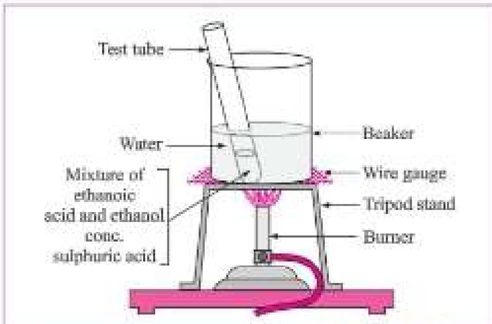


Fig. 9.19

Ethanoic acid reacts with ethanol in presence of an acid catalyst, an ester, ethyl ethanoate is formed.

$$\underset{\text{(Ethanoic acid)}}{CH_3-COOH} + \underset{\text{(Ethanol)}}{CH_3-CH_2-OH} \xrightarrow[\text{Catalyst}]{\text{Acid}} \underset{\substack{\text{(Ethyl Ethanoate)}\\ \text{Ester}}}{CH_3-COO-CH_2-CH_3} + \underset{\text{(Water)}}{H_2O}$$

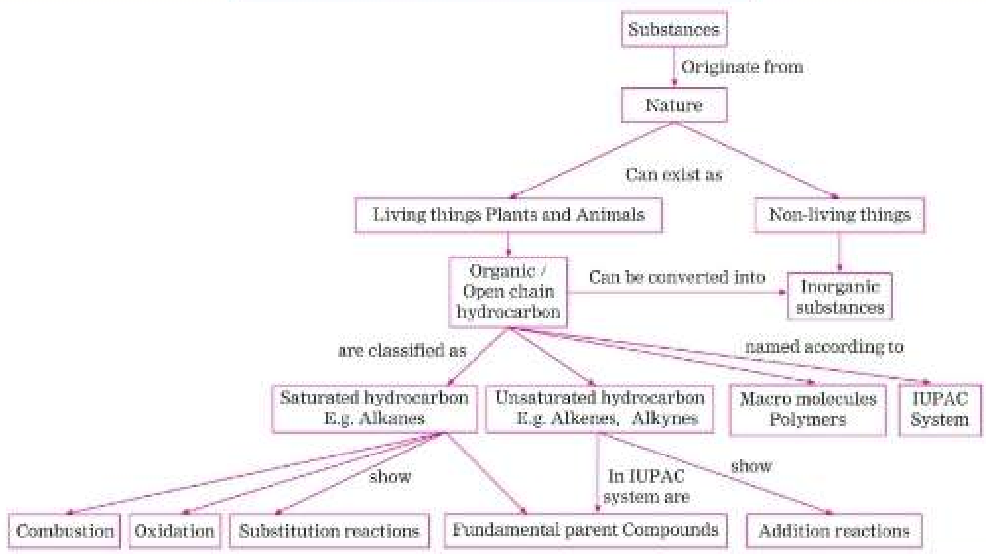
Inference : Esters have sweet odour. The fruits owe their fruity odour to the esters present in them. Esters are used for making fragrances and flavouring agents.

PROJECT

(1) Prepare a chart giving detailed information of carbon compounds in everyday use. Display it in the class and discuss.

(2) Prepare a list of carbon compounds which occur in nature and discuss their uses in daily life.

MEMORY MAP/CONCEPT MAP



Did you study the lesson/chapter from the **Navneet Digest?** Now, solve the self-test to ensure solid learning. Scan this **QR Code** for the test and its model answers.

10 SPACE MISSIONS

[**Note :** Students should revise chapter 1 (Gravitation) before studying this chapter.]

CHAPTER OUTLINE

10.1 Space mission
10.2 Artificial satellites
10.3 Classification of artificial satellites
10.4 Orbits of artificial satellites
10.5 Satellite launch vehicles
10.6 Space missions away from the earth

• Can you recall? (Textbook page 135)

(1) What is the difference between space and sky?

Ans. (1) The visible portion of the atmosphere and outer space seen by simple eyes, without any equipment from the earth, is known as the sky.

(2) The infinite three-dimensional expanse in which the Solar system, stars, celestial bodies, galaxies and the endless Universe exist is known as space.

(3) Both sky and space lack a definite boundary. However, the sky is a very tiny part of space.

(2) What are different objects in the Solar system?

Ans. (1) Our Solar system is a very tiny part of a huge Galaxy–Milky Way.

(2) The Sun is at the centre of the Solar system. Sun is a star.

(3) Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune are planets in our Solar system. These planets revolve around the Sun. Some of these planets have their own natural satellites.

(4) Besides, there are asteroids, meteoroids, comets and meteors in the Solar system.

(3) What is meant by a satellite?

Ans. (1) An astronomical object orbiting any planet of our Solar system is called a satellite.

(2) Mercury and Venus have no satellites.

(3) Some planets have more than one satellite. E.g. Jupiter has 69 satellites.

(4) How many natural satellites does the earth have?

Ans. The earth has one natural satellite called the moon.

(5) Which type of telescopes are orbiting around the earth? Why is it necessary to put them in space?

Ans. (1) The following three types of telescopes are orbiting around the earth :

(i) Optical Refracting Telescope.
(ii) Optical Reflecting Telescope.
(iii) Radio Telescope.

(2) Visible light and radio waves emitted by celestial bodies in space pass through the atmosphere before reaching the earth's surface. During this journey, some light is absorbed by the atmosphere. Hence, the intensity of the light reaching the earth's surface decreases. Besides, temperature and air pressure cause the atmospheric turbulence. Hence, light rays change their path, resulting in a change in the position of the image of a celestial body. City lights during night, and bright sunlight during day also put limitations on usage of optical telescopes on the earth. To minimize these problems, optical telescopes are situated on mountain top, away from inhabited places. However, limitations caused by the atmosphere still persist.

To get rid of these problems scientists have successfully launched telescopes in space. Images obtained by these telescopes are brighter and clearer than those obtained by the telescopes located on the earth's surface.

• Do you know? (Textbook page 135)

The first person to go into space in a spacecraft was Yuri Gagarin of the then USSR. He orbited the earth in 1961. The first person to step on the Moon (1969) was Neil Armstrong of USA. Rakesh Sharma of India orbited the earth in 1984 in a Russian spacecraft. Kalpana Chawla and Sunita Williams of Indian origin also participated in space explorations through missions organized by NASA (National Aeronautics and Space Administration) of USA.

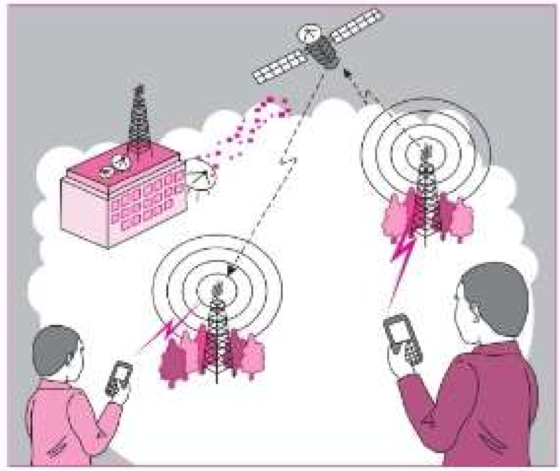
• Can you recall? (Textbook page 135)

(1) Where does the signal in your cellphone come from?

Ans. In nearby area of our residence, many mobile towers are installed at various places. Cellphones receive signals from one of these mobile towers.

(2) Where from does it come to mobile towers?

Ans. All mobile towers are connected to satellites. Cellphone signal reaching the nearest mobile tower in our vicinity is first transmitted to the satellite. The satellite transmits the signal to the mobile tower near the destination.



Mr. 'B' Mr. 'A'

Fig. 10.1 : Communication between Mr. 'A' and Mr. 'B' by an artificial satellite

(3) Where does the signal to your TV set come from?

Ans. (1) Television Centre or Studio transmits the TV programme which first reaches the satellite. The dish antenna of the cable operator in our area receives these signals. The TV programmes reach our TV set through a cable connected between the cable operator's receiving station and our TV set.

(2) Alternatively, a small portable dish antenna fixed on the rooftop is also used to receive the TV signals directly from the satellites. Finally, a cable connected to the dish antenna and TV set brings the programme to our TV set.

(4) You may have seen photographs showing the position of monsoon clouds over the country in the newspaper. How are these images obtained?

Ans. Weather satellites take photographs of the sky above the earth's surface at regular intervals. Some satellites, capable of receiving radio signals, also collect the information of weather conditions and finally images of the sky are built with computers. Territorial boundaries of the states and the country are drawn later on these images. Such satellite images with imposed boundaries are printed in media or shown on the television.

• Think about it (Textbook page 136)

Prepare a power point presentation showing India's contribution in space research and present it in the class.

Students can prepare this presentation on the basis of the following outline :

(1) Formation and objectives of ISRO
(2) Indian space scientists
(3) Space missions of India
(4) Current functional satellites of India
(5) Research and other centres of ISRO in India
(6) India's moon mission and mars mission
(7) Information regarding the launching of satellites of other countries by India.
(8) Indian astronauts and astronauts of Indian origin
(9) Future plans of India's space mission.

• Keep it in mind / Do Remember (Textbook page 136)

INSAT : Indian National Satellite
GSAT : Geosynchronous Satellite
IRNSS : Indian Regional Navigation Satellite System
IRS : Indian Remote Sensing Satellite
GSLV : Geosynchronous Satellite Launch Vehicle
PSLV : Polar Satellite Launch Vehicle

IMPORTANT POINTS

10.1 Space mission :

(1) Man has always been curious about the Sun, moon, stars and the world beyond the earth.

(2) Initially, man tried to observe space with telescopes. Later, he launched many artificial satellites and equipment like telescopes in space.

(3) Man eventually made many journeys to space and has even built a space station for his stay and research in space. Subsequently, he undertook many unmanned space missions beyond the earth's orbit to understand and study space beyond the earth and even beyond the Solar system.

(4) There are 4 specific objectives of a space mission :

(i) To launch artificial satellites in the earth's orbit for study and research.

(ii) To launch artificial satellites in the earth's orbit for various purposes like telecommunication, weather study, radio and TV programme transmission, etc.

(iii) To send artificial satellites beyond the earth's orbit to observe, study and collect the information about other planets, meteors, meteoroids, asteroids and comets.

(iv) To understand the part of the Universe beyond the Solar system.

(5) Importance of space mission :

(i) Real-time communication across the globe.

(ii) Entertainment and receiving the abundant information from the desk at home or office.

(iii) Access to huge information available on the internet.

(iv) Management of natural resources.

(v) Advanced alerts and management of some natural calamities.

(vi) Satellite surveillance for defence purpose.

(vii) Access to various activities like trade, tourism and navigation.

10.2 Artificial satellites :

(1) A manmade object orbiting the earth or any other planet is called an artificial satellite.

(2) Satellites work on solar energy and hence photovoltaic panels are attached on both sides of the satellite, which look like wings.

(3) Satellites are installed with various transmitters and other equipment to receive and transmit signals between the earth and the satellites.

10.3 Classification of artificial satellites :

(1) Weather satellite : To study and predict the weather conditions.

(2) Communication satellite : To communicate between different locations in the world.

(3) Broadcasting satellite : To telecast television and radio programmes.

(4) Navigational satellite : To locate the place precisely in terms of its latitude and longitude and assist the surface, water and air transportation.

(5) Military satellite : Collecting information regarding security aspects including international borders.

(6) Earth observation satellite : To study various aspects of the earth's surface including forests, oceans, polar regions and collect information about natural calamities.

10.4 Orbits of artificial satellites :

(1) Orbit of a satellite is its path around the earth.

(2) The function of a satellite decides its orbit.

(3) The orbit can be circular or elliptical. The orbital plane of a satellite can be the equatorial plane of the earth or a plane at an angle to the equatorial plane.

(4) Based on the height of the satellite from the earth's surface, satellites are classified as follows :

(i) High Earth Orbit Satellites
(ii) Medium Earth Orbit Satellites
(iii) Low Earth Orbit Satellites

High Earth Orbit Satellite (HEO) : A satellite orbiting at a height equal to or greater than 35780 km above the earth's surface is called High Earth Orbit satellite. If such a satellite revolves in the equatorial plane of the earth, in the same sense as the earth's rotation and has period equal to that of the earth's rotation, it will appear stationary with respect to a place on the earth. This satellite is, therefore, called geostationary or geosynchronous satellite. Such satellites are used for climatology, telecommunication, transmission of TV and radio programmes, etc.

Medium Earth Orbit Satellite (MEO) : A satellite orbiting at a height between 2000 km and 35780 km above the earth's surface is called a Medium Earth Orbit satellite. The orbital path of such a satellite is normally elliptical and passes through the North and the South polar regions. These satellites are useful for navigation.

Low Earth Orbit Satellite (LEO) : A satellite orbiting at a height between 180 km and 2000 km above the earth's surface is called a Low Earth Orbit satellite. Weather satellites, and International Space Station are low Earth orbit satellites.

10.5 Satellite Launch Vehicles :

(1) A Satellite Launch Vehicle carries an artificial satellite to a desirable height above the earth's surface and places it in the desired orbit. It needs a specific velocity as well as a thrust to reach to the desired height.

(2) The velocity and thrust of a Satellite Launch Vehicle depend on the weight and orbital height of the satellite. Accordingly, the structure of the launch vehicle is decided and designed.

(3) The weight of the fuel also contributes a major portion in the total weight of the launch vehicle. This also influences the structure of the launch vehicle.

(4) In order to use the fuel optimally, multiple stage launch vehicles are now designed and used.

(5) As the journey of the launch vehicle progresses, the vehicle achieves a specific velocity and a

certain height. The fuel in the first stage is exhausted and the empty fuel tank gets detached from the main body of the launch vehicle and falls back into a sea or on unpopulated land.

(6) As the fuel in the first stage is exhausted, the fuel in the second stage is ignited. However, the weight of the launch vehicle is now less than what it was earlier and hence it can move with higher velocity.

(7) Most of the launch vehicles are made up of two or more stages.

(8) Polar Satellite Launch Vehicle, that is, PSLV, developed by ISRO (Indian Space Research Organisation) has four stages.

(9) Launch vehicles are very costly as they can be used only once.

(10) To overcome this problem, USA has developed space shuttles which can be reused many times.

(11) Space shuttles can be used for both, (a) launching a satellite in space and (b) journey of astronauts.

10.6 Space missions away from the earth :

(1) Centripetal force on a satellite $\frac{mv_c^2}{R+h}$ =

Gravitational force exerted by the earth on the satellite $\frac{GMm}{(R+h)^2}$

where

m : mass of the satellite,

M : mass of the earth,

R : radius of the earth,

h : height of the satellite from the surface of the earth,

v_c : critical velocity of the satellite,

G : gravitational constant

$\therefore v_c^2 = \frac{GM}{R+h}$

$\therefore$ Critical velocity $= \sqrt{\frac{GM}{R+h}}$

(2) The orbital duration of the satellite, i.e., the time required for one revolution of the satellite around the earth, $T = \frac{2\pi r}{v_c}$

where $r = (R + h)$ and

v_c = critical velocity

(3) Escape velocity $v_{esc} = \sqrt{\frac{2GM}{R}}$

where

v_{esc}: escape velocity,

G : gravitational constant,

M : mass of the planet,

R : radius of the planet

[**Note** : For details, refer Chapter 1.]

(4) **Moon mission :**

(i) As of now, only Russia, USA, European Union, China, Japan and India have successfully undertaken moon missions.

(ii) Russia executed 15 moon missions between 1959 and 1976. Of these, last four missions brought the stone samples from the moon for study and analysis. However all these missions were unmanned.

(iii) USA executed moon missions between 1962 and 1972. Some of these missions were unmanned. However, the historic moon mission took place on 20th July 1969, when American astronaut Neil Armstrong became the first human to step on the moon.

(iv) Indian Space Research Organisation (ISRO) successfully launched *Chandrayaan–I* and placed it in the orbit of the moon. It sent useful information to the earth for about a year. The most important discovery made during the mission was the presence of water on the moon's surface. India was the first country to discover this.

(5) **Mars mission :**

(i) Many nations have sent spacecraft towards Mars, but only few of these missions have been successful.

(ii) However, performance of *Mangalyaan*, the Indian spacecraft sent by ISRO towards Mars was remarkable. *Mangalyaan* was launched in November 2013 and was placed in the orbit of Mars successfully in September 2014. It has obtained useful information about the surface and atmosphere of Mars.

(6) **Other missions :**

(i) Some spacecrafts orbited the planets, some have landed on some planets and some just observed the planets, passed near them and went further to study other celestial bodies.

(ii) Some spacecrafts were sent specifically to study asteroids and comets. Some spacecrafts have successfully brought dust and stone samples from the asteroids for study.

(iii) All these space missions are very useful in getting information and helping us in clarifying our concepts about the origin of the earth and the Solar system.

• Contribution of ISRO :

(1) India has indigenously built various launchers which can put the satellites having the mass up to 2500 kg in the orbit.

(2) Indian Space Research Organisation (ISRO) has designed and built two important launchers; Polar Satellite Launch Vehicle (PSLV) and Geo Satellite Launch Vehicle (GSLV).

(3) Successful space missions as well as scientific and technological accomplishments by India in space technology have made a significant contribution in the national and social development of our country.

(4) Many satellites in INSAT and GSAT series are active in telecommunication, television broadcasting, meteorological services, disaster management and monitoring and management of natural resources.

(5) EDUSAT is used specifically for education while satellites in IRNSS series are used for navigation.

(6) Thumba, Sriharikota and Chandipur are Indian satellite launch centres.

(7) Vikram Sarabhai Space Centre at Thiruvananthapuram, Satish Dhawan Space Research Centre at Sriharikota and Space Application Centre at Ahmadabad are space research organisations of India.

• Management of space debris :

(1) Though very few countries in the world have the capability to launch satellites in orbit, the international cooperation and commercial prospects have led to many other countries having their own satellites in space. Due to failed launching, there are many satellites and parts of launchers, which are roaming freely in different orbits around the earth. In a way, they form space debris (fragments of satellites and launchers) orbiting in uncontrolled manner. By an estimate there are about two crore small and large pieces of satellites and launchers revolving around the earth.

(2) These debris certainly pose a threat to the current functional satellites, space shuttles and space stations.

(3) If this collection of fragments remains unchecked and uncontrolled, it is likely to be risky to all future launching of satellites and space shuttles and there is a growing possibility of space accidents. Research and dedicated efforts are on to find the means and ways of managing the space debris.

• Always Remember. (Textbook page 141)

The 'rocket', a type of firecracker used in Diwali, is also a sort of launcher. In this rocket, the fuel is ignited using a fuse and the rocket is projected into the sky just like a satellite launcher. Similarly, if a balloon is blown and released with its end open, the air in the balloon is forcefully ejected and the balloon is pushed in the opposite direction. This can be explained using Newton's third law of motion.

• Do you know? (Textbook page 141)

The astronomical object closest to us is the moon. Light takes about 1 s to reach from the

Fig. 10.2

moon to the earth. It means that if we travel with the speed of light, it will take about 1 s to reach the moon. However, since a spacecraft travels at much slower speed, it takes longer time to reach the moon. The shortest time taken by a spacecraft to reach the moon, so far, is 8 hours and 36 minutes.

• Do you know? (Textbook page 139)

A group of students from COEP (College of Engineering, Pune) made a small satellite and sent it to space through ISRO in 2016. The name of the satellite is 'Swayam' and its mass is around 1 kg. It is orbiting the earth at a height of 515 km. The main objective of the satellite was to provide point to point messaging services using a special method.

• Read about (Textbook page 143)

Satellite Launch Centres :

(1) Thumba, Thiruvananthapuram

(2) Sriharikota

(3) Chandipur, Odisha

Space Research Organizations :

(1) Vikram Sarabhai Space Centre, Thiruvananthapuram.

(2) Satish Dhawan Space Research Centre, Sriharikota.

(3) Space Application Centre, Ahmedabad.

QUESTIONS & ANSWERS

***Q. 1 Fill in the blanks and explain the statements with reasoning :**

(1) If the height of the orbit of a satellite from the earth's surface is increased, the tangential velocity of the satellite will ....

(2) The initial velocity (during launching) of the Mangalyaan must be greater than ...... from the earth.

Ans.

(1) If the height of the orbit of a satellite from the earth's surface is increased, the tangential velocity of the satellite will decrease.

Explanation : The gravitational force (F) exerted by the earth on the satellite will decrease if the height of the orbit of the satellite from the earth's surface is increased. Hence, the tangential velocity of the satellite will decrease.

The formula

$$\frac{mv_c^2}{R+h} = \frac{GMm}{(R+h)^2} \text{ or } v_c = \sqrt{\frac{GM}{R+h}}$$ shows that v_c decreases with increasing h.

(2) The initial velocity (during launching) of the *Mangalyaan* must be greater than the escape velocity from the earth.

Explanation : If a satellite is to travel beyond the gravitational pull of the earth, its velocity must be more than the escape velocity from the earth.

[**Note :** The velocity must be atleast equal to the escape velocity. Refer the definition of escape velocity.]

Q. 2 Fill in the blanks :

(1) A man-made object revolving around the earth in a fixed orbit is called ....

(2) *Chandrayaan–I* discovered the presence of ...... on the moon.

(3) Apart from launching a satellite around the earth, India has been able to launch a satellite around ....

(4) All satellites work on ...... energy.

(5) ...... are used to carry and place a satellite in a specific orbit.

(6) USA has developed .... as an alternative to space launch vehicles.

(7) Hubble telescope is a ...... satellite.

(8) ...... executed the first ever mission to the moon in the world.

(9) ...... executed the first manned mission to the moon in the world.

Ans.

(1) A man-made object revolving around the earth in a fixed orbit is called an artificial satellite.

(2) *Chandrayaan–I* discovered the presence of water on the moon.

(3) Apart from launching a satellite around the earth, India has been able to launch a satellite around Mars.

(4) All satellites work on solar energy.

(5) Satellite launchers are used to carry and place a satellite in a specific orbit.

(6) USA has developed space shuttles as an alternative to space launch vehicles.

(7) Hubble telescope is a Low Earth Orbit (LEO) satellite.

(8) Russia executed the first ever mission to the moon in the world.

(9) USA executed the first manned mission to the moon in the world.

Q. 3 Choose the correct alternative and write it along with its allotted alphabet : *(1 mark each)*

(1) Which one of the following is a Low Earth Orbit (LEO) satellite?

(a) Navigational satellite

(b) Geostationary satellite

(c) International Space Station

(d) All of the above

(2) Which of the following satellite launchers is developed by India?

(a) INSAT *(b) IRNSS*

(c) EDUSAT *(d) PSLV*

(3) The minimum velocity of the spacecraft to escape from the earth's gravitational force must be .... ***(Nov. '20)***

(a) 112 km/s *(b) 11.2 km/s*

(c) 1.12 km/s *(d) 0.112 km/s*

(4) The astronomical object closest to us is .... in our galaxy. ***(March '20)***

(a) Mars *(b) Venus* *(c) Jupiter* *(d) Moon*

Ans.

(1) (c) International Space Station (2) (d) PSLV

(3) (b) 11.2 km/s (4) (d) Moon.

Q. 4 Considering the correlation between the words of the first pair, pair the third word accordingly with proper answer. *OR* Considering the first correlation, complete the second.

(1) IRNSS : Direction showing satellite :: INSAT : ....

(2) Hubble telescope : 569 km high from the earth's surface :: Revolving orbit of Hubble telescope : ...... ***(March '19)***

Ans.

(1) IRNSS : Direction showing satellite :: INSAT : Weather satellite

(2) Hubble telescope : 569 km high from the earth's surface :: Revolving orbit of Hubble telescope : Low Earth Orbit.

***Q. 5 Complete the following table. (Table is given with complete answers which are marked in bold)**

IRNSS	**Navigational Satellite**	**To fix the location in terms of precise latitude and longitude**
INSAT	Weather study and predict	**Weather Satellite**
IRS	**Earth observation satellite**	Observation of the earth

Q. 6 Match the column :

Column A	Column B
(1) Clouds over India	(a) Low Earth Orbit
(2) Global communication	(b) Communication satellite
	(c) EDUSAT
	(d) Weather satellite

Ans. (1) Clouds over India – Weather satellite

(2) Global communication – Communication satellite.

***Q. 7 State with reasons whether the following statements are *true* or *false*. (If a statement is false, correct it and rewrite it.) :**

(1) If a spacecraft has to be sent away from the influence of the earth's gravitational field, its velocity must be less than the escape velocity.

(2) The escape velocity on the moon is less than that on the earth.

(3) A satellite needs a specific velocity to revolve in a specific orbit.

(4) If the height of the orbit of a satellite increases, its velocity must also increase.

Ans.

(1) False.

Explanation : The escape velocity of a body is the minimum velocity with which it should be projected from the earth's surface, so that it can escape the influence of the earth's gravitational field. This clearly shows that the given statement is false.

(2) True.

Explanation : Escape velocity of an object from the earth,

$$v_{esc}(1) = \sqrt{\frac{2GM_1}{R_1}}$$

Escape velocity of an object from the moon,

$$v_{esc}(2) = \sqrt{\frac{2GM_2}{R_2}}$$

$$\therefore \frac{v_{esc}(2)}{v_{esc}(1)} = \sqrt{\frac{M_2}{M_1} \times \frac{R_1}{R_2}}$$

Now, $\frac{M_1 \text{ (Earth)}}{M_2 \text{ (Moon)}} = 81$ and $\frac{R_1 \text{ (Earth)}}{R_2 \text{ (Moon)}} = 3.7$

[***Reference*** : Solved example on page 10 of the textbook.]

$$\therefore \frac{v_{esc}(2)}{v_{esc}(1)} = \sqrt{\frac{3.7}{81}} < 1$$

So, $v_{esc}(2) < v_{esc}(1)$

(3) True.

Explanation :

Centripetal force on the satellite $\frac{mv_c^2}{R+h}$ = gravitational force exerted by the earth on the satellite $\frac{GMm}{(R+h)^2}$

where,

m : mass of the satellite,

v_c : critical velocity of the satellite,

h : height of the satellite from the surface of the earth,

M : mass of the earth,

R : radius of the earth,

G : gravitational constant

$$\therefore v_c^2 = \frac{GM}{R+h}$$

$$\therefore v_c = \sqrt{\frac{GM}{R+h}}$$

Thus, if the value of h changes, the value of v_c also changes. It means a satellite needs to be given a specific velocity (in the tangential direction) to keep it revolving in a specific orbit.

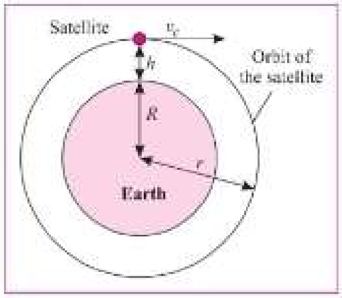


Fig. 10.3 : Orbit of an artificial satellite

(4) False.

Explanation : *Refer the answer to Q. 7 (3).* As per the formula $v_c = \sqrt{\frac{GM}{R+h}}$, if the value of h increases, the value of v_c decreases. Hence, if the height of the satellite from the surface of the earth increases, its velocity decreases.

Q. 8 Answer the following questions :

***(1) What is meant by an artificial satellite? How are the satellites classified based on their functions?** *OR*

What is an artificial satellite? Name any two types of artificial satellite and state their functions. ***(3 marks) (March '20)*** *OR*

Write the importance of artificial satellites in your words.

Ans. A manmade object orbiting the earth or any other planet is called an artificial satellite. Satellites work on solar energy and hence photovoltaic panels are attached on both sides of the satellite, which look like wings. Satellites are also installed with various transmitters and other equipment to receive and transmit signals between the earth and the satellites.

Classification of satellites depending on their functions :

(1) **Weather satellites :** Weather satellites collect the information regarding weather conditions of the region. It records temperature, air pressure, wind direction, humidity, cloud cover, etc. this information is sent to the space research station on the earth, and then with this information weather forecast is made.

(2) **Communication satellites :** In order to establish communication between different places on the earth through mobile phones or computer assisted internet, communication satellites are used. Many artificial satellites placed at various locations in the earth's orbit are well interconnected and help us to have communication with any place, from anywhere, at any time and in any form including voicemail, email, photographs, audio mail, etc.

(3) **Broadcasting satellites :** Broadcasting satellites are used to transmit various radio and television programmes and even live programmes from any place on the earth to any other place. As a result, one can have access to information about current incidents, events, programmes, sports and other events right from his drawing room with these satellites.

(4) **Navigational satellites :** Navigational satellites assist the surface, water and air transportation and coordinate their busy schedule. These satellites also assist the user with current live maps as well as real time traffic conditions.

(5) **Military satellites :** Every sovereign nation needs to keep the real time information about the borders. Satellites help to monitor all movements of neighbouring countries or enemy countries. Military satellites also help to guide the missiles effectively.

(6) **Earth observation satellites :** These satellites observe and provide the real time information about the earth. These satellites also help us to collect the information about the resources, their management, continuous observation about a natural phenomenon and the changes within it.

(7) **Other satellites :** Apart from these various satellites, certain satellites for specific works or purposes are also sent in the space. E.g. India has sent EDUSAT for educational purpose; CARTOSAT for surveys and map making. Similarly, satellites with telescopes, like Hubble telescope or a satellite like International Space Station help to explore the universe. In fact, ISS (International Space Station) provides a temporary residence where astronauts can stay for a certain short or long period and can undertake the research and study space activities.

The various functions listed above show the importance of artificial satellites.

(2) Name the first artificial satellite sent by Russia in space. ***(1 mark) (March '20)***

Ans. Sputnik 1.

[**Note :** It was launched in space in 1957.]

(3) What is meant by the orbit of a satellite? On what basis and how are the orbits of artificial satellites classified?** ***(3 marks)

(Board's Model Activity Sheet)

Ans. Orbit of a satellite is its path around the earth.

Orbits of artificial satellites can be classified on various basis.

(1) On the basis of the angle of the orbital plane : Orbital plane of a satellite can be the equatorial plane of the earth or it can be at an angle to it.

(2) On the basis of the nature of the orbit : Orbital plane can be circular or elliptical in shape.

(3) On the basis of the height of the satellite : Orbit of a satellite can be HEO, MEO or LEO.

(i) **High Earth Orbit (HEO) satellite :** A satellite orbiting at a height equal to or greater than 35780 km above the earth's surface is called a High Earth Orbit satellite.

(ii) **Medium Earth Orbit (MEO) satellite :** A satellite orbiting at a height between 2000 km and 35780 km above the earth's surface is called a Medium Earth Orbit satellite.

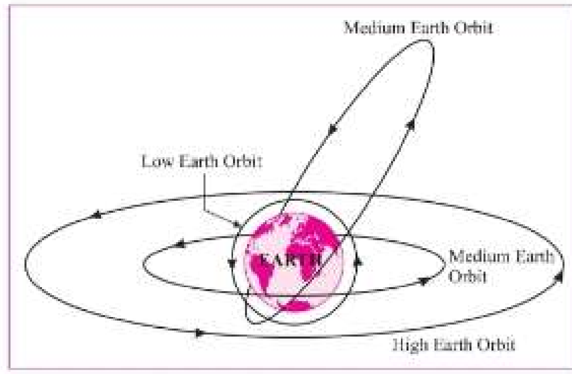


Fig. 10.4 : Orbits of satellites

(iii) **Low Earth Orbit (LEO) satellite :** A satellite orbiting at a height between 180 km and 2000 km above the earth's surface is called a Low Earth Orbit satellite.

(4) Write the proper name of the orbits of satellites shown in the following figure with their height from the earth's surface.

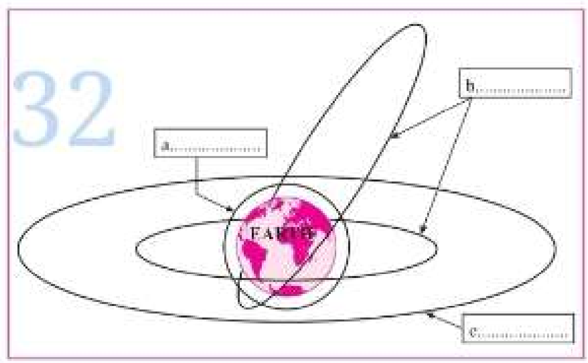


Fig. 10.5

Ans. See Fig 10.4.

(a) Low earth orbits : height above the earth's surface : 180 km to 2000 km

(b) Medium earth orbits : height above the earth's surface : 2000 km to 35780 km

(c) High earth orbits : height from the earth's surface > 35780 km

(5) Why are geostationary satellites not useful for studies of polar regions?** ***(2 marks)

OR

What is a geostationary satellite? Why are geostationary satellites not useful for studies of polar regions? ***(3 marks) (July '19)***

Ans.

(1) Consider a satellite that revolves around the earth in the equatorial plane, at 35780 km from the earth's surface, in the same sense as the earth's revolution and has a period of 24 hours which is the same as that of the earth's rotation. Such a satellite appears stationary when observed from the earth. Hence, it is called a geostationary satellite.

Fig. 10.6 : Orbit of a geostationary satellite

(2) A geostationary satellite revolves in the equatorial plane of the earth, and thus, not around the polar regions.

Hence, geostationary satellites are not useful for studies of polar regions.

***(6) What is meant by a satellite launch vehicle? Explain the satellite launch vehicle developed by ISRO with the help of a schematic diagram.**

Ans. A rocket used to carry an artificial satellite to a desired height above the earth's surface and then project it with a proper velocity so that the satellite orbits the earth in the desired orbit is called a launch vehicle. A satellite launch vehicle needs a specific velocity as well as a thrust to reach the desired height above the earth's surface. The velocity and the thrust of a satellite launch vehicle depend on the weight and orbital height of the satellite. Accordingly, the structure of the launch vehicle is decided and designed. The weight of the fuel also contributes a major portion in the total weight of the launch vehicle. This also influences the structure of the launch vehicle. In order to use the fuel optimally, multiple stage launch vehicles are now designed and used.

The Polar Satellite Launch Vehicle (PSLV) developed by ISRO is shown below in a schematic diagram.

Place for a satellite

Fourth stage using liquid fuel

Third stage using solid fuel

Second stage using liquid fuel

First stage using solid fuel

Engine using solid fuel which provides the initial thrust

Fig. 10.7 : Structure of PSLV made by ISRO

***(7) Why is it beneficial to use a satellite launch vehicle made up of more than one stage?**

Ans. Earlier Satellite Launch Vehicles (SLV) used to be of a single stage vehicles. Such SLVs used to be very heavy as well as expensive in terms of its fuel consumption. As a result, SLVs with multiple stages were developed.

In multistage SLVs, as the journey of the launch vehicle progresses and the vehicle achieves a specific velocity and a certain height, the fuel of the first stage is exhausted and the empty fuel tank gets detached from the main body of the launch vehicle and falls back into a sea or on unpopulated land. As the fuel in the first stage is exhausted, the engine in the second stage is ignited. However, the weight of the launch vehicle is now less than what it was earlier and hence it can move with higher velocity. Thus, it saves fuel consumption. Hence, it is beneficial to use a multistage satellite launch vehicle.

(8) Explain the need and importance of space missions.

Ans. Man has always been curious about the sun, moon, stars and the world beyond the earth. Initially, man tried to observe space with the help of telescopes. However, later he dreamt to fly into space and finally succeeded to reach into space.

Space missions are now essential to understand the origin and evolution of our solar system as well as to study the Universe beyond the Solar system.

Space missions have given us many benefits and made our life simpler. It is because of space missions that the real-time immediate communication and exchange of information across the globe is now possible. We can receive the abundant information at the desk at our home or office. We also get information about any topic at any time and anywhere at fingertips through the Internet. Besides, the advanced alerts about some natural calamities like cyclones or storms are received through satellites sent as a part of space missions. Satellites have also helped us in entertainment. Programmes, sports events, etc., can be telecast live and can reach millions at a time throughout the world. Satellite surveillance of the enemy, exploring the reserves of various minerals resources, access to various activities like trade, tourism and navigation, and easy global reach to make world a global village is all possible due to the space missions. Thus, space missions are extremely important in defence, communication, weather forecast, observation, direction determination, etc.

(9) What are space expeditions? Explain their need and importance in your words.

Ans. A mission planned (i) for establishing artificial satellites in the earth's orbit, using them for research or for the benefit of life, or (ii) for sending a spacecraft to the various components of the solar system or outside is called a space expedition.

For the answer to the second part of the question, see the answer to Q. 8 (8).

(10) What are the objectives of the space mission?

Ans. Man initially tried to satisfy his curiosity to know the world and universe beyond the earth with the help of telescopes. However, it has some obvious limitations and to overcome these limitations, man later ventured into space missions.

Space missions carried out by man were aimed at four specific objectives :

(1) To launch artificial satellites in the earth's orbit for study and research.

(2) To launch artificial satellites in the earth's orbit for various purposes like telecommunication, weather forecast, radio and TV programme transmission, etc.

(3) To send artificial satellites beyond the earth's orbit to observe, study and collect the information from other planets, meteors, meteoroids, asteroids and comets.

(4) To sense and understand space beyond the solar system.

(11) Write on significant space missions carried out by man.

Ans. Man has carried out many space missions within and beyond the earth's orbit. Significant space missions are as follows:

(1) **Space missions within the earth's orbit :** Man has so far sent many artificial satellites of various types in the earth's orbit. These satellites have made the life of man simpler. Besides, it has also helped us in resource management, communication, disaster management, etc.

(2) **Moon missions :** Moon is the natural satellite of the earth and it is the nearest celestial body to us. Naturally, our initial space missions were directed to the moon. As of now, only Russia, USA, European Union, China, Japan and India have successfully undertaken moon missions. Russia executed 15 moon missions between 1959 and 1976. Of these,

last 4 missions brought the stone samples from the moon for study and analysis. However all these missions were unmanned. USA executed moon missions between 1962 and 1972. Some of these missions were unmanned. However, the historic moon mission took place on 20th July, 1969, when American astronaut Neil Armstrong became the first human to step on the moon. India has undertaken the moon mission. Indian Space Research Organisation (ISRO) successfully launched *Chandrayaan–I* and placed it in orbit of the moon. It sent useful information to the earth for about a year. The most important discovery made during the mission was the presence of water on moon's surface. India was the first country to discover this.

(3) **Mars mission :** The second nearest celestial object to the earth is Mars and many nations sent spacecraft towards it. But only few of them have been successful. However, the performance of *Mangalyaan*, the Indian spacecraft sent by ISRO towards Mars, was remarkable. *Mangalyaan* was launched in November 2013 and was placed in the orbit of Mars successfully in September 2014. It has obtained useful information about the surface and atmosphere of Mars.

(4) **Space missions to other planets :** Other than moon and Mars missions, many other space missions were undertaken for studying other planets. Some spacecraft orbited the planets, some landed on some planets, and some just observed the planets, passed near them and went further to study other celestial bodies. Some spacecraft were sent specifically to study asteroids and comets. Some spacecrafts have brought dust and stone samples from asteroids for the study.

All these space missions are very useful in getting information and helping us in clarifying our concepts about the origin of the earth and the Solar system.

(12) Bring out the contribution of India's space missions.

Ans. Successful space missions as well as scientific and technological accomplishments by India in space technology have made a significant contribution in the national and social development of our country.

India has indigenously built various launchers and these launchers can put the satellites having the mass up to 2500 kg in orbit.

Indian Space Research Organisation (ISRO) has designed and built two important launchers : Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV).

Many satellites in INSAT and GSAT series are active in telecommunication, television broadcasting, meteorological services, disaster management and in monitoring and management of natural resources.

EDUSAT is used specifically for education while satellites in IRNSS series are used for navigation.

Thumba, Sriharikota and Chandipur are Indian satellite launch centres.

Vikram Sarabhai Space Centre at Thiruvananthapuram, Satish Dhawan Space Research Centre at Sriharikota and Space Application Centre at Ahmedabad are space research organisations of India.

(13) Which satellite is used in educational field among INSAT and GSAT series?

(1 mark) (Nov.'20)

Ans. EDUSAT.

(14) What is meant by space debris? Why is there need to manage the debris? ***(March '19)***

Ans. In a space nonessential objects such as the parts of launchers and satellites, revolving around the earth are called the debris in space.

The debris can be harmful to the artificial satellites. It can collide with the satellites or spacecrafts and damage them. Therefore the future of artificial satellites or spacecrafts are in danger.

Hence, it is necessary to manage the debris.

(15) (a) What is the principle behind the working of a satellite launch vehicle?

(b) Write the formula for the escape velocity.

(c) Write the long form of ISRO.

(3 marks) (Nov. '20)

Ans. (a) The principle behind the working of a satellite launch vehicle is Newton's third law of motion. It states that every action force has an equal (in magnitude) and opposite (in direction) reaction force which acts simultaneously.

(b) Escape velocity,

$v_{esc} = \sqrt{\frac{2GM}{R}}$, where

$G \equiv$ the universal gravitational constant,

$M \equiv$ mass of a planet (or star or moon) and

$R \equiv$ radius of the planet (or star or moon).

(c) Indian Space Research Organisation.

Q. 9 Solve the following examples/ numerical problems :

[**Note :** See the textbook for the relevant data.]

***(1) If the mass of a planet is eight times the mass of the earth and its radius is twice the radius of the earth, what will be the escape velocity for that planet?**

Ans. Given :

(1) The mass of the planet (M) is eight times the mass of the earth, i.e., $8 \times 6 \times 10^{24}$ kg

(2) The radius of the planet (R) is twice the radius of the earth, i.e., $2 \times 6.4 \times 10^6$ km

(3) $G = 6.67 \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2}$

Escape velocity for that planet

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

$$= \sqrt{\frac{2 \times 6.67 \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2} \times 8 \times 6 \times 10^{24}\ \mathrm{kg}}{2 \times 6.4 \times 10^6\ \mathrm{m}}}$$

$$= \sqrt{\frac{6.67 \times 10^{13} \times 8 \times 6}{64 \times 10^5}}\ \mathrm{m/s}$$

$$= \sqrt{\frac{6.67 \times 3}{4} \times 10^8\ \mathrm{m/s}}$$

$$= \sqrt{\frac{20.01}{4}} \times 10^4\ \mathrm{m/s}$$

$$= \mathbf{2.237 \times 10^4\ m/s}$$

$$= \mathbf{22.37\ km/s.}$$

(2) If the mass of a planet is 8 times that of the earth and its radius is twice the radius of the earth, what will be the escape velocity for that planet? (Escape velocity for the earth = 11.2 km/s)

Ans. Given :

Mass of the planet $= 8M_E$, radius of the planet, $R_P = 2R_E$,

escape velocity for the earth, $v_{escE} = 11.2$ km/s

escape velocity for the planet, $v_{escP} = ?$

$$v_{escP} = \sqrt{\frac{2GM_P}{R_P}} = \sqrt{\frac{2G(8M_E)}{2R_E}}$$

$$= \sqrt{\frac{8}{2} \times \frac{2GM_E}{R_E}} = \sqrt{\frac{8}{2}} \times \sqrt{\frac{2GM_E}{R_E}}$$

$$= \sqrt{4} \times v_{escE} \quad \because v_{escE} = \sqrt{\frac{2GM_E}{R_E}}$$

$$= 2\ v_{escE} = 2 \times 11.2$$

$$v_{escP} = \mathbf{22.4\ km/s}$$

(3) If the mass of a planet is eight times the mass of the earth and its radius is twice the radius of the earth, what will be the ratio of the escape velocity on the earth to the escape velocity on the planet? ***(2 marks) (July '19)***

Solution : *See the solved problem (2) above.*

$v_{escP} = 2\ v_{escE}$

$\therefore \frac{v_{escE}}{v_{escP}} = \mathbf{\frac{1}{2}}$

***(4) How much time would a satellite in an orbit at a height of 35780 km above the earth's surface take to complete one revolution around the earth, if the mass of the earth were four times its original mass?**

Ans.

Given : R (Earth) $= 6400$ km $= 6.4 \times 10^6$ m,

M (Earth) $= 6 \times 10^{24}$ kg

$\therefore M' = 4M = 4 \times 6 \times 10^{24}$ kg

$h = 35780 \text{ km} = 3.578 \times 10^7 \text{ m} = 35.78 \times 10^6 \text{ m}$,

$G = 6.67 \times 10^{-11} \text{ N·m}^2/\text{kg}^2 \quad T = ?$

The time that the satellite would take to complete one revolution around the earth,

$$T = \frac{2\pi\,(R+h)}{v_c}$$

Now $v_c = \sqrt{\dfrac{GM}{R+h}}$

$$\therefore\ T = \frac{2\pi\,(R+h)}{\sqrt{GM/(R+h)}}$$

$$= \frac{2\pi}{\sqrt{GM}}\,(R+h)^{3/2}$$

$$= \frac{2\pi\,(6.4 \times 10^6 \text{ m} + 35.78 \times 10^6 \text{ m})^{3/2}}{\sqrt{6.67 \times 10^{-11} \text{ N·m}^2/\text{kg}^2 \times 4 \times 6 \times 10^{24} \text{ kg}}}$$

$$= \frac{2\pi\,(42.18 \times 10^6)^{3/2}}{\sqrt{6.67 \times 24 \times 10^{13}}} \text{ s}$$

$$= \frac{2\pi\sqrt{(42.18)^3 \times 10^{18}}}{\sqrt{6.67 \times 2.4 \times 10^{14}}} \text{ s}$$

$$= 2 \times 3.142 \times \sqrt{\frac{(42.18)^3 \times 10^4}{6.67 \times 2.4}} \text{ s}$$

$$= \text{Approx } \frac{4.303 \times 10^4}{3600} \text{ hours}$$

$= \text{Approx } 4.303 \times 10^4 \text{ s}$

= 11 hours 57 minutes 10 seconds

or Approx 11.95 h.

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(5) If the height of a satellite completing one revolution around the earth in T seconds is h_1 metres, then what would be the height of a satellite taking $2\sqrt{2}\,T$ seconds for one revolution?

Ans. Given :

(1) Time : T seconds

(2) Height : h_1 *metres*

Let us assume the height of the satellite completing one revolution in $2\sqrt{2}\,T$ seconds as h_2 *metres.*

$$T = \frac{2\pi r}{v_c}, \text{ i.e., } T = \frac{2\pi\,(R+h_1)}{\sqrt{\dfrac{GM}{(R+h_1)}}}$$

$$\therefore\ T = 2\pi\sqrt{\frac{(R+h_1)^3}{GM}} \qquad \ldots (1)$$

and $$2\sqrt{2}\,T = 2\pi\sqrt{\frac{(R+h_2)^3}{GM}} \qquad \ldots (2)$$

from Eqs. (1) and (2),

$$\therefore\ \frac{T}{2\sqrt{2}\,T} = \frac{2\pi\sqrt{\dfrac{(R+h_1)^3}{GM}}}{\sqrt{\dfrac{(R+h_2)^3}{GM}}}$$

$$\therefore\ \frac{1}{\sqrt{8}} = \frac{\sqrt{(R+h_1)^3}}{\sqrt{(R+h_2)^3}}$$

$$\therefore\ \frac{1}{2} = \frac{(R+h_2)}{(R+h_2)}$$

$$\therefore\ R + h_2 = 2R + 2h_1$$

$$\therefore\ \boldsymbol{h_2 = R + 2h_1.}$$

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(6) Calculate the critical velocity (v_c) of the satellite to be located at 35780 km above the surface of the earth.

Ans. Given :

$G : 6.67 \times 10^{-11} \text{ N·m}^2/\text{kg}^2$,

M (Earth) : 6×10^{24} kg,

R (Earth) : 6.4×10^6 m,

h : $35780 \text{ km} = 35780 \times 10^3$ m,

$v_c = ?$

Critical velocity of the satellite

$$v_c = \sqrt{\frac{GM}{R+h}}$$

$$= \sqrt{\frac{6.67 \times 10^{-11} \text{ N·m}^2/\text{kg}^2 \times 6 \times 10^{24} \text{ kg}}{6.4 \times 10^6 \text{ m} + 35780 \times 10^3 \text{ m}}}$$

$$= \sqrt{\frac{6.67 \times 6 \times 10^{13}}{10^3\,(6400 + 35780)}} \text{ m/s}$$

$$= \sqrt{\frac{40.02 \times 10^{10}}{42180}} \text{ m/s}$$

$$= \sqrt{\frac{400200 \times 10^6}{42180}} \text{ m/s}$$

$$= \sqrt{9.488} \times 10^3 \text{ m/s}$$

$$= 3.08 \times 10^3 \text{ m/s}$$

$$= \mathbf{3.08\ km/s.}$$

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(7) In the above example (6) how much time will the satellite take to complete one revolution around the earth?

Ans. Given :

R : 6400 km = 6.4×10^6 m

h : 35780 km = 3.5780×10^7 m

v_c : 3.08 km/s = 3.08×10^3 m/s

T = ?

The time required for the satellite to complete one revolution around the earth,

$$T = \frac{2\pi (R + h)}{v_c}$$

$$= \frac{2 \times 3.142 \times (6.4 \times 10^6 + 35.78 \times 10^6)\text{ m}}{3.08 \times 10^3 \text{ m/s}}$$

$$= \frac{6.284 \times 42.18 \times 10^3}{3.08}\text{ s}$$

= Approx 86060 s

= **23 hours 54 minutes 20 seconds.**

(8) Calculate the critical velocity (v_c) of the satellite to be located at 2000 km above the surface of the earth.

Ans. *Refer to the example (6) above.*

Here, $h = 2 \times 10^6$ m

$\boldsymbol{v_c = 6902}$ **m/s.**

(9) In the above example (8), how much time will the satellite take to complete one revolution around the earth?

Ans. *Refer to example (7) above.*

Approx 7647 s

= 2 hours 7 minutes 27 seconds.

[**Note** : For more solved problems and problems for practice, refer Chapter 1 (Gravitation)]

PROJECT

(Textbook page 144)

(1) Collect information about the space missions undertaken by Sunita Williams.

The following sources can be used to get the information on the above topic :

(1) Google Search Engine

(2) YouTube

(3) E-books on Sunita Williams

(4) English and other regional language books on Sunita Williams available in your library

(5) Newspaper clippings

- Based on the information you have collected from the above sources, complete the project in about 5 pages. You can do value addition to your project with the help of suitable photos, clippings, charts, graphs and sketches.

(2) Assume that you are interviewing Sunita Williams. Prepare a questionnaire and also the answers.

- Points to make a list of questionnaire for the interview of Sunita Williams :

(1) Primary and higher education

(2) The source of inspiration to become an astronaut

(3) Information about her mentor

(4) General and specific training

(5) Initial experience of being an astronaut

(6) First space mission, its nature, duration and experience

(7) Nature of research carried out in space

(8) Some special memories

(9) Future plans

(10) Tips and guidance for the younger generation.

MEMORY MAP / CONCEPT MAP

Space Missions

- Need
- Objectives
- Importance
- Instruments
  - Artificial satellites
    - Types
    - Orbits
  - Satellite launcher
  - Space shuttle
- Imp. concepts
  - Critical velocity
  - Escape velocity
- Imp. Space missions
  - Moon missions
  - Mars missions
  - Other missions
- Contribution of ISRO
- Space debris

Books are my friends : For more information read the reference books in your library. (Textbook page 143)

(1) Space and Science – Dr. J. V. Narlikar. (2) Story of ISRO – Dr. V. R. Gowarikar.

Did you study the lesson/chapter from the **Navneet Digest**? Now, solve the self-test to ensure solid learning. Scan this **QR Code** for the test and its model answers.

BOARD'S ACTIVITY SHEET : MARCH 2020

Time : 2 Hours] **[Total Marks : 80**

Note : *(i) All questions are compulsory.*

(ii) Use of a calculator is not allowed.

(iii) The numbers to the right of the questions indicate full marks.

(iv) In case of MCQs (Q. No. 1(A)) only the first attempt will be evaluated and will be given credit.

(v) For each MCQ, the correct alternative (A), (B), (C), (D) with subquestion number is to be written as an answer.

***For Eg. :** (i) (A), (ii) (B), (iii) (C)*

(vi) Scientifically correct, labelled diagrams should be drawn wherever necessary.

Q. 1. (A) Write the *correct* alternative : **5**

(i) According to Mendeleev's periodic law, properties of elements are periodic function of their .... **[Ch. 2, Q. 2 (14)]**

(A) atomic numbers (B) atomic masses (C) densities (D) boiling points

(ii) The vapour content in the air is measured using a physical quantity called ....

[Ch. 5, Q. 2 (15)]

(A) absolute humidity (B) relative humidity (C) dew point (D) humidity

(iii) For the normal human eye, the near point is at .... cm. **[Ch. 7, Q. 2 (13)]**

(A) 10 (B) 20 (C) 25 (D) 30

(iv) The astronomical object closest to us is .... in our galaxy. **[Ch. 10, Q. 3 (4)]**

(A) Mars (B) Venus (C) Jupiter (D) Moon

(v) In the Wilfley table method, the particles of gangue are separated by .... separation method. **[Ch. 8, Q. 2 (25)]**

(A) magnetic (B) froth floatation (C) hydraulic (D) gravitational

Q. 1. (B) Answer the following : **5**

(i) Find the odd one out :

Voltmeter, Ammeter, Thermometer, Galvanometer. **[Ch. 4, Q. 6 (2)]**

(ii) Complete the correlation :

Alkene : C = C : : Alkyne : .... **[Ch. 9, Q. 5 (1)]**

(iii) State true or false :

The frequency of AC is 50 Hz. **[Ch. 4, Q. 5 (8)]**

(iv) Match the columns : **[Ch. 6, Q. 7]**

Column 'A'	Column 'B'
The wavelength of red light	(a) 600 nm
	(b) 700 nm
	(c) 500 nm

(v) Name the first artificial satellite sent by Russia in space. **[Ch. 10, Q. 8 (2)]**

Q. 2. (A) Give scientific reasons : *(any two)* **4**

(i) The weight of an object changes from place to place though its mass is constant. **[Ch. 1, Q. 9 (2)]**

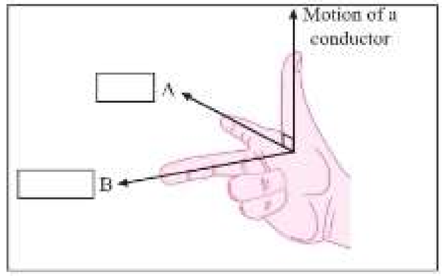
(ii) Stars twinkle but we do not see the twinkling of planets. **[Ch. 6, Q. 10 (6)]**

(iii) Elements belonging to the same group have the same valency. **[Ch. 2, Q. 14 (4)]**

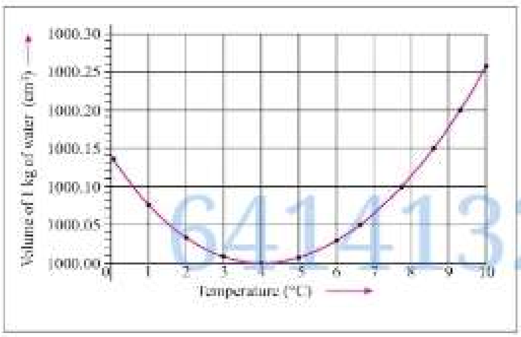
Q. 2. (B) Answer the following : *(any three)* **6**

(i) How much heat energy is necessary to raise the temperature of 5 kg of water from 20°C to 100°C? **[Ch. 5, Q. 9 (9)]**

(ii) Observe the given figure of Fleming's Right Hand Rule and write the labels of A and B correctly : **[Ch. 4, Q. 9 (62)]**



(iii) Observe the given graph and answer the following questions : **[Ch. 5, Q. 6 (15)]**



(a) Name the process represented in the figure.

(b) At what temperature does this process take place?

(iv) Complete the given chemical reaction :

$CuSO_4(aq) + Fe\ (s) \rightarrow$ .... + ...

Name the type of the reaction. **[Ch. 3, Q. 10 (32)]**

(v) Write a short note on alloying. **[Ch. 8, Q. 9 (64) (5)]**

Q. 3. Answer the following : *(any five)* **15**

(i) An element has its electronic configuration as 2, 8, 2. Now answer the following questions :

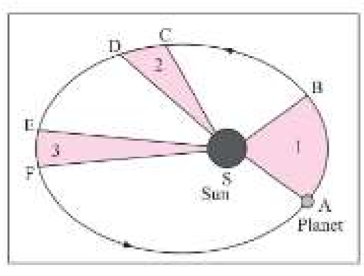
(a) What is the atomic number of this element?

(b) What is the group of this element?

(c) To which period does this element belong? **[Ch. 2, Q. 12 (a)]**

(ii) Observe the given figure showing the orbit of a planet moving around the Sun and write the three laws related to it :

[Ch. 1, Q. 7 (6)]



The orbit of a planet moving around the Sun.

(iii) Read the given passage and answer the following questions :

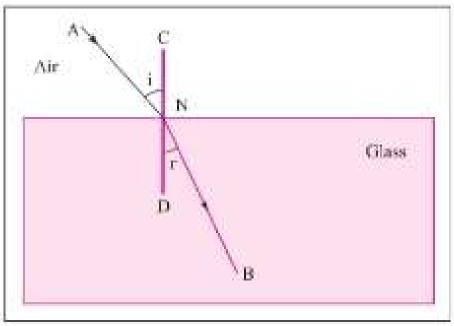
The home electrical connection consists of 'live', 'neutral' and 'earth' wires. The 'live' and the 'neutral' wires have potential difference of 220 V. The 'earth' wire is connected to ground. Due to a fault in the equipment or if the plastic coating on the 'live' and the 'neutral' wires gives away the two wires come in contact with each other and a large current flows through it producing heat. If any inflammable material (such as wood, cloth, plastic, etc.) exists around that place it can catch fire. Therefore a fuse wire is used as a precautionary measure.

(a) Name the two wires having potential difference of 220 V.

(b) What is short circuit?

(c) Write the function of a fuse. **[Ch. 4, Q. 12)]**

(iv) Observe the given figure and answer the following questions :



(a) Name the process represented by the figure.

(b) State the two laws related to the process. **[Ch. 6, Q. 8 (7)]**

(v) What is an artificial satellite? Name any two types of artificial satellite and state their functions. **[Ch. 10, Q. 8 (1)]**

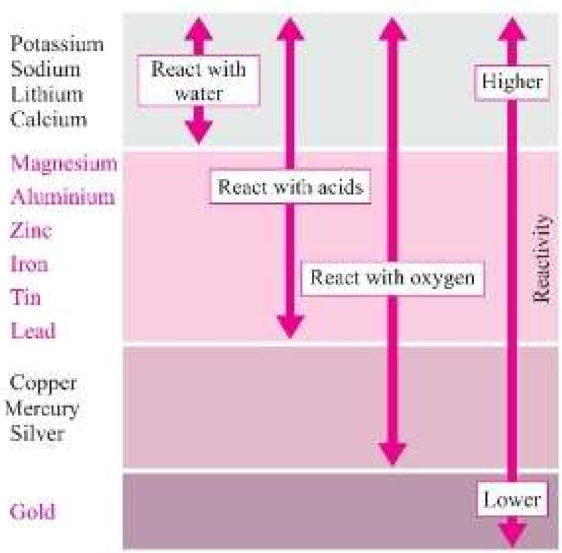
(vi) Answer the following questions :

(a) Define hydrocarbons. **[Ch. 9, Q. 12 (9)]**

(b) Name the types of hydrocarbons. **[Ch. 9, Q. 12 (10)]**

(c) Name two carbon compounds used in day-to-day life. **[Ch. 9, Q. 10 (13)]**

(vii) Observe the given figure of reactivity series of metals and answer the following questions :



Reactivity series of metals

(a) Name two metals which react with water.

(b) Name two moderately reactive metals.

(c) Name the most highly reactive metal and the most less reactive metal. **[Ch. 8, Q. 9 (17)]**

(viii) Complete the following table : **[Ch. 9, Q. 17 (4)]**

Straight chain of carbon compounds	Structural formula	Molecular formula	Name
C	$H-\underset{H}{\overset{H}{C}}-H$	CH_4	Methane
C – C	------------------------	----------------------	Ethane
C – C – C	------------------------	C_3H_8	---------------
C – C – C – C	$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H$	----------------------	---------------

Q. 4. Answer the following : *(any one)* **5**

(i) Draw a scientifically correct labelled diagram of the human eye and answer the questions based on it :

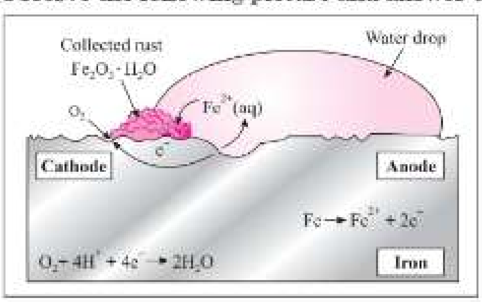
(a) Name the type of lens in the human eye.

(b) Name the screen at which the maximum amount of incident light is refracted.

(c) State the nature of the image formed of the object on the screen inside the eye.

[Ch. 7, Q. 10 (62)]

(ii) Observe the following picture and answer the questions :



(a) What is rust?

(b) Write the chemical formula of rust.

(c) Write the reaction of oxidation of iron at anode.

(d) Write the reaction of oxidation of iron at cathode.

(e) What is corrosion? **[Ch. 3, Q. 10 (79)]**

***Shailesh** E0585*