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1

Light Reflection & Refraction

1. INTRODUCTION

A thought always comes to our mind that how the various things (objects) become visible to us? Which phenomenon is the cause for it? Actually it is the light that helps us in visualizing the objects.

Light is an electromagnetic waves within a small range of wavelength of about 400×10^{-9} m to 750×10^{-9} m.

When the light reflected from an object excites the retina of our eye then the object becomes visible to us. In this chapter, first of all, we will study about the nature of light and will try to understand in what form the light is emitted from a source and it propagates from one place to another place?

After this, we will consider the phenomenon of reflection and refraction, using the ray picture of light. Using the basic laws of reflection and refraction, we shall study the image formation by plane and spherical reflecting and refracting surfaces.

➤ ACTIVITY-01

• Different theories on nature of light

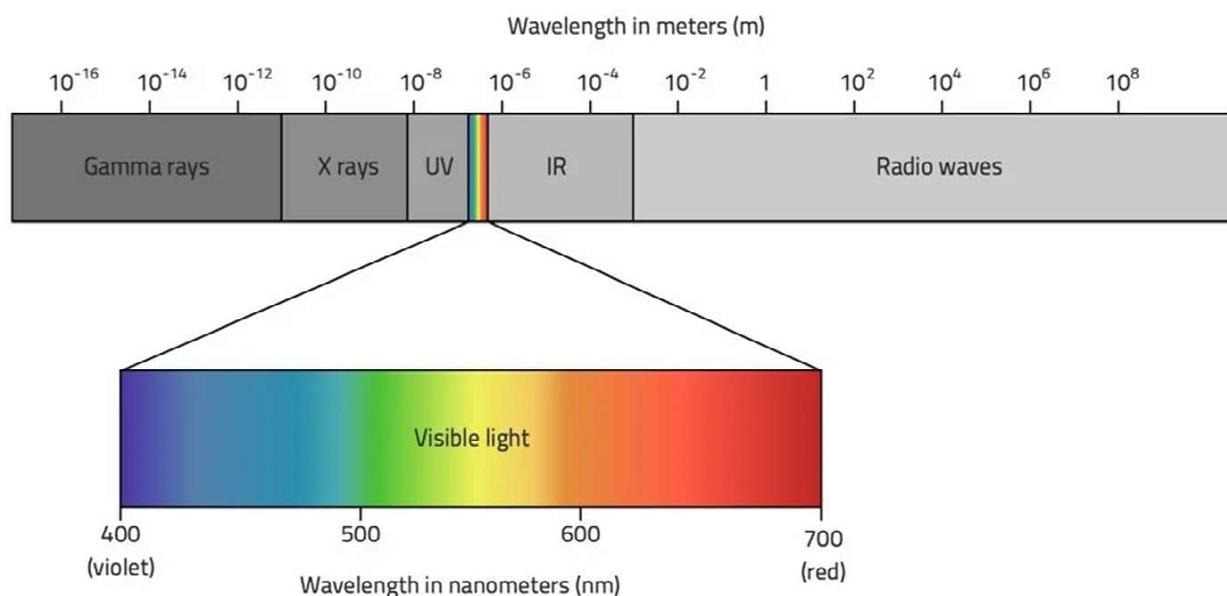
The different theories proposed by different scientists are as follows.

1. **Electromagnetic theory :** Electromagnetic theory was proposed by Sir, Maxwell. According to him, light is an electromagnetic wave consisting of time-varying electric and magnetic fields. Both the fields are perpendicular to each other and also perpendicular to the direction of propagation of light.

2. **Wave theory :** Wave Nature of Light :

(i) This theory is given by Maxwell.

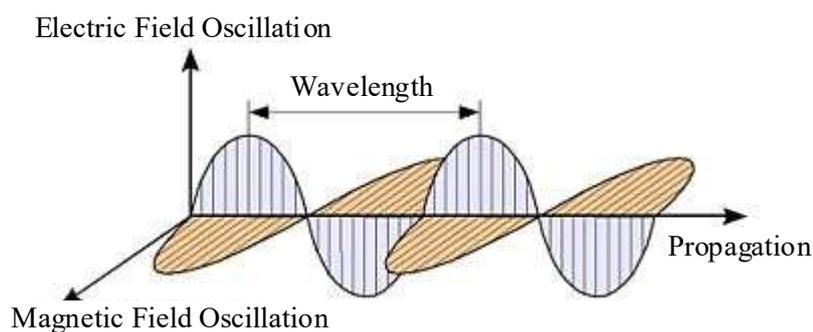
(ii) Maxwell declared light waves as electromagnetic waves ,so there is no need of medium for the propagation of these waves. The speed of these waves in air or in vacuum is maximum i.e., 3×10^8 m/s.



Light is electromagnetic radiation, such as that emitted by the Sun, which acts like a wave in frequency range that the human eye can perceive. At the same time, light also acts like a stream of particles, which are called photons (hence the expression "beam of light").

Electrons emitted from atoms and molecules can split, simply by the impact of photon striking them. A film in a camera is exposed in this way; the light splits the silver bromide into silver and bromine. The silver darkens the film and a negative is created. Light is a combination of electric and magnetic oscillations in mutually perpendicular directions as shown in Figure. But the light wave itself propagates in a direction perpendicular to both the oscillation.

Electromagnetic Radiation



3. **Quantum theory :** This theory was proposed by Einstein. According to this theory, light is a bunch of energy, packet of energy or bundle of energy. Each bundle or each packet or each bunch is called a photon. Energy of each photon is

$$E = h\nu$$

where, E = Energy of photon; h = Planck's constant; ν = Frequency of light

4. **Corpuscular theory :** This theory was first proposed by Isaac Newton. According to this theory, light is emitted by a luminous source as a stream of weightless particles called corpuscles. These particles move in straight line with very high speed.
5. **Dual nature of light :** According to de-Broglie, light exhibits both the wave nature as well as the particle nature. In some phenomenon like reflection, refraction, polarization light exhibits its wave nature and can be explained by wave theory. In some phenomenon like photoelectric effect, Raman effect, light exhibits its particle nature and can be explained on the basis of the quantum theory. But de-Broglie proposed that light has a dual nature. The wavelength (λ) associated with any moving particle of momentum 'p' is given by

$$\lambda = \frac{h}{p}$$

where, λ = shows the wave nature, h = plank's constant , $p = mv$ shows the particle nature

2. PROPERTIES OF LIGHT

Light is an electromagnetic wave within a small range of wavelength of about 400×10^{-9} m to 750×10^{-10} m. In some phenomena light behaves as particle and in some other phenomena it behaves as wave.

Since wavelength of light is very small compared to the size of ordinary objects that we encounter commonly. So, it can be considered to travel from one point to another along a straight line joining them. The path is called a ray of light, and the bundle of such rays constitutes a beam of light.

The light has the following properties:

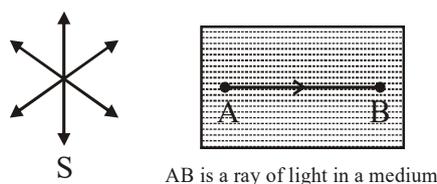
- (i) Light travels in a straight line
- (ii) Medium is not required for the propagation of this wave.
- (iii) Velocity of light is maximum in vacuum and is equal to 3×10^8 m/s.
- (iv) These waves are transverse in nature and the properties of the medium through which these waves propagate remain unaffected.

➤ ACTIVITY-02

• Ray of Light

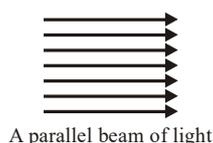
Let us consider a source of light(s). Also consider the light which passes from the point A to the point B in medium.

Actually, the light passes through all the points of the straight line AB. Such a straight line path is called a ray of light, generally represented by a directed arrow (\rightarrow).



• Beam of Light

A bundle of light ray is called a beam of light. The following figure shows a parallel beam of light.



A parallel beam of light

• Source of light

A body which emits light or reflect the light falling on it in all possible direction is said to be the source of light. The source can be point one or an extended one.

• Types of sources :

- (1) **Luminous Source** : Any object which by itself emits light is called as a luminous source.

E.g. : Sun and stars (natural luminous sources), electric lamps, candles and lanterns (artificial luminous sources).

- (2) **Non-luminous Source** : Those objects which do not emit light but become visible only when light from luminous objects falls on them. They are called non-luminous sources.

E.g. : Moon, planets (natural non- luminous sources), wood, table (artificial non-luminous sources).



Let's know

Boost your knowledge

- Sources are also classified as isotropic and non isotropic. Isotropic sources give out light in all direction whereas non-isotropic sources do not give out light in all direction
- **Medium of light** : Substance through which light propagates or tends to propagate is called medium of light.

- **Types of medium :**

- (1) **Transparent Object** : Bodies that allow light to pass through them i.e. transmit light through them, are called transparent bodies. **E.g.** : Glass, water, air etc.
- (2) **Translucent Object** : Bodies that can transmit only a part of light through them are called translucent objects. **E.g.:** Frosted or ground glass, greased paper, paraffin wax.
- (3) **Opaque Object** : Bodies that do not allow light to pass through them at all are said to be opaque object. **eg.** : Chair, desk etc.

- Depending on composition optical medium are divided into two type.

- (1) **Homogeneous medium** : An optical medium which has a uniform composition throughout is called homogeneous medium.

E.g.: Vacuum, distilled water, pure alcohol, glass, plastics, diamond, etc.

- (2) **Heterogeneous medium** : An optical medium which has different composition at different points is called heterogeneous medium. **eg.:** Air, muddy water, fog, mist, etc

EXAMPLES

Example: 1 : **A person in a dark room looking through a window can clearly see a person outside in the daylight, whereas the person outside cannot see the person inside. Explain.**

Solution When a person inside a darkroom is looking through a window to another person outside in broad daylight, then enough reflected rays come inside to the eye of the observer from the person outside. So he can be seen clearly. But if the person in daylight, looks through the same window to the person inside the dark room, there is hardly any reflected rays coming from the body of person inside the dark room to the eye of the observer outside. So the outside observer can't see the person inside the room.

3. REFLECTION OF LIGHT

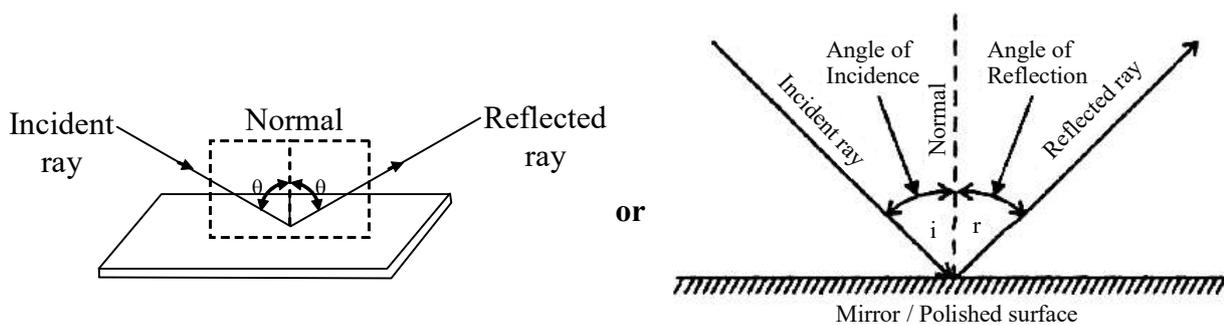
When a ray of light falls upon any smooth surface, it is sent back into the same medium from which it came. This phenomenon is called reflection of light.

OR

The process of returning (or coming back) the light to the same medium after striking a surface is called reflection of light.

➤ **Behaviour of light at the interface of two media :**

- When light travelling in one medium falls on the surface of a second medium the following three effects may occur. Some part reflected and some part refracted and the remaining third part of light energy is absorbed by the second medium. This is called absorption of light.



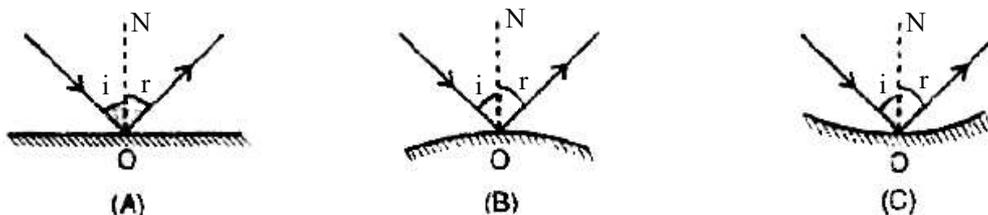
According to the law of reflection $\angle i = \angle r$. The incident ray, the reflected ray, and the normal all lie in the same plane.

Laws of reflection

- (i) The angle of incidence is equal to the angle of reflection ($\angle i = \angle r$).
- (ii) The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.

➤ **ACTIVITY-03**

1. Laws of reflection are applicable for plane surface as well as curved surfaces.

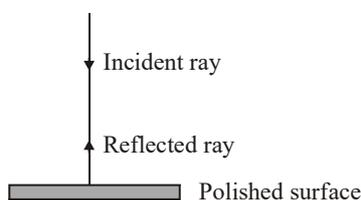


2. Most people are surprised by the fact that light can be reflected back from a denser medium. For instance, if you are diving and you look up at the surface of the water, you will see a reflection of yourself.

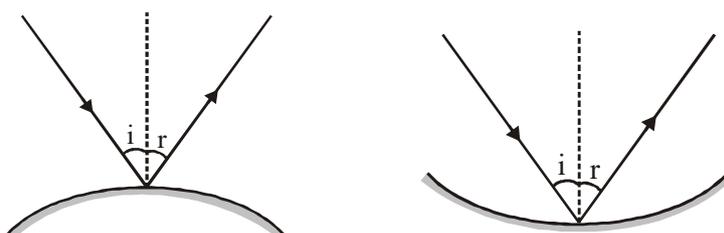
Important Information

1. **A ray of light striking the surface normally retraces its path.**

Explanation : When a ray of light strikes a surface normally, then angle of incidence is zero, i.e. $\angle i = 0$. According to the law of reflection, $\angle r = \angle i = 0$ i.e. the reflected ray is also perpendicular to the surface. Thus, an incident ray normal to the surface (i.e. perpendicular to the surface) retraces its path as shown in figure.

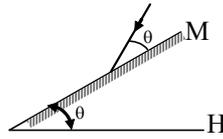


2. Laws of reflection are also obeyed when light is reflected from the spherical or curved surface as shown in figure. **In other words, laws of reflection hold good for all types of mirrors.**



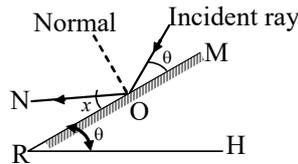
EXAMPLES

Example: 2 : A mirror is inclined at an angle of θ° with the horizontal. If a ray of light is incident on mirror making an angle θ° with the mirror, then the reflected ray makes the following angle with the horizontal.



- (A) θ° (B) $2\theta^\circ$ (C) $\theta^\circ/2$ (D) none of these

Solution :

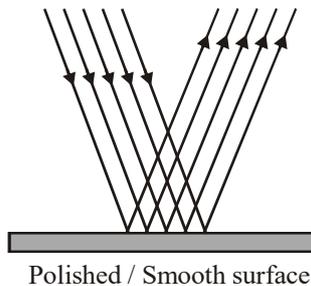


Angle of incidence = $(90 - \theta)$
 Angle of reflection = Angle of incidence = $(90 - \theta)$
 But angle of reflection + $x = 90^\circ$
 or $90^\circ - \theta + x = 90^\circ$
 or $x = \theta$
 or $\angle NOR = \angle ORH$ (but these are alternate angles)
 or $NO \parallel RH$
 or Reflected ray is parallel to horizontal
 or Angle between reflected ray and horizontal = 0° \therefore (D)

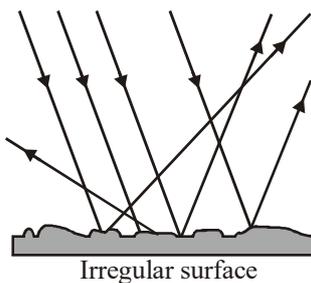
4. TYPES OF REFLECTION

(i) **Regular reflection (or Specular reflection) :** When a parallel beam of light falls on a smooth and highly polished surface, then the reflected beam is also parallel and directed in a fixed direction. Such reflection of light is called regular reflection.

The glare of regular reflected light beam is dazzling **Search light** and **Automobile head light** are the examples of regular reflection of light.



(ii) **Irregular reflection (Diffused reflection):** When a parallel beam of light falls on a rough surface, then the reflected light is not parallel but spreads over a wide area. Such reflection of light is called **irregular** or **diffused reflection**. This type of reflection of light is shown in figure.



Light reflected from the wooden table, newspaper etc. is the example of diffused reflection of light.



TRY YOURSELF

1. A ray of light making an angle 10° with the horizontal is incident on a plane mirror making an angle θ with the horizontal. What should be the value of θ . So that the reflected ray goes vertically upwards?
 (A) 20° (B) 30° (C) 40° (D) 45°

5. IMAGE

When we stand in front of a looking mirror, we see our face. The picture of our face in the mirror is known as the image of our face. Image are of two types (1) Real image and (2) Virtual image.

- (i) **Real Image** : When a beam of light from an object actually meets at a point after reflection, then the image of the object formed at that point is known as real image.
- (ii) **Virtual image** : When a beam of light from an object does not meet at a point but appears to diverge from it after reflection, then the image of the object at that point is known as virtual image.

S.No.	Real Image	Virtual Image
1	When Rays of light after reflection meet at a point, real image is formed.	When rays of light do not meet at a point but appears to meet at a point, virtual image is formed.
2	Real image can be obtained on a screen.	Virtual image cannot be obtained on a screen.
3	Real image is formed in front of a mirror.	Virtual image is formed behind the mirror.
4	Real image is always inverted.	Virtual image is always erect (i.e. upright).



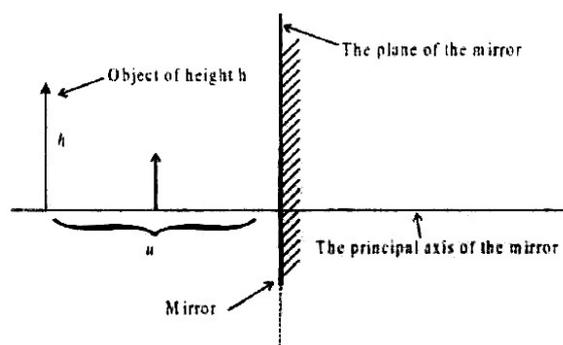
Let's know

Properties of the image formed by a plane mirror

- (i) Image formed by a plane mirror is virtual and erect.
- (ii) Size of the image formed by plane mirror is equal to the size of the object.
- (iii) The distance of the image (of an object) behind the plane mirror is equal to the distance of the object from the mirror.
- (iv) The right side of the object appears as the left side of its image and vice - versa. That is, image formed by plane mirror laterally inverted.

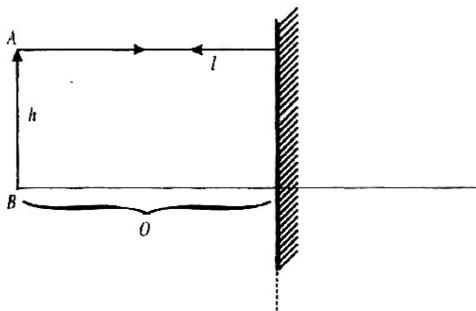
6. REFLECTION FROM PLANE SURFACE

Let's apply ray-diagram methods to the case of an object in front of a plane mirror in order to determine the position of the image of that object. Here's the configuration.

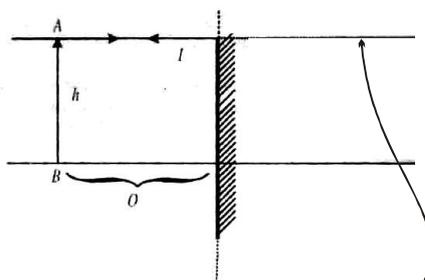


We have an object of height h , at distance u from the plane of the mirror. Our object is represented by an arrow. The tail of the arrow is on a reference line that is perpendicular to the plane of the mirror i.e. the reference line "the principal axis of the mirror." The plane of the mirror is the infinite plane that contains the surface of the mirror.

We use the method of principal rays to determine the position of the image of the object. In the method of principal rays, we consider only a few incident rays for which the reflected rays are particularly easy to determine. Experimentally, we find that the position of the image is independent of the size of the mirror, so we consider the mirror to be as large as it needs to be for the principal rays to hit it. In particular, if a principal ray appears to miss the mirror in our diagram, we show the ray as reflecting off the plane of the mirror nevertheless. Our Principal Ray 'I' for the case at hand is one that approaches the plane of the mirror along a line that is parallel to the principal axis of the mirror.

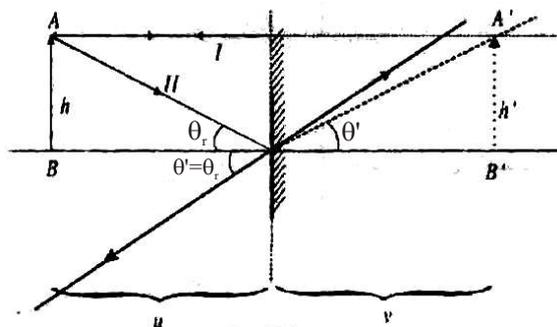


According to the law of reflection, principal ray I is reflected straight back on itself as depicted in the following diagram.



Using the trace-back method we know that the tip of the object lies somewhere along this line

Principle ray II hits the mirror right where the principal axis of the mirror intersects the mirror. In accordance with the Law of Reflection, with, for the ray in question, the principal axis of the mirror being the normal, the reflected ray makes the same angle with the principal axis of the mirror as the incident rays does.

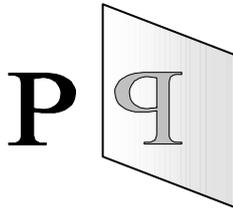


Tracing back the second reflected ray, to the point where it intersects the first reflected ray trace-back line, yields the position of the image of the tip of the arrow. The image height h' is the distance between the same two parallel lines that the object height h is the distance between. So $h' = h$. Since vertical angles are equal, we have θ' in the diagram above being equal to θ_R which we know to be equal to θ_I from the law of reflection.

Thus the right triangle of side h' and angle θ' is congruent to the triangle of height h and angle θ_1 . Hence, since corresponding sides of congruent triangles are equal, we have $v = u$. That is to say that the image distance, from the plane of the mirror, is equal to the object distance.

➤ **Characteristics of image formed by plane mirror :**

1. Distance of object from mirror = Distance of image from mirror.
2. The image is laterally inverted.



Lateral Inversion

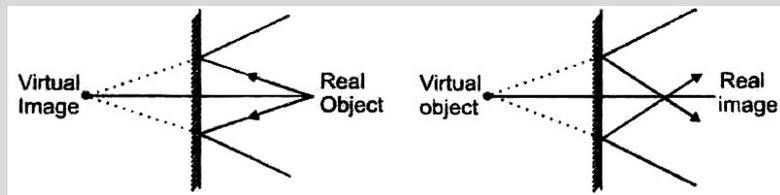
Cause of Lateral inversion : Lateral inversion is due to the fact that the image of points on the object which are at a lesser distance from the mirror are formed nearer in the mirror and for those points which are at some more distance will be formed at larger distance. So the image appears to be laterally inverted.

3. The line joining the object point with its image is normal to the reflecting surface.
4. The size of the image is the same as that of the object.
5. The image of Real object formed by plane mirror is virtual & erect.

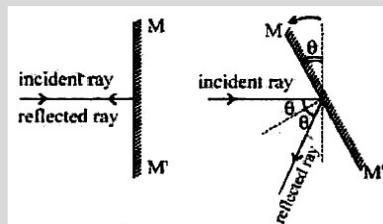


Let's know

- (i) For a real object the image is virtual and for a virtual object the image is real.



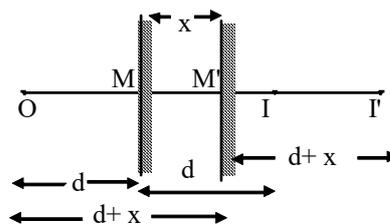
- (ii) If keeping the incident ray fixed, the mirror is rotated by an angle θ , about an axis in the plane of mirror, the reflected ray is rotated through an angle 2θ .



EXAMPLES

Example: 3 : An object is placed in front of a plane mirror. If the mirror is moved away from the object through a distance x , by how much distance will the image move?

Solution : Suppose the object O was initially at a distance d from the plane mirror M as shown in fig. The image formed at O' is at a distance d behind the mirror. Now, the mirror is shifted by a distance x to M' such that the distance of the object from M' becomes $d + x$. The image now formed at O'' which is also at a distance $d + x$ from M' .



So, $OM = MI = d$

$OM' = M'I' = d + x$

Thus, $OI' = OM' + M'I' = 2(d + x) \dots(1)$

when $OI = OM + MI = 2d \dots(2)$

$\therefore I'I = OI' - OI = 2(d + x) - 2d = 2x$

Thus, the image is shifted from O' to O'' by a distance $2x$.

Example: 4 :

An insect is at a distance of 1.5m from a plane mirror. Calculate the following?

(i) Distance at which the image of the insect is formed.

(ii) distance between the insect and its image.

Solution :

(i) The distance of insect from the mirror = 1.5 m

\therefore The distance of insect from the mirror is also equal to 1.5 m. The image is formed at 1.5 m behind the mirror.

(ii) The distance between the insect and image = $1.5 + 1.5 = 3\text{m}$

➤ **ACTIVITY-03**

1. If two plane mirrors are kept inclined to each other at angle θ with their reflecting surfaces facing each other, multiple reflection takes place and more than one images are formed. Number of images (n) for $\theta \leq 180^\circ$ are given by :

$$n = \begin{cases} \frac{360^\circ}{\theta} - 1 & \text{if } \frac{360^\circ}{\theta} \text{ is even (object may be placed symmetrically or asymmetrically)} \\ \frac{360^\circ}{\theta} - 1 & \text{if } \frac{360^\circ}{\theta} \text{ is odd, the object is kept symmetrically (on bisector) w.r.t. the mirrors.} \\ \frac{360^\circ}{\theta} & \text{if } \frac{360^\circ}{\theta} \text{ is odd, the object is kept asymmetrically (not on bisector) w.r.t. the mirrors.} \\ \frac{360^\circ}{\theta} & \text{if } \frac{360^\circ}{\theta} \text{ is not an integer.} \end{cases}$$

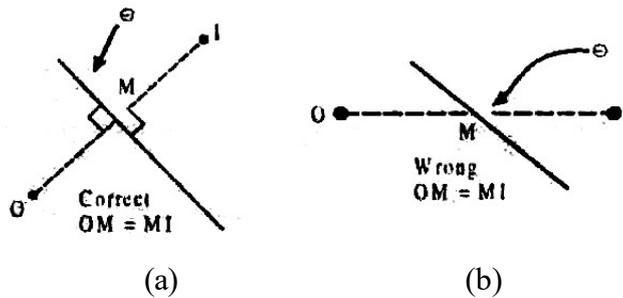
All this is given below in a tabular form.

S.No.	θ in degress	$m = (360/\theta)$	No. of images formed if object is placed	
			asymmetrically	symmetrically
1	0	∞	∞	∞
2	30	12	11	11
3	45	8	7	7
4	60	6	5	5
5	72	5	5	4
6	75	4.8	4	4
7	90	4	3	3
8	112.5	3.2	3	3
9	120	3	3	2

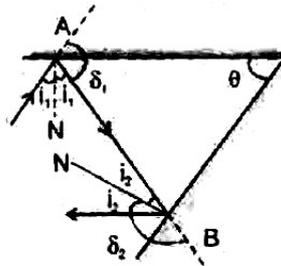
- (a) If an object is placed between two parallel mirrors ($\theta = 0^\circ$), the number of images formed will be $\frac{360}{0} = \infty$ but of decreasing intensity in accordance with $I \propto \frac{1}{r^2}$.
- (b) The number of images formed by two mutually perpendicular mirrors ($\theta = 90^\circ$) will be 3. All these three images will lie on a circle with centre at C – the point of intersection of mirrors M_1 and M_2 and whose radius is equal to the distance between C and object O.
- (c) Two mirrors inclined to each other at different angles may provide same number of images, e.g. for any value of θ between 90° and 120° the number of maximum images formed (n) is 3. This in turn implies that if θ is given, n is unique but if n is given, θ is not unique.
- (d) The number of images seen may be different from the number of images formed and depends on the position of observer relative to object and mirrors – e.g., if $\theta = 120^\circ$ maximum number of images formed will be 3 (object not on bisector) but no. of images seen can only be 1, 2, or 3 depending on the position of observer.

2. If an object moves towards (or away from) a plane mirror at speed v , the image will also approach (or recede) at same speed v , i.e., the speed of image relative to object will be $v - (-v) = 2v$. Similarly if the mirror is moved towards (or away from) the object with a speed v the image will move towards (or away from) the object with a speed $2v$.

3. To locate the image of an object from an inclined mirror, see the perpendicular distance of the object from the mirror.



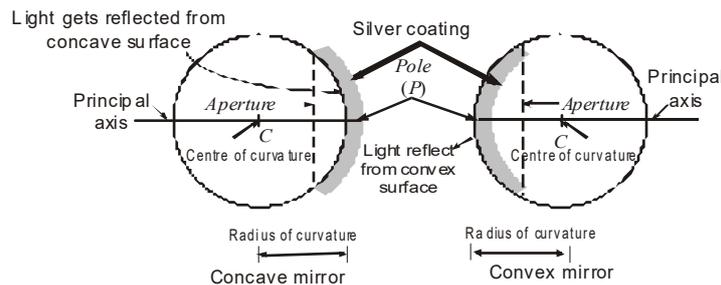
4. If angle between two mirrors is θ after consecutive reflection total deviation $d = \delta_1 + \delta_2 = 2\pi - 2\theta$.



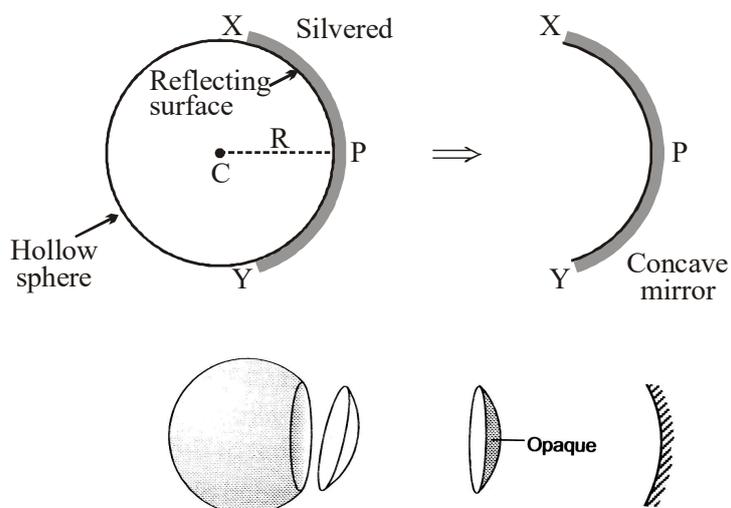
7. REFLECTION FROM SPHERICAL SURFACE
 ➤ CURVED OR SPHERICAL MIRRORS

A curved or spherical mirror is the reflecting part of a spherical surface.

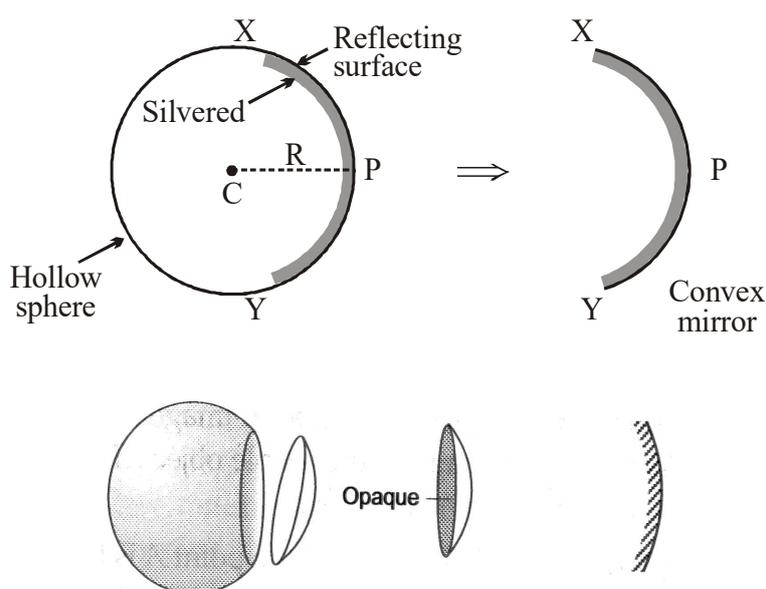
- **Types of (polished) spherical mirrors.** There are two types of spherical mirrors:
 - (i) Concave Mirror (ii) Convex Mirror



- (i) **Concave mirror:** Concave mirror is the part of a hollow sphere whose outer surface (i.e. bulging surface) is silvered and the inner surface (i.e. depressed surface) acts as reflecting surface (polished) (As shown in the figure below).

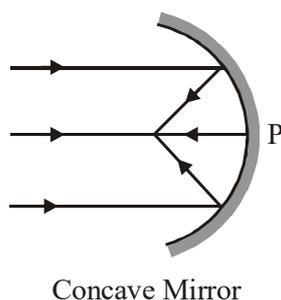


- (ii) **Convex mirror:** Convex mirror is the part of a hollow sphere whose outer surface (i.e. bulging surface) acts as a reflecting surface (polished) and the inner surface (i.e. depressed surface) is silvered (As shown in the figure below).

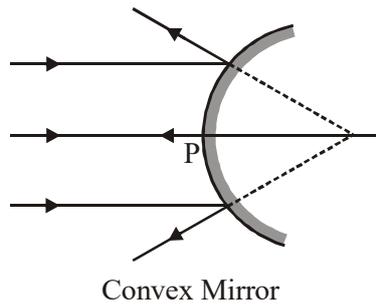


➤ **Convergence and divergence of light**

- **Convergence of light:** If a parallel beam of light after reflection meets at a point, then the process is known as convergence of light.



- **Divergence of light:** If a parallel beam of light after reflection diverges (i.e. spreads out) and appears to come from a point, then the process is known as divergence of light.

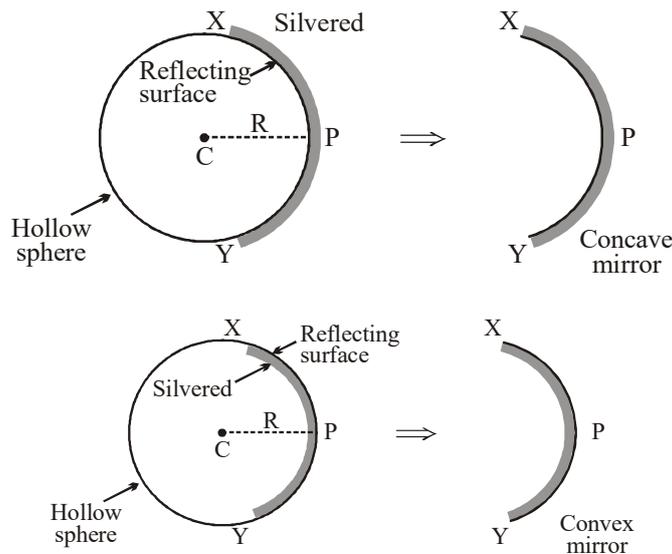


Let's know

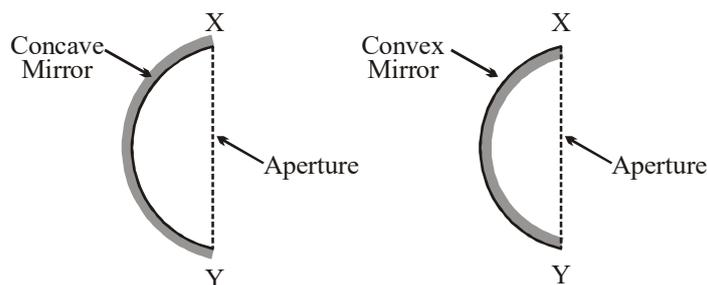
- (i) Concave mirror converges a parallel beam of light falling on it, so concave mirror is also known as **convergent mirror**.
- (ii) Convex mirror diverges a parallel beam of light falling on it, so convex mirror is also known as **divergent mirror**.

8. IMPORTANT TERMS WITH RESPECT TO SPHERICAL MIRRORS

- (i) **Centre of curvature:** The center of a hollow sphere of which the curved or spherical mirror forms a part is called centre of curvature. It is denoted by C.

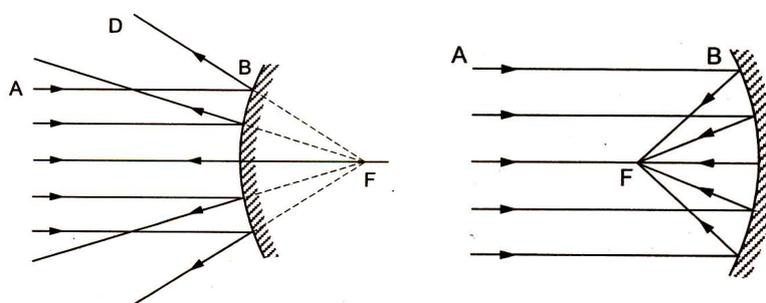


- (ii) **Radius of curvature:** The radius of a hollow sphere of which the spherical mirror forms a part is called radius of curvature. It is denoted by R.
- (iii) **Pole:** The mid point of a spherical mirror is called its pole. It is denoted by P.
- (iv) **Aperture:** The part of a spherical mirror exposed to the incident light is called the aperture of the spherical mirror. In other words, diameter of a spherical mirror is known as its aperture. The apertures of a concave mirror and a convex mirror are represented by XY as shown in figure.



- (v) **Principal Axis:** A line joining the centre of curvature (C) and pole (P) of a spherical mirror and extended on either side is called principal axis .
- (vi) **Principal Focus:** A point on the principal axis of a spherical mirror where the rays of light parallel to the principal axis meet or appear to meet after reflection from the spherical mirror is called principal focus. It is denoted by F.

Focus of concave mirror	Focus of convex mirror
A parallel beam of light after reflection from a concave mirror converges at a point in front of the mirror. This point (F) is the focus of a concave mirror and it is real.	A parallel beam of light after reflection from a convex surface diverges and the rays do not meet. However on producing backward, the rays appear to meet at a point behind the mirror. This point is focus of the convex mirror and it is virtual.



- (vii) **Focal Plane:** A plane normal or perpendicular to the principal axis and passing through the principal focus (F) of a spherical mirror is called focal plane of the spherical mirror.
- (viii) **Focal length:** The distance between the pole (P) and the principal focus (F) of a spherical mirror is called the focal length of the mirror. It is denoted by f . Focal length of a mirror is given by $f = PF$

➤ **ACTIVITY-04**

• **Important Terms**

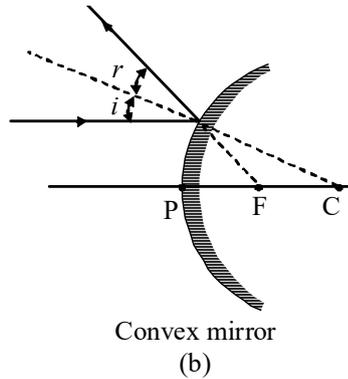
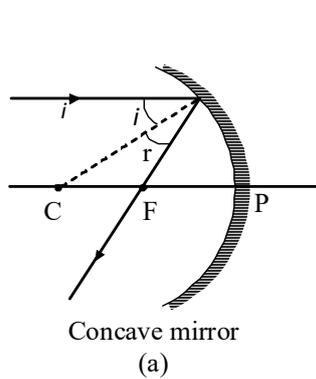
- (i) **Pole :** The centre of the spherical mirror.
- (ii) **Centre of Curvature :** Centre of the sphere of which the mirror forms a part.
- (iii) **Radius of curvature :** The radius of the spherical surface of which the mirror is a part.
- (iv) **Linear aperture :** Distance between two extreme points on the periphery of the spherical mirror.
- (v) **Angular aperture :** The angle which the periphery of spherical mirror subtends at the centre of curvature.
- (vi) **Principal axis :** The line joining the pole and the centre of curvature.
- (vii) **Principal focus (F) :** The point on the principal axis at which all the light rays parallel to the principal axis after reflection from the spherical mirror converge (concave mirror) or appear to diverge from (convex mirror).
- (viii) **Focal length (f):** The distance between the pole and principal focus denoted by f .
- (ix) **Paraxial rays :** The rays parallel and close to the principal axis.
- (x) **Marginal or Peripheral rays :** The rays parallel and away from the principal axis and strike the mirror near its boundary.
- (xi) **Focal Plane :** Plane passing through the principal focus and at right angles to the principal axis.

8.1 Rules for Constructing the Images Formed by Spherical Mirrors :

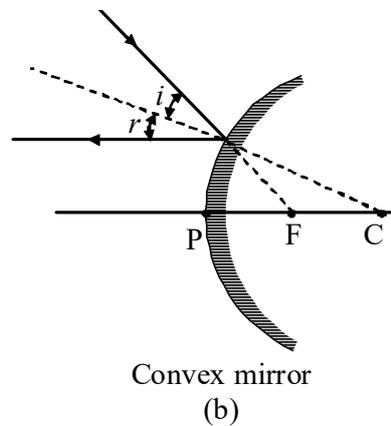
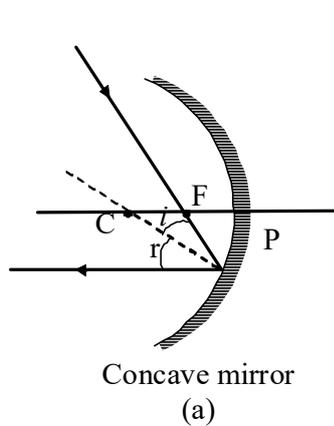
To construct the ray diagram, in order to locate the image of an object, it is convenient to consider only two rays.

The intersection of at least two reflected rays give the position of image of the point object. Any two of the following rays can be considered for locating the image.

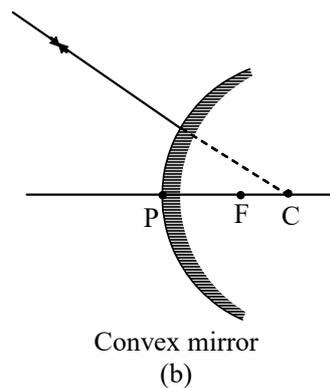
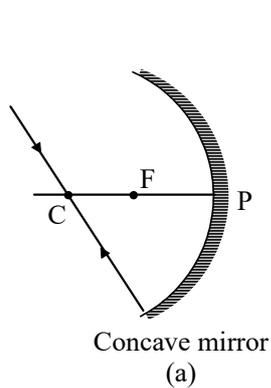
- (i) A ray parallel to the principal axis after reflection passes through (concave) or appear to come from the principal focus (convex).



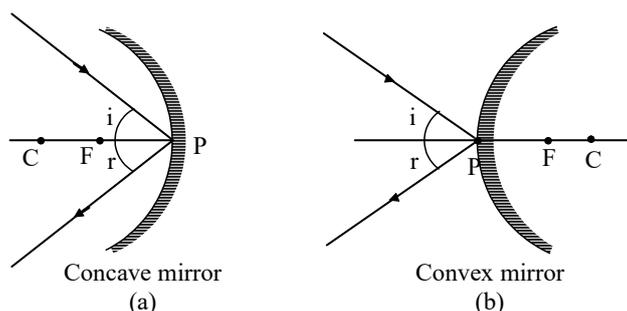
- (ii) A ray which passes through (concave) or directed towards (convex) the principal focus after reflection becomes parallel to the principal axis.



- (iii) A ray which passes through the centre of curvature after reflection retraces its path back.



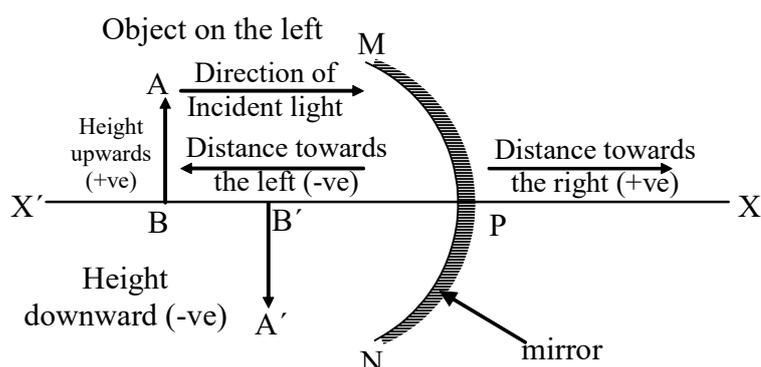
- (iv) A ray of light incident at the pole and making an angle with the principal axis, after reflection goes on the other side of the principal axis making the same angle with it.



8.2 Sign Convention for Reflection by Spherical Mirrors :

While studying the reflection of light by spherical mirrors and formation of image by spherical mirrors, we use some sign conventions as given below:

- All distance are measured **from the pole** of a spherical mirror.
- Distance measured **in the direction of incident light** are taken as **positive** while distance measured **in a direction opposite to the direction of the incident light** are taken as **negative**. (As shown in the figure below).
- The **upward distance** perpendicular to the principal axis are taken as **positive**, while the **downward distance** perpendicular to the principal axis are taken as **negative**.



Let's know

- Focal length and radius of a curvature of a concave mirror are taken as *negative*.
- Focal length and radius of curvature of a convex mirror are taken as *positive*.

8.3 Image Formation in Case of Spherical Mirrors :

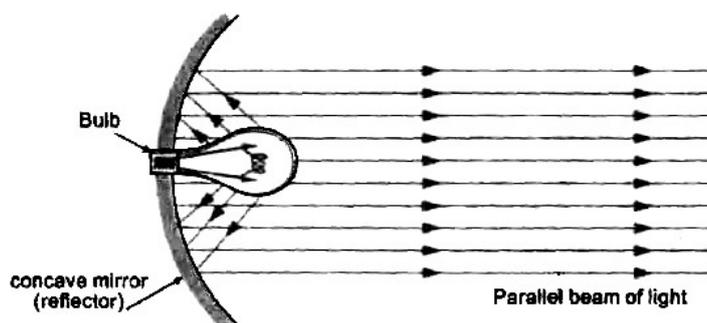
- As the object gradually moves from infinity towards the focus of a concave mirror, the image moves from focus to infinity. The image formed is real, inverted and its size increases gradually.
- As the object comes at the focus of the concave mirror, its real inverted and highly magnified image is formed at infinity.
- As the object come between the focus and pole of the concave mirror, its virtual, erect and magnified image is formed behind the mirror.
- As the object gradually moves from infinity towards the pole of a convex mirror, then irrespective of the placement of the object in front of the mirror, the image formed is always virtual, erect and diminished and is formed behind the mirror. The size of the image goes on increasing as the object is moved closer to the mirror.

Image formed by the concave mirror

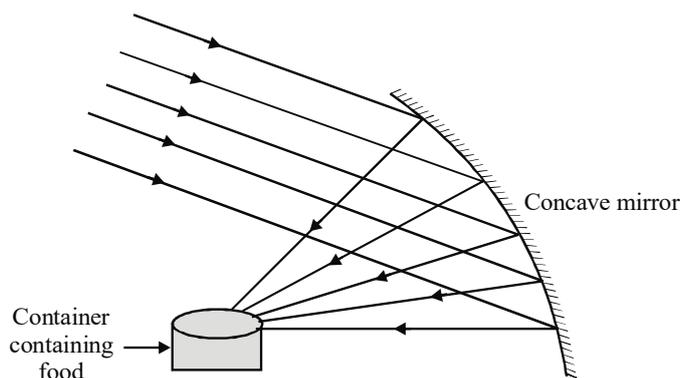
Position of object	Position of image	Nature	Figure
At infinity	At the focus	Real, inverted & diminished	
Between infinity & centre of curvature	Between focus & centre of curvature	Real, inverted & small in size	
At centre of curvature	At centre of curvature	Real, inverted and of the same size	
Between Focus & centre of curvature	Between centre of curvature and infinity	Real, inverted and enlarged	
At Focus	At infinity	Real, inverted and very large	
Between Focus & Pole	Behind the mirror	Erect, virtual & enlarged	

8.4 Applications / Uses of a Concave Mirror :

- (i) **Reflector :** Concave mirrors are used in motor head lights, search lights and torches etc., to produce an intense parallel beam of light. A bulb is placed at the focus of a concave mirror. The beam of light from the bulb after reflection from the concave mirror goes as a parallel beam (figure).



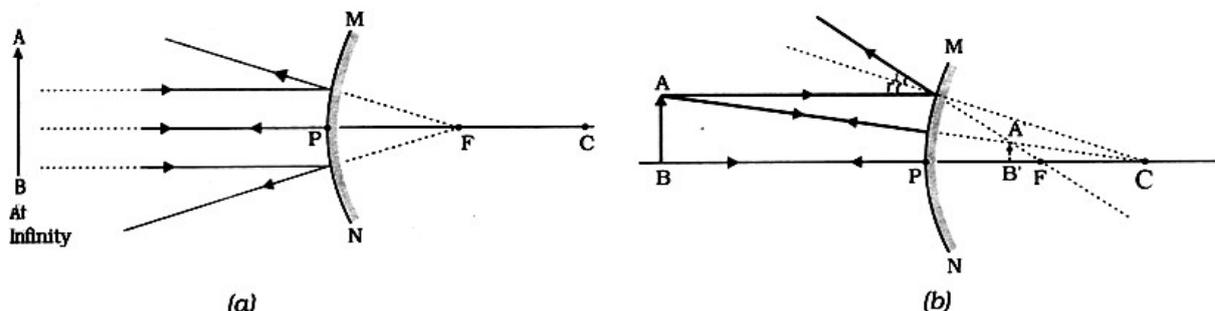
- (ii) **Shaving and make up mirror:** When an object is placed close to a concave mirror (i.e. between the pole and focus of the concave mirror), an erect and enlarged (large in size) image is formed. Because of this fact, concave mirror is used by men to see their enlarged face while shaving. Similarly, a lady can see her face better with the help of a concave mirror while doing makeup.
- (iii) **Solar Cooker:** When a parallel beam of sun light falls on a concave mirror, this beam is brought to the focus of the concave mirror, as a result of this, the temperature of an object (say a container containing un-cooked food) placed at this focus increase considerably. Hence the food in the container is cooked (The arrangement as shown in figure given below).



- (iv) **Hospitals :** Concave mirrors are used by dentists and ENT specialists to focus light on teeth, nose, eye and throat to examine these organs.

Image formation by convex mirror

Position of the object	Position of the image	Size of the image	Nature of the image
At infinity (figure a)	At the focus F, behind the mirror	Highly diminished, point-sized	Virtual and erect
Between infinity and the pole P of the mirror (figure b)	Between P and F, behind the mirror	Diminished	Virtual and erect



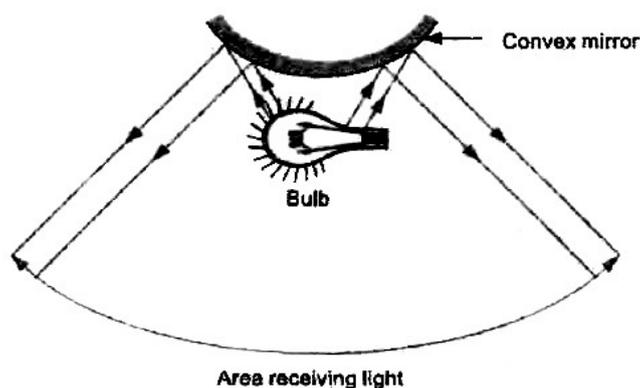
➤ **ACTIVITY-05**

Important Information :

- (1) Concave mirror produces **real** as well as **virtual image** depending upon the position of the object.
- (2) A concave mirror produces **virtual image** when object lies between the pole (P) and focus (F) of the mirror.
- (3) A convex mirror always produces **virtual** and diminished image irrespective of the position of the object in front of the mirror.
- (4) A real image is **inverted** while virtual image **erect**.

8.5 Applications / Uses of a Convex Mirror :

- (i) **Rear view or driver’s mirror:** Convex mirror is used as a rear view mirror because this mirror produces an effect and diminished image of an object behind the vehicle. Since the image of the object formed is small in size, so the field of view is increased. It means, the driver of a vehicle can see the traffic over large area behind his vehicle. **This mirror is also known as driver’s mirror.**
- (ii) **In street lights:** Convex mirror is used in street lights to diverge light over a large area (As shown in the figure given below).

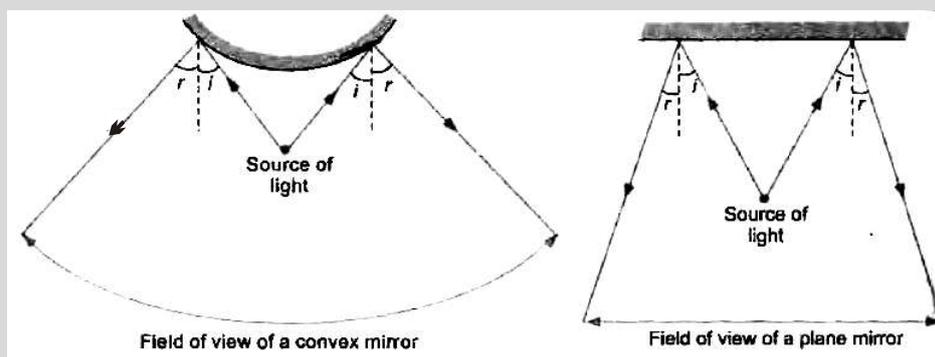


- (iii) **In big shopping stores:** Convex mirrors are used in big shopping stores to watch the activities of the customers. This is because the field of view of a convex mirror is large and even a single convex mirror can monitor the activities of customers in a large area of the store.



Let's know

1. Convex mirrors definitely form a full length image of a distant tall building or a tall tree.
2. A small **convex mirror** fitted on the wall of **Agra Fort** is used to see the full length **image of Taj Mahal**.
3. The field of view of a plane mirror is smaller than the field of view of a convex mirror as shown in the figure.



4. To form the full length image of an object in a plane mirror, the size of the plane mirror should be half the size of the object.
5. Full length image of an object is formed by a concave mirror, only when the object is far away from the mirror.

9. MIRROR FORMULA

The distance of the position of an object on the principal axis from the pole of a spherical mirror is known as **object distance**. It is denoted by u .

The distance of the position of the image of an object on the principal axis from the pole of a spherical mirror is known as **image distance**. It is denoted by v .

The relation among u , v , and focal length (f) of a spherical mirror is known as mirror formula.

It is given by
$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

or
$$\frac{1}{\text{Object distance}} + \frac{1}{\text{Image distance}} = \frac{1}{\text{focal length}}$$

- Note:** (i) Mirror formula holds good for both concave and convex mirrors.
 (ii) While solving Numerical Problems, sign conventions are used when values of u , v and f substituted.

9.1 Power of Mirror :

A spherical mirror has infinite number of focus. Optical power of a mirror (in Diopters)

$$P = -\frac{1}{f(\text{in metre})}$$

Relation between focal length (f) and radius of curvature (r)

- $R = 2f$ or $f = \frac{R}{2}$ [For paraxial rays]

10. MAGNIFICATION (OR LINEAR MAGNIFICATION)

10.1 Linear Magnification :

produced by a mirror is defined as the ratio of the size (or height) of the image to the size (or height) of the object. It is denoted by m .

If h_i = Size (or height) of the image produced by the mirror

and h_o = Size (or height) of the object.

Then, linear magnification,
$$m = \frac{h_i}{h_o} = -\frac{v}{u}$$

Linear magnification has **no unit**.

10.2 Magnification Produced by a Concave Mirror :

Let AB be an object placed perpendicular to the principal axis in front of a concave mirror. A ray BD parallel to the principal axis passes through the focus (F) after reflection from the mirror (as shown in the figure & a ray BP incoming to pole passes as PB' after reflection). These two reflected rays intersect each other at B' . So $A'B'$ is the real, inverted and diminished image of the object AB .

Δ 's APB and $A'PB'$ are similar.

$\therefore \frac{A'B'}{AB} = \frac{PA'}{PA}$ (1)

Applying sign conventions, we have

$A'B' = -h'$ (Size of image)

$AB = +h$ (Size of object)

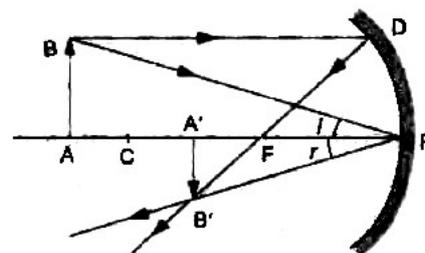
$PA' = -v$ (Distance of image from the pole)

and $PA = -u$ (Distance of object from the pole)

Hence equation (1) becomes

$$\frac{-h_i}{h_o} = \frac{-v}{-u} \quad \text{or} \quad \frac{h_i}{h_o} = -\frac{v}{u}$$

Since $\frac{h_i}{h_o} = m$ \therefore
$$m = \frac{h_i}{h_o} = -\frac{v}{u}$$



10.3 Magnification :

- (i) The transverse or **linear magnification**

$$m = \frac{\text{size of image}}{\text{size of object}} = \frac{I}{O} = -\frac{v}{u} = \frac{f}{f-u} = \frac{f-v}{f}$$

The arbitrary minus sign given to linear magnification has nothing to do with the relative sizes of the object and the image but we can use it to tell whether the image is erect or inverted w.r.to. object.

- **For virtual image :** m is positive [as virtual image is erect h_2 is positive as well as h_1 is positive]
- **For real image :** m is negative [as real image is always inverted h_2 is negative while h_1 is positive]



Let's know

If $|m| > 1$ the image is enlarged
 If $|m| = 1$ the image is of same size
 If $|m| < 1$ the image is reduced
 If $m > 0$ the image is erect
 If $m < 0$ the image is inverted

- (ii) If an object lies along the axis, then its magnification is called the **longitudinal magnification**.

$$\text{It is given by } m = -\frac{v^2}{u^2}$$

- (iii) For a convex mirror, the magnification is positive and less than one. That means, the image is virtual erect and diminished in size, for all positive of the object.
- (iv) For concave mirror, if object lies between the pole and focus, then, image is virtual, erect and enlarged.



Let's know

Newton's Formula :

This formula provides a relationship among the focal length (f), the distance of the object from focus (x) and the distance of the image from the focus (y)

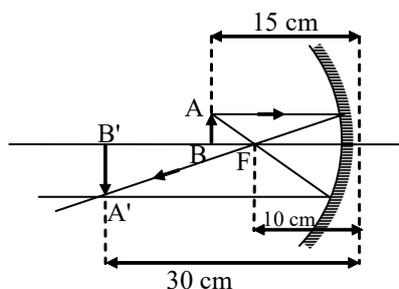
This can be expressed as

$$xy = f^2$$

Note that here the object distance and the image distance are measured from the focus of the mirror not from the pole.

EXAMPLES

Example: 5 : An object is placed at a distance of 15 cm from a concave mirror of focal length 10 cm. Find the position of the image.



Solution : We have $u = -15$ cm and $f = -10$ cm

Using the relation,
$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

we get $\frac{1}{v} + \frac{1}{-15} = \frac{1}{-10}$

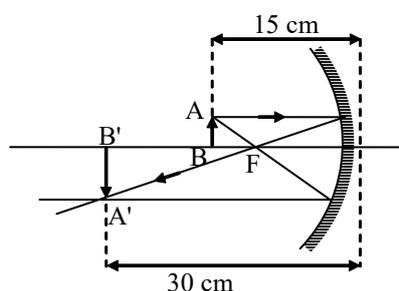
or $\frac{1}{v} = \frac{1}{15} - \frac{1}{10} = -\frac{1}{30}$ or $v = -30$ cm

So the image will be formed 30 cm from the mirror. Since v has a negative sign, the image is formed to the left of the mirror, i.e. in front of the mirror as shown in fig.

Example: 6 :

A 3 cm long object is placed perpendicular to the principal axis of a concave mirror. The distance of the object from the mirror is 15 cm, and its image is formed 30 cm from the mirror on the same side of the mirror as the object .

Calculate the height of the image formed.



Solution :

Here $u = -15$ cm and $v = -30$ cm

Size of the object, $h = 2$ cm

Magnification, $m = \frac{h'}{h} = -\frac{v}{u}$

or $\frac{h'}{h} = -\frac{(-30)}{(-15)} = 2$

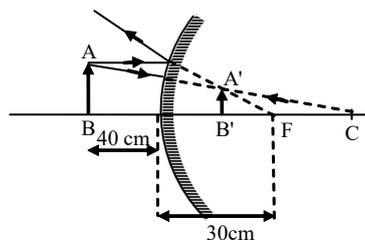
or $h' = -2 \times h = -2 \times 3 = -6$ cm

So the height of the image is 6 cm.

The minus sign shows that it is on the lower side of the principal axis, i.e. the image is inverted.

Example: 7 :

An object is placed at a distance of 40 cm from a convex mirror of focal length 30 cm. Find the position of image and its nature.



Solution :

Here, object distance, $u = -40$ cm

Focal length of convex mirror, $f = +30$ cm

Now, using mirror formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ we get

$$\frac{1}{v} + \frac{1}{-40} = \frac{1}{30}$$

$$\text{or } \frac{1}{v} = \frac{1}{40} + \frac{1}{30} = \frac{7}{120}$$

$$\text{or } v = \frac{120}{7}$$

The positive sign shows that the image is formed on the right, i.e. behind the mirror.

$$\text{Now, magnification, } \Rightarrow m = -\frac{v}{u} = -\frac{120}{7 \times (-40)} = +\frac{3}{7}$$

Since, the magnification is positive, the image is erect. Thus, the image is formed 17.1 cm behind the mirror. The image is virtual, erect and diminished.

Example: 8 :

A 3 cm high object is placed at a distance of 30 cm from a concave mirror. A real image is formed 60 cm from the mirror. Calculate the focal length of the mirror and the size of the image.

Solution :

Object distance, $u = -30$

Image distance, $v = -60$

(real image is formed on the same side)

Now, using the mirror formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$\text{We get } \frac{1}{-60} + \frac{1}{-30} = \frac{1}{f} \text{ or } \frac{1}{f} = -\frac{3}{60} = -\frac{1}{20} \text{ or } f = -20 \text{ cm}$$

\therefore Focal length of the mirror = 20 cm

$$\text{Magnification } m = \frac{h'}{h} = -\frac{v}{u}$$

$$\text{or } \frac{h'}{3} = -\frac{(-60)}{(-30)} \text{ or } h' = 3 \times (-2) = -6 \text{ cm}$$

The height of the image is 6 cm. The negative sign shows that the image is inverted.

Example: 9 :

A 1 cm high object is placed at 20 cm in front of a concave mirror of focal length 15 cm. Find the position and nature of the image.

Solution :

$u = -20 \text{ cm, } f = -15 \text{ cm, } h_0 = 1 \text{ cm}$

Using mirror formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ we get

$$\frac{1}{v} + \frac{1}{-20} = \frac{1}{-15}$$

$$\text{or } \frac{1}{v} = -\frac{1}{15} + \frac{1}{20} = -\frac{1}{60}$$

$\therefore v = -60 \text{ cm}$

The image is formed 60 cm from the mirror. Since, the signs of u and v are the same, the object and image are formed on the same side of the mirror.

Therefore, the image is real.

Now magnification,

$$m = \frac{h'}{h} = \frac{v}{u} = \frac{-(-60)\text{cm}}{(-20)\text{cm}} = -3$$

$$\therefore h' = -3h = -3 \times 1 \text{ cm} = -3 \text{ cm}$$

The negative sign shows that the image is inverted. Thus, the image is real, inverted and of size 3 cm and formed 60 cm in front of the mirror.

Example: 10 : An object 4 cm high is placed 25 cm in front of a concave mirror of focal length 15 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Find the nature and size of image.

Solution : Here, $u = -25$ cm, $f = -15$ cm, $h = +4$ cm

Using the mirror formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$, we get

$$\text{or } \frac{1}{v} + \frac{1}{-25} = \frac{1}{-15}$$

$$\text{or } \frac{1}{v} = \frac{1}{-15} - \frac{1}{-25} = -\frac{1}{15} + \frac{1}{25} = -\frac{2}{75}$$

$$\text{or } v = \frac{-75}{2} = -37.5 \text{ cm}$$

Thus, the screen must be placed 37.5 cm from the mirror on the same side as the object.

Now, magnification,

$$m = \frac{h'}{h} = -\frac{v}{u}$$

$$\frac{h'}{4.0\text{cm}} = -\frac{(-37.5)}{(-25)} = -1.5 \quad \text{or } h' = -1.5 \times 4 = -6 \text{ cm}$$

Negative sign shows that the image is inverted. Hence, the image is real, inverted and of size 6 cm.

Example: 11 : An object 5 cm high is placed at a distance of 20 cm from a convex mirror of radius of curvature 30 cm. Find the position, nature and size of image.

Solution : Here, $u = -20$ cm, $h = 5$ cm

Radius of curvature, $r = +30$ cm

$$\therefore \text{Focal length, } f = \frac{r}{2} = +\frac{30}{2} = +15 \text{ cm}$$

Using the mirror formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$,

$$\text{we get } \frac{1}{v} + \frac{1}{-20} = \frac{1}{+15}$$

$$\text{or } \frac{1}{v} = \frac{1}{15} + \frac{1}{20} = \frac{7}{60} \quad \text{or } v = \frac{60}{7} \text{ cm}$$

The image is formed 8.5 cm from the mirror. The positive sign shows that the image is formed on the other side or behind the mirror. So the image is virtual.

$$\text{Magnification, } m = \frac{h'}{h} = -\frac{v}{u}$$

$$\text{or } \frac{h'}{5} = -\frac{60/7}{(-20)} = +\frac{60}{7 \times 20} = \frac{3}{7}$$

or $h' = 5 \times \frac{3}{7} = \frac{15}{7}$ cm. The height of the image is 2.1 cm. Positive sign shows that the image is erect.

Example: 12: A 2 cm high object is placed at a distance of 32 cm from a concave mirror. The image is real, inverted and 3 cm in size. Find the focal length of the mirror and the position of the image.

Solution : We have, $m = -\frac{v}{u} = \frac{h_i}{h_o}$

From the question, $h_i = -3$ cm and $h_o = 2$ cm.

$$\therefore m = \frac{h_i}{h_o} = \frac{-3 \text{ cm}}{2 \text{ cm}} = -1.5$$

$$\text{or } -\frac{v}{u} = -1.5$$

$$\text{or } \frac{v}{-32 \text{ cm}} = 1.5 \text{ or } v = -48 \text{ cm.}$$

$$\text{We have } \frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{-32 \text{ cm}} + \frac{1}{-48 \text{ cm}} = \frac{-5}{96 \text{ cm}}$$

$$\text{or } f = \frac{-96}{5} = -19.2 \text{ cm.}$$

So the focal length of the concave mirror is 19.2 cm and the image is formed 48 cm in front of it.

Example: 13 : An object is placed at (i) 10 cm, (ii) 5 cm in front of a concave mirror of radius of curvature 15 cm. Find the position, nature and magnification of the image in each case.

Solution : The focal length $f = -15/2$ cm, $= -7.5$ cm

(i) The object distance, $u = -10$ cm

$$\frac{1}{v} + \frac{1}{-10} = \frac{1}{-7.5} \quad \text{or} \quad \frac{1}{v} = -\frac{1}{7.5} + \frac{1}{10}$$

$$\text{or } \frac{1}{v} = \frac{-10 + 7.5}{7.5 \times 10} \quad \text{or} \quad v = \frac{7.5 \times 10}{-2.5}$$

or $v = -30$ cm

The image is 30 cm from the mirror on the same side as the object.

Also, magnification, $m = -\frac{v}{u} = -\left(\frac{-30}{-10}\right) = -3$

The image is magnified, real and inverted.

(ii) The object distance, $u = -5$ cm. Then $\frac{1}{v} + \frac{1}{-5} = \frac{1}{-7.5}$

or $\frac{1}{v} = -\frac{1}{7.5} + \frac{1}{5}$ or $\frac{1}{v} = \frac{-5 + 7.5}{7.5 \times 5}$

or $v = \frac{7.5 \times 5}{2.5}$ or $v = 15$ cm

This image is formed at 15 cm behind the mirror. It is a virtual image.

Magnification, $m = -\frac{v}{u} = -\frac{15}{(-5)} = 3$

The image is magnified, virtual and erect.

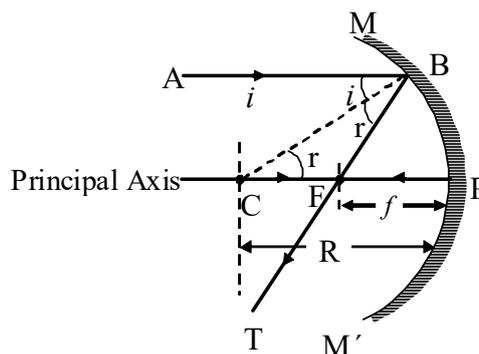


TRY YOURSELF

2. The radius of curvature of a convex mirror used on a moving automobile is 2 m. A truck is coming behind it at a distance of 3.5 m. Calculate (i) the position and (ii) the size of the image relative to the size of the truck. What will be the nature of the image?

10.4 Relation Between ‘f’ and ‘R’ :

Let two incident rays AB (parallel to the principal axis) and CP (coinciding with the principal axis) fall on the concave mirror MM'. BT and PC are corresponding reflected rays.



$\angle ABC = \angle CBF$ (i) (since $\angle i = \angle r$)

Also $\angle ABC = \angle BCF$ (ii) (Alternate angles)

From equation (i) and (ii), we have

$\angle CBF = \angle BCF$

$\therefore BF = CF$ (iii) (sides opposite to equal angles)

For the mirror of small aperture, the point B is very near to the point P, then

$BF = PF$ (iv) (nearly equal)

From equation (iii) and (iv),

$CF = PF$ (v)

Now, $CP = CF + PF = PF + PF$ (from equation (v))

$$CP = 2PF$$

$$\Rightarrow PF = CP/2$$

But $PF = f$ and $CP = R \Rightarrow \boxed{f = \frac{R}{2}}$

The same relation is also true for a convex mirror.

10.5 Spherical Aberration :

The rays of light after reflection from a concave mirror meet at a single point only if a narrow beam of light falls on the mirror. In case of a wide beam, it is found that the marginal rays get focussed relatively close to the pole in comparison to the paraxial rays.

The reflected lines form a pattern and this has an envelope known as the **caustic curve**. Because of this the image is distorted. This defect is called **spherical aberration**. The spherical aberration is not present in **parabolic mirrors**.

10.6 Identification of Mirrors :

(a) By Touching :

- (i) Plane, it is a plane mirror.
- (ii) Depressed inwards at the middle, it is a concave mirror.
- (iii) Projected outwards at the middle, it is a convex mirror.

(b) By Seeing the Image :

- (i) If the image formed is always erect and of the same size, it is a plane mirror.
- (ii) If the image formed is always erect and smaller in size, it is a convex mirror.
- (iii) If the image formed is erect and magnified when mirror is close to the face and the size and nature (virtual to real) of the image change on moving the mirror, it is concave mirror.



Let's know

Uses of Mirror

(a) Concave Mirror :

- (i) As reflectors in the headlights of cars, searchlights, etc.
- (ii) Dentists (as the dentist's mirror) to focus light on the tooth to be examined.
- (iii) Shaving mirrors and as make-up mirrors to see the enlarged erect image of the face. For this to happen, face must be placed closer to the mirror.
- (iv) Concave mirror (or parabolic mirrors) are used as radiation collector in solar heating devices.

(b) Convex Mirror :

- (i) Rear-view mirrors or side-mirror (also called driver's mirror) on automobiles, such as cars, trucks and buses to see the traffic coming from behind.
- (ii) Staircase-mirrors on the double-decker buses.
- (iii) Vigilance-mirrors in big shops and stores.



EXAMPLES



Example 14 : A concave mirror produces two times magnified real image of an object placed at 10 cm in front of it. Find the position of the image?

Solution : Here, $u = -10$ cm (Sign convention)

$$m = -2 \quad (\because \text{Image is real}) \text{ But } m = -\frac{v}{u}$$

$$-2 = -\frac{v}{u} \quad \therefore v = 2u = 2(-10 \text{ cm}) = -20 \text{ cm}$$

Example 15 : An object of 5.0 cm in size is placed at a distance of 20.0 cm from a concave mirror of focal length 15.0 cm. At what distance from the mirror, should a screen be placed to get the sharp image? Also calculate size of the image.

Solution : Here, $h = + 5.0$ cm,
 $f = - 15.0$ cm (sign convention)
 $u = - 20.0$ cm (sign convention)

Step 1. Determination of the position of the image

Using $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$, we get $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-15} - \frac{1}{(-20)}$

$$\text{or } \frac{1}{v} = -\frac{1}{15} + \frac{1}{20} = -\frac{1}{60}$$

$$\text{or } v = - 60 \text{ cm}$$

So the screen must be placed at a distance of 60 cm in front of the concave mirror.

Step 2. Determination of size and its nature.

$$\text{Using, } m = \frac{h'}{h} = \frac{-v}{u}$$

$$\text{or } h' = \frac{-v}{u} h = - \frac{-(-60) \times 5.0}{-20.0} = -15.0 \text{ cm}$$

Thus, size of image = 15.0 cm

Negative sign with h' shows that the image is inverted

Example 16 : An object 4 cm high is placed at a distance of 6 cm in front of a concave mirror of focal length 12 cm. Find the position, nature and size of the image formed.

Solution: Here, size of the objects: $h = 4$ cm
 $u = - 6$ cm (sign convention)
 $f = - 12$ cm (sign convention)

Step 1: Using $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$,

$$\text{we get } -\frac{1}{6} + \frac{1}{v} = \frac{1}{-12}$$

$$\text{or } \frac{1}{v} = -\frac{1}{12} + \frac{1}{6} = \frac{1}{12} \quad \text{or } v = 12 \text{ cm}$$

Thus, image is formed at a distance of 12 cm behind the concave mirror as v is positive.

Therefore image is virtual (nature).

Step 2. Using $\frac{h'}{h} = \frac{-v}{u}$, we get

$$h' = \frac{-v}{u} \times h = \frac{-12 \text{ cm}}{-6 \text{ cm}} \times 4 \text{ cm} = 8 \text{ cm}$$

So image is 8 cm tall. Since h' is positive, so image is erect.

➤ ACTIVITY-04

Power of mirror :

The power of a mirror is defined as its capacity to converge or diverge. Mathematically, it is defined as inverse of focal length. For **concave mirror** power is **positive** as it is a **converging mirror** and for **convex** it is **negative** as it is a **diverging mirror**

$$P = -\frac{1}{f(\text{in m})} = -\frac{100}{f(\text{in cm})}$$

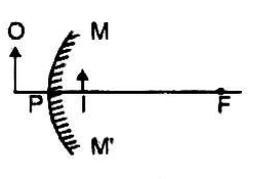
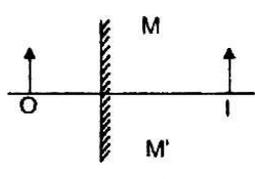
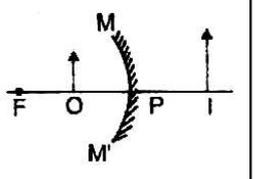
The unit of power is diopter.

In sign convention, **f (or R) is negative for concave** or converging mirror and **positive for convex** or diverging mirror.

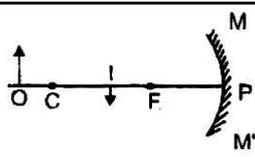
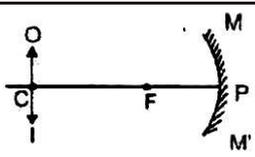
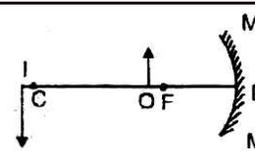
10.7 Identification of the mirror by the size and nature of the image:

- (i) If object and image are of the same nature (i.e. both on the same side of the mirror) then they will be inverted.
- (ii) If the object and image are on the opposite sides of the mirror then image is erect relative to object.

For real extended object, if the image formed by a single mirror is erect, it is always vertical (i.e. m is $+ve$) and in this situation if the size of image is

Smaller than object, the mirror is convex	Equal to object, the mirror is plane	Larger than object, the mirror is concave
 <p style="text-align: center;">$m < +1$</p>	 <p style="text-align: center;">$m = +1$</p>	 <p style="text-align: center;">$m > +1$</p>

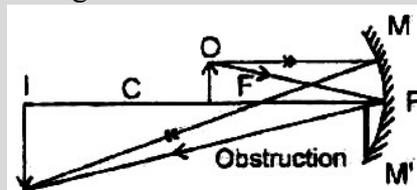
So by observing the size of erect image in a mirror, we can decide the nature of the mirror i.e. whether it is convex, concave or plane. For a real extended object if the image formed by a single mirror is inverted it is always real (i.e. m is $-ve$) and the mirror is concave. In this situation if the size of the image is

Smaller than object, object is placed between ∞ and C and then image is formed between F and C.	Equal to object, if object is at C and then image is also at C.	Larger than object, object is placed between C and F and then image is formed between C and ∞ .
 <p style="text-align: center;">$m < -1$</p>	 <p style="text-align: center;">$m = -1$</p>	 <p style="text-align: center;">$m > -1$</p>



Let's know

As every part of the mirror forms complete image, if a part of mirror (say half) is obstructed (say covered with black paper) full image will be formed but intensity will be reduced.



11. REFRACTION

When light goes from air to glass, it bends towards the normal to the interface separating these two media (Figure (a)). On the other hand, when light goes from glass to air, it bends away from the normal to the interface separating these two media (Figure (b)). This phenomenon of bending light is known as refraction of light.

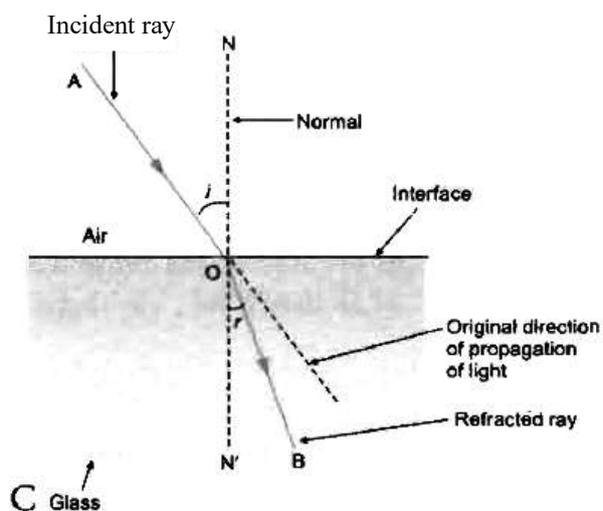


figure (a)

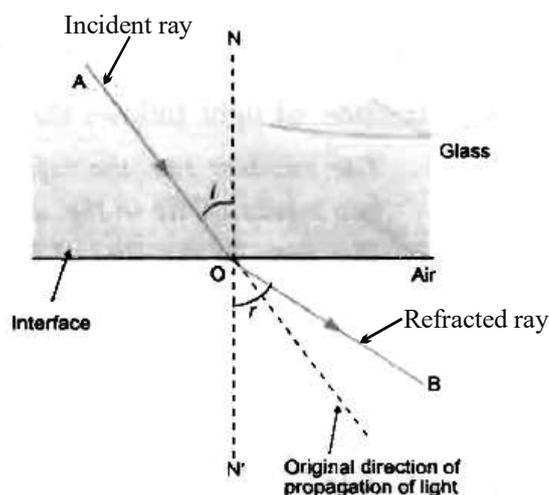


figure (b)

Definition : The bending of light rays when they pass obliquely from one medium to another medium is called refraction of light.

The ray AO in figure (a) and (b) are called incident rays. The rays OB in figure (a) and (b) are called refracted rays. NON' is normal to the interface separating two media.

$\angle AON$ is called incident angle $\angle i$ and $\angle BON'$ is called refracted angle $\angle r$.



Let's know

Interface : A boundary or surface separating two media is called interface.

11.1 Cause of Refraction of Light :

We come across many media like air, glass, water etc. **A medium is a transparent material through which light is transmitted.** Every transparent medium has a property known as optical density. The optical density of a transparent medium is closely related to the speed of light in the medium. If the optical density of a transparent medium is low, then the speed of light in that medium is high. Such a medium is known as **optically rarer medium**. Thus, **optically rarer medium is that medium through which light travels fast.**

On the other hand, if the optical density of a transparent medium is high, then the speed of light in that medium is low. Such a medium is known as **optically denser medium**. Thus, **optically denser medium is that medium through which light travels slow.**

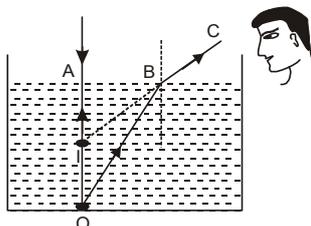
Speed of light in air is more than the speed of light in water, so air is optically rarer medium as compared to the water. In other words, water is optically denser medium as compared to air. Similarly, speed of light in water is more than the speed of light in glass, so water is optically rarer medium as compared to the glass. In words, glass is optically denser medium as compared to water.

When light ray goes from air (optically rarer medium) to glass (optically denser medium) such that the light ray in air makes an angle with the normal to the interface separating air and glass, then it bends towards the normal. Similarly, if light ray goes from glass to air, again it bends away from the normal. The phenomena of bending of light ray from its path is known as refraction. We have seen that the speed of light in different media is different, so we can say that refraction of light takes place because the speed of light is different in different media. Thus, the cause of refraction can be summarised as follows:

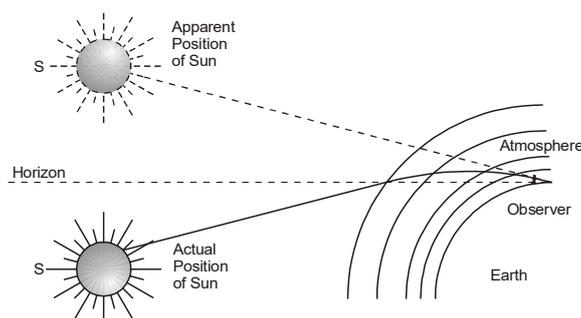
"The refraction of light takes place because speed of light changes when light goes from one medium to another medium."

11.2 Effects of Refraction of Light :

- A pencil appears bent and short in water :
- A water tank appears shallow i.e. less deep than its actual depth :



- **Apparent shift in the position of the sun at sunrise and sunset :** Due to the atmospheric refraction, the sun is visible before actual sunrise and after actual sunset.



Refraction effect at sunset and sunrise

- **Twinkling of stars :** It also happens due to refraction of light

11.3 Laws of Refraction :

Refraction of light follows the following two laws:

- (1) The incident ray, the refracted ray and the normal to the surface separating the two media all lie in the same plane.
- (2) The ratio of the sine of the incident angle ($\angle i$) to the sine of the refracted angle ($\angle r$) is constant for a pair of two media.

$$\text{i.e. } \frac{\sin i}{\sin r} = \frac{n_2}{n_1} \text{ constant} \quad \dots(1)$$

This constant is known as the **refractive index** of the medium in which refracted ray travels with respect to the medium in which incident ray travels. **Refractive index is denoted by n.**

Refractive index of second medium with respect to the first medium is denoted by

n_{21} .

Thus, equation (1) can be written as

$$n_{21} = \frac{\sin i}{\sin r} = \frac{n_2}{n_1} \quad \dots(2)$$

This law is also known as **Snell's law** as it was stated by **Prof. Willebrord Snell** (Dutch mathematician and astronomer).

11.4 Refractive Index :

Speed of light in vacuum is maximum and is equal to $3 \times 10^8 \text{ ms}^{-1}$. In air, speed of light is little smaller than in vacuum. But for all practical purposes, we consider the speed of light in air equal to the speed of light in vacuum. However speed of light decreases in denser media like water, glass, its speed decreases.

The amount of change in the speed of light in a medium. This property is known as refractive index of the medium. Refractive index is a measure of how much the speed of light changes when it enters the medium from air.

(a) **Absolute Refractive Index :** Absolute refractive index of a medium is defined as the ratio of the speed of light in vacuum or air to the speed of light in the medium. **It is denoted by n.**

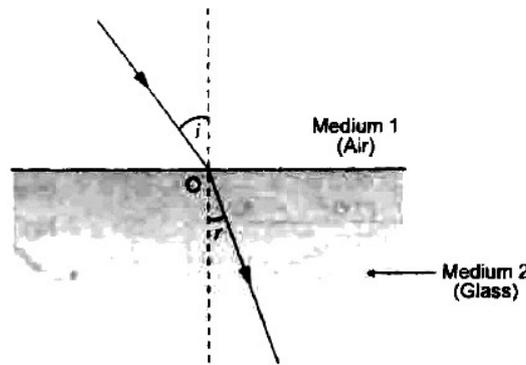
i.e. **Refractive index,**
$$n = \frac{\text{Speed of light in air or vacuum}(c)}{\text{Speed of light in medium}(v)}$$

or
$$n = \frac{c}{v}, \text{ where } c = 3 \times 10^8 \text{ ms}^{-1}$$

Refractive index is a pure number. It has no unit.

(b) **Relative Refractive Index**

Consider a material medium 2 surrounded by another material medium 1 as shown in figure. Let the light goes from medium 1 to the medium 2, then the refractive index of medium 2 with respect to medium 1 is known as the relative refractive index of medium 2. It is given by



$$n_{21} = \frac{\text{Speed of light in medium 1}(v_1)}{\text{Speed of light in medium 2}(v_2)}$$

i.e.
$$n_{21} = \frac{v_1}{v_2} \quad \dots(1)$$

Multiply and divide R.H.S. of equation (1) by c (speed of light in air), we get

$$n_{21} = \frac{cv_1}{cv_2} = \left(\frac{c}{v_2}\right) \times \left(\frac{v_1}{c}\right) = \left(\frac{\frac{c}{v_2}}{\frac{c}{v_1}}\right) \quad \dots(2)$$

Hence equation (2) can be written as

$$n_{21} = \frac{n_2}{n_1} \quad \dots(3)$$

Thus, relative refractive index of medium 2 with respect to medium 1 is defined as the ratio of absolute refractive index of medium 2 to the absolute refractive index of medium 1.

Also,
$$n_{21} = \frac{\sin i}{\sin r} \quad \dots(4)$$

Comparing equation (3) and (4), we get

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

or
$$n_1 \sin i = n_2 \sin r \quad \dots(5)$$

Explanation of bending of light when it travels from one medium to another medium.

(i) When light goes from rarer medium of refractive index n_1 to a denser medium of refractive index $n_2(n_2 > n_1)$.

According to Snell's law : $\frac{\sin i}{\sin r} = \frac{n_2}{n_1} > 1$ or $\sin i > \sin r$

$\therefore \angle i > \angle r$ or $\angle r < \angle i$

Since, $\angle r < \angle i$, so the refracted ray makes less angle with the normal as compared to the angle made by incidence ray with the normal. Hence, refracted ray bends towards the normal.

- (ii) When light goes from denser medium of refractive index n_2 to a rarer medium of refractive index n_1 ($n_1 < n_2$).

According to Snell's law : $\frac{\sin i}{\sin r} = \frac{n_1}{n_2} < 1$ or $\sin i < \sin r$

or $\angle i < \angle r$ or $\angle r > \angle i$

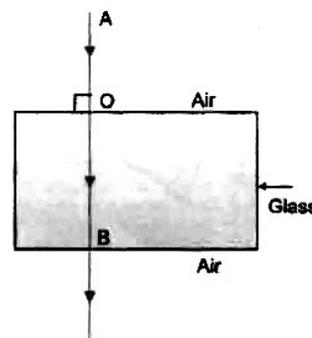
Since, $\angle r > \angle i$, so the refracted ray makes greater angle with the normal as compared to the angle made by incidence ray with the normal. Hence, refracted ray bends away from the normal.

- (iii) When incident light falls perpendicular to the interface separating two media of refractive indices n_1 and n_2 .

According to Snell's law : $\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$, or $\sin r = \frac{n_1}{n_2} \sin i$

Since $\angle i = 0$, so $\sin r = \frac{n_1}{n_2} \sin 0^\circ = 0$ or $\angle r = 0$

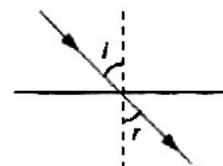
Therefore, the refracted light travels along the normal and hence, there is no bending of light (or no refraction of light as shown in figure.



- (iv) When light goes from one medium to another medium of same refractive index (i.e. $n_1 = n_2$)

According to Snell's law : $\frac{\sin i}{\sin r} = \frac{n_2}{n_1} = 1$ or $\sin i = \sin r$ or $\angle i = \angle r$

Thus, no refraction of light takes place as shown in figure.



11.4 Factors on Which the Refractive Index of Medium Depends :

Refractive index of a medium depends upon:

- (i) Nature of the material of the medium.
- (ii) Density of the medium.
- (iii) Colour or wavelength of the light.

11.5 Refractive Index of Medium 2 w.r.t. Medium 1 is Reciprocal of the Refractive Index of Medium 1 w.r.t. Medium 2 :

We know, refractive index of medium 2 w.r.t. medium 1 is given by,

$$n_{21} = \frac{\text{Speed of light in medium 1 } (v_1)}{\text{Speed of light in medium 2 } (v_2)}$$

or $n_{21} = \frac{v_1}{v_2}$ (1)

Similarly, refractive index of medium 1 w.r.t. medium 2 is given by,

$$n_{12} = \frac{v_2}{v_1}$$
(2)

Multiplying equation (1) and (2),

we get, $n_{21} \times n_{12} = \frac{v_1}{v_2} \times \frac{v_2}{v_1} = 1$ or $n_{21} = \frac{1}{n_{12}}$

➤ **ACTIVITY-06**

1. When light travels from one medium to another medium, the speed of light and its wavelength (λ) change but **frequency (ν) of light remains the same.**

2. Since $c = f\lambda$ and $\nu = f\lambda_m$

$$n = \frac{c}{\nu} = \frac{\lambda}{\lambda_m}$$

Thus, refractive index of a medium or material depends upon the wavelength of the light falling on it.

Refractive index of a medium is minimum for red light and maximum for violet light.

Wavelength of light in medium,

$$\lambda_m = \frac{\lambda}{n} = \frac{\text{wavelength of light in air}}{\text{refractive index of medium}}$$

3. As $n > 1$, so $\lambda_m < \lambda$. Thus, **wavelength of light decreases when it travels from air to another medium like water, glass etc.**

4. When a ray of light falls normally on a medium, $\angle i = 0$ and hence $\angle r = 0$. Then refraction of light does not take place.

5. $n = \frac{c}{\nu}$ or $\nu = \frac{c}{n}$. More is the refractive index of a medium, less is the speed of light in that medium and vice versa.

Refractive index of few substances with respect to vacuum for yellow light (sodium light of wave length 5.89×10^{-7} m or 589 nm) are given in table.

S.No.	Name of Substance	Refractive Index
1	Air	1.0003
2	Hydrogen	1.00013
3	Carbon dioxide	1.00045
4	Ice	1.31
5	Water	1.333
6	Alcohol	1.36
7	Kerosene	1.44
8	Carbon tetrachloride	1.46
9	Turpentine oil	1.47
10	Glycerine	1.47
11	Benzene	1.501
12	Crown glass	1.52
13	Rock salt	1.54
14	Carbon disulphide	1.63
15	Flint glass	1.66
16	Ruby	1.71
17	Diamond	2.42

Optical density and **mass density** of a medium are two different entities. **Optical density of a medium determines the ability of the medium to refract light. However mass density is defined as the mass per unit volume of the substance.** Optical density of a medium is directly proportional to the refractive index of the medium. For example, **refractive index of kerosene oil is 1.44 and that of water is 1.33. Therefore, the optical density of kerosene oil is more than the optical density of water. However, mass density of kerosene is less than the mass density of water.**


EXAMPLES


Example 17 : If, while standing on the bank of a stream, you wished to spear a fish swimming in the water out in front of you, would you aim above, below, or directly at the observed fish to make a direct hit? If you decided instead to zap the fish with a laser, would you aim above, below, or directly at the observed fish? Defend your answer.

Solution : When you try to hit the fish with a spear, you need to aim below as the fish is actually at a lower depth than that observed by you from outside the water due to refraction of light.

When you aim with a laser light then also you should aim much below as the path of laser will change as it enters in water. Since it is going from rarer to denser medium, it bends towards the normal and deviates from the original path.

Example 18 : The refractive index of water is $\frac{4}{3}$ and of glass is $\frac{3}{2}$. Calculate the refractive index of glass with respect to water.

Solution : Let the 3 media be 1, 2 and 3, 1 for air, 2 for water, 3 for glass in that order.

$$\text{Given: } {}_1\mu_2 = \frac{4}{3}, {}_2\mu_3 = ?, {}_3\mu_1 = \frac{1}{3},$$

$$[\because {}_1\mu_3 = \frac{3}{2} \text{ and } \therefore {}_3\mu_1 \text{ is the reciprocal of } {}_1\mu_3]$$

Now using the formula, ${}_1\mu_2 \times {}_2\mu_3 \times {}_3\mu_1 = 1$ and substituting values, we have

$$\frac{4}{3} \times {}_2\mu_3 \times \frac{2}{3}$$

$${}_2\mu_3 = \frac{1 \times 3 \times 3}{4 \times 2} = \frac{9}{8}$$

\therefore The refractive index of glass with respect to water is $\frac{9}{8}$.



Let's know

If ${}_1\mu_2$, ${}_2\mu_3$ and ${}_3\mu_1$ be refractive index of medium 2 w.r.t. medium 1, refractive index of medium 3 w.r.t. medium 2 and refractive index of 1 w.r.t. 3 respectively then ${}_1\mu_2 \times {}_2\mu_3 \times {}_3\mu_1 = 1$.

Cauchy's relation

It gives relation between refractive index (μ) and wavelength (λ) of light. The Cauchy's relation is given by

where A and B are constants.

$$\text{Thus, } \lambda_{\text{red}} > \lambda_{\text{violet}} \quad \Rightarrow \quad \mu_{\text{red}} < \mu_{\text{violet}}$$



Let's know

If the speed of light were the same in all media refraction would not occur when light passes from one medium to another.

EXAMPLES

Example 19 : Light reflected from a fish strikes the surface of the water at an angle of 38° to the normal. What is the angle of refraction of the light into the air? (Given : $\sin 38^\circ = 0.61$ and $\sin 55^\circ = 0.81$)

Solution : Snell's law gives, $n_w \sin \theta_1 = n_a \sin \theta_2$
 $\sin \theta_2 = (1.33) \sin 38^\circ$
 $\theta_2 = 55^\circ$

Example 20 : Light strikes an interface between two materials of refractive indices n_1 and n_2 , at an angle θ_1 to the normal to the surface. Show that a ray of the light is bent towards the normal if $n_1 < n_2$ and that a ray is bent away from the normal if $n_1 > n_2$.

Solution : Snell's law gives from any light ray $\sin \theta_2 = \frac{n_1}{n_2} \sin \theta_1$

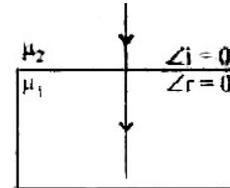
If $n_1 < n_2$, then $\sin \theta_2 < \sin \theta_1$ and $\theta_2 < \theta_1$. This means that the ray is bent toward the normal.

If $n_1 > n_2$, then $\sin \theta_2 > \sin \theta_1$ and $\theta_2 > \theta_1$. This means that the ray is bent away from the normal.

➤ **ACTIVITY-07**

Conditions of no refraction : If light is incident normally on a boundary i.e. $\angle i = 0^\circ$.

Then for Snell's law
 $\mu_1 \sin 0 = \mu_2 \sin r$
 $\Rightarrow \sin r = 0$ i.e., $\angle r = 0$
 i.e. light passes undeviated from the boundary.
 (so boundary will be invisible)



If the refractive indices of two media are equal i.e., if

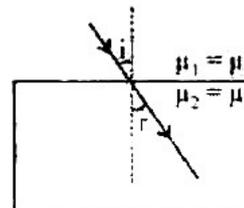
$$\mu_1 = \mu_2 = \mu$$

Then from Snell's law

$$\mu_1 \sin i = \mu \sin r$$

$$\Rightarrow \angle i = \angle r$$

i.e., ray passes undeviated from the boundary with $\angle i = \angle r \neq 0$ and boundary will not be visible.
 This is also why a transparent solid is invisible in a liquid if $\mu_s = \mu_L$.



EXAMPLES

Example 21 : The speed of light in air is 3×10^8 m/s. What will be its speed in diamond whose refractive index is 2.4?

- (A) 3×10^8 m/s (B) 1.25×10^8 m/s (C) 7.2×10^8 m/s (D) 332 m/s

Solution : Speed of light in air = 3×10^8 m/s
 Refractive index of diamond = 2.4
 Let the speed of light in diamond = v m/s
 Then, $n = c/v$

$$\text{or } v = \frac{c}{n} = \frac{3 \times 10^8}{2.4} = 1.25 \times 10^8 \text{ m/s} \quad \therefore \quad \text{(B)}$$

Example 22 : A beam of monochromatic blue light of wavelength 420 nm in air travels in water ($n = 4/3$). Its wavelength in water will be

Solution : Wavelength of blue light in air = 420×10^{-9} m
 Refractive index of water = $4/3$
 Let the wavelength of blue light in water be ' λ '

$$\text{Then, } n = \frac{c}{v} = \frac{\lambda_{\text{air}}}{\lambda_{\text{medium}}} \quad \text{or} \quad \frac{4}{3} = \frac{420 \times 10^{-9}}{\lambda}$$

$$\text{or } \lambda = \frac{420 \times 10^{-9}}{4} \times 3 = 315 \times 10^{-9} \text{ m} = 315 \text{ nm}$$



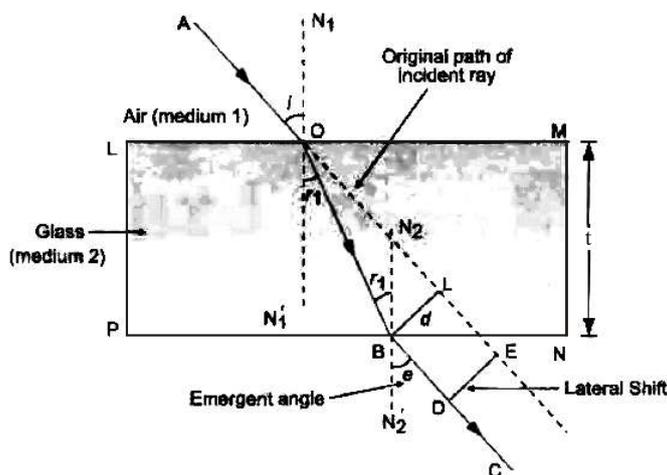
TRY YOURSELF

3. The velocity of light in glass is $2 \times 10^8 \text{ ms}^{-1}$, while in vacuum it is $3 \times 10^8 \text{ ms}^{-1}$. What is the absolute refractive index of glass?

11.6 Refraction Through a Glass Slab :

When a ray of light falls on a glass slab obliquely (i.e. by making a certain angle with the normal), it emerges out of the glass slab parallel to its original direction of propagation. However, **there is a shift in the path of the incident ray. This shift is known as lateral shift or lateral displacement of the ray of light.**

Consider a rectangular glass slab LMNP of thickness ' t '. Let incident ray AO travelling in air strikes the glass slab at an angle of incidence $\angle i$ (as shown in the given figure). After refraction, the ray bends towards the normal N_1N_1' . Let the refracted ray OB makes $\angle r_1$ with the normal N_1N_1'



According to Snell's law of refraction

$$n_{21} = \frac{\sin i}{\sin r_1} \quad \dots(1)$$

The ray OB suffers refraction at B and emerges out of the glass slab into the air.

Let the emergent ray BC makes an angle e with the normal N_2N_2'

According to Snell's law of refraction,

$$n_{12} = \frac{\sin r_1}{\sin e} \quad \dots(2)$$

We know $n_{21} = \frac{1}{n_{12}}$ (3)

Substituting the values of equation (1) and (2) in equation (3), we get

$$\frac{\sin i}{\sin r_1} = \frac{1}{\frac{\sin r_1}{\sin e}} = \frac{\sin e}{\sin r_1}$$

or $\sin i = \sin e$ or $\angle i = \angle e$

This shows that in refraction through a rectangular slab the incident ray and emergent ray of light are parallel to each other.

Lateral Shift (or displacement): The perpendicular distance between the original path of incident ray and the emergent ray coming out of a glass slab is called lateral shift or lateral displacement of the emergent ray of light.

Factors on which Lateral Shift depends

- Lateral shift varies directly proportional to the thickness of glass slab.
- Lateral shift varies directly proportional to the incident angle.
- Lateral shift varies directly proportional to the refractive index of glass slab
- Lateral shift varies inversely proportional to the wavelength of incident light



Let's know

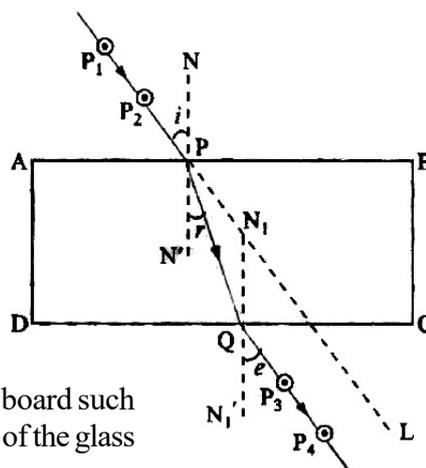
Lateral displacement depends on the following factors.

- | | | |
|-------|-------------------------------------|-------------------------------|
| (i) | Refractive index of the medium (n), | $x \propto n$ |
| (ii) | Thickness of the medium (t), | $x \propto t$ |
| (iii) | Angle of incidence (i), | $x \propto i$ |
| (iv) | Wavelength of light (λ), | $x \propto \frac{1}{\lambda}$ |

➤ PRACTICAL LEARNING

1. **Perform an activity to show that light bends from its path, when it falls obliquely on the surface of a glass slab. Also show that angle of incidence is about equal to the emergent angle.**

- Take a glass slab and place it on a white sheet of paper fixed on a drawing board.
- Mark the boundary ABCD of the glass slab.
- Fix two pins P_1 and P_2 , vertically on the drawing board such that line joining the pins is inclined to the edge AB of the glass slab.
- Now, look through the glass slab from opposite side so that the images of pins P_1 and P_2 are seen exactly in line. Fix two P_3 and P_4 , vertically on the drawing board such that pins P_3 , P_4 and image of P_1 and P_2 are exactly in one line.
- Remove the glass slab and all pins. Join the points P_1 and P_2 with a line and extend this line to touch the edge AB at P. Similarly join the points P_3 and P_4 with a line and extend the line to touch the edge DC at Q.
- Join points P and Q with a straight line.
- Draw normal NN' at P on the edge AB and a normal N_1N_1' at Q on the edge DC.

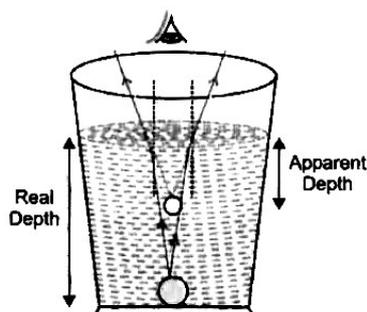


- (viii) Measure $\angle P_2PN$ and $\angle P_3QN_1'$.

This activity shows that when light falls obliquely on a glass slab, it bends along PQ from its original path along PL.

Also $\angle P_2PN \simeq \angle P_3PN_1'$. That is, angle of incidence is about equal to the emergent angle.

2. Describe an activity to show that the apparent depth of a coin at the bottom of a bucket filled with water is less than the real depth of the coin in the water.



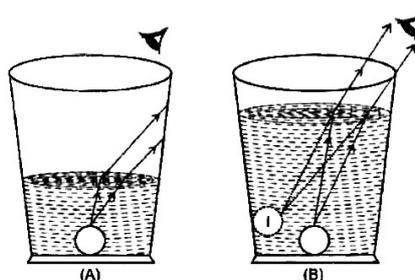
- (i) Place a fifty paise coin at the bottom of a bucket filled with water.
 (ii) Look at the coin through water and try to pick up the coin at one go. It is observed that the coin is not picked up at one go.

This is because, the coin appears to be raised from its actual position due to refraction of light (as shown in the figure given above). When we try to pick up the coin in the water, we think that the coin is somewhere above the bottom of the bucket.

This activity shows that the apparent depth of the coin in water is less than its real depth in water.

$$\text{Now, } \frac{\text{Real Depth}}{\text{Apparent Depth}} = n \text{ (refractive index of the medium)}$$

3. Describe an activity to make a coin visible at the bottom of a bucket half filled with water, which was not visible when you look at the coin from one side above the water.



- (i) Place fifty paise coin at the bottom of a bucket half filled with water.
 (ii) Place your eye at one side of the bucket and look at the water in the bucket as shown in figure A. You will not see the coin in water.
 (iii) Now keep your eye at the same position and ask your friend to pour more water in the bucket.
 (iv) You will see the coin in water at I when the bucket is almost filled with water (as shown in the figure above).

Conclusion : This activity shows that the distance through which an object (say coin) appears to be raised in water increases with the increase in the real depth of the object.

11.7 Real and Apparent Depths :

When an object is seen from other medium, we don't see its actual depth or height. **The depth we see is called apparent depth and the actual depth is called the real depth.**

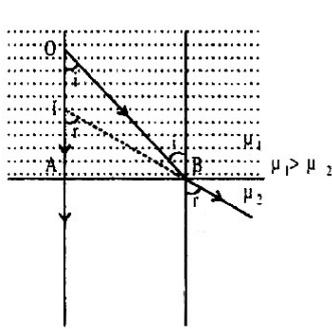


figure (a)

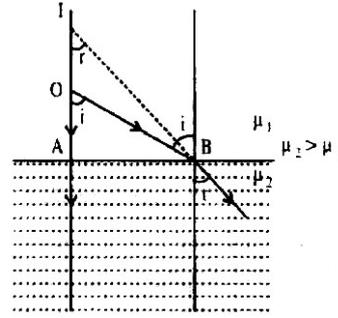


figure (b)

Let us consider an object O placed in a medium of refractive index μ_1 . It is being observed by an observer in other medium of refractive index μ_2 .

Two rays OA and OP are made incident on the interface separating the two media where they get refracted. OA passes through second medium undeviated as it falls normally. When the refracted rays are produced backward, they meet at I producing virtual image of O there. If $\mu_1 > \mu_2$ (fig.a) i.e. observer is in rarer medium, the image is formed at a distance less than the object from the observer. In other words the image shifts towards the observer.

If $\mu_1 < \mu_2$ (Fig.b), i.e. observer is in denser medium, the image is formed at a distance greater than the distance of the object from the observer. That is, the image shifts away from the observer.

Let us now calculate the shift $OI (= \Delta t)$

If i and r are small,

$$\sin i = \tan i = \frac{AB}{OA} \quad \text{and} \quad \sin r = \tan r = \frac{AB}{IA}$$

By Snell's law,

$$\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1} \Rightarrow \frac{AB}{OA} \times \frac{IA}{AB} = \frac{\mu_2}{\mu_1} \Rightarrow \frac{IA}{OA} = \frac{\mu_2}{\mu_1}$$

Clearly, $IA =$ Apparent depth of an object

$OA =$ Real depth of object

$$\therefore \frac{\text{Apparent depth}}{\text{Real Depth}} = \frac{\mu_2}{\mu_1}$$

Case I: If $\mu_1 = \mu$ and $\mu_2 = 1$ (for air), then

$$\frac{AI}{AO} = \frac{\text{Apparent depth}}{\text{Real Depth}} = \frac{\mu_2}{\mu_1} \dots (1) \Rightarrow \mu = \frac{\text{Real Depth}}{\text{Apparent Depth}}$$

$$\text{Now, Shift in image } (\Delta t) = OI = AO - AI = \left[\frac{AO - AI}{AO} \right] AO = \left[1 - \frac{AI}{AO} \right] AO$$

$$\text{or } \Delta t = \left[1 - \frac{1}{\mu} \right] t, \text{ From equation (1)}$$

Where $r = AO =$ thickness of the medium in which object is placed

Note: If the object is placed in the medium which consists of a number of media of refractive indices $\mu_1, \mu_2, \mu_3, \dots$ and the thickness t_1, t_2, t_3, \dots respectively, then

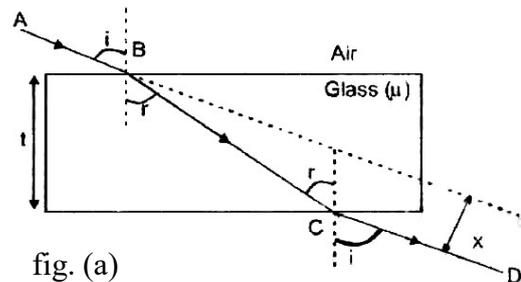


fig. (a)

$$\text{Virtual depth (AI)} = \frac{t_1}{\mu_1} + \frac{t_2}{\mu_2} + \frac{t_3}{\mu_3} + \dots$$

Virtual displacement (OI) =

$$t_1 \left[1 - \frac{1}{\mu_1} \right] + t_2 \left[1 - \frac{1}{\mu_2} \right] + t_3 \left[1 - \frac{1}{\mu_3} \right] + \dots$$

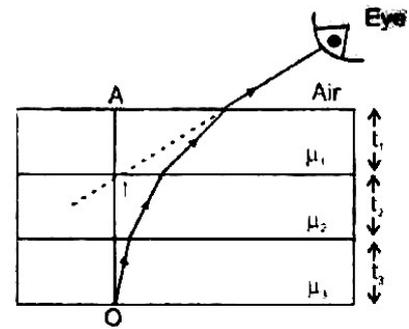


fig. (b)

Case II : If $\mu_1 = 1$ (for air) and $\mu_2 = \mu$ then

$$\frac{AI}{AO} = \frac{\text{Apparent Depth}}{\text{Real Depth}} = \frac{\mu_2}{\mu_1} = \frac{\mu}{1} \dots(2)$$

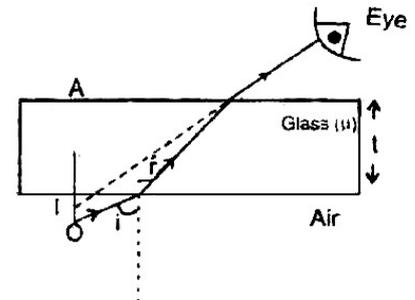
$$\therefore \text{shift in image} = OI = AI - AO = \left[\frac{AI - AO}{AO} \right] AO = \left[\frac{AI}{AO} - 1 \right] AO$$

$$\Rightarrow \Delta t = (\mu - 1)t$$

Case III : When object and observer both are in rarer medium.

Let observer is in air & object is at a point O in air, as shown in figure, A glass is there in between observer & object. Image form at point I. Refractive index of glass is μ

$$\text{Virtual displacement} = OI = \left[t - \frac{1}{\mu} \right]$$



EXAMPLES

Example: 23 :

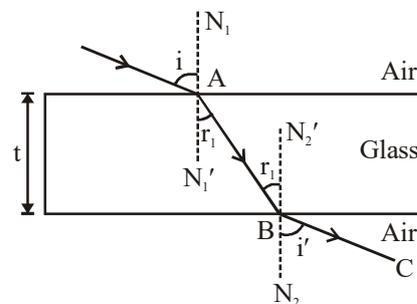
When a glass slab is placed on a dot on a paper, it appears displaced by 4 cm, viewed normally. What is the thickness of slab if the refractive index is 1.5.

Solution:

We know that Displacement = $t \left[1 - \frac{1}{\mu} \right]$ So $4 = t \left[1 - \frac{1}{\mu} \right]$

$$t = \frac{\mu \times 4}{\mu - 1} = \frac{1.5 \times 4}{1.5 - 1} = 12 \text{cm}$$

Consider a rectangular glass slab of refractive index n_{21} and thickness t .



where n_{21} is refractive index of glass slab with respect to air.

At point A,

$$n_{21} = \frac{\sin i}{\sin r_1} \dots(i)$$

At point B, the refractive index of air w.r.t. glass slab.

$$n_{12} = \frac{\sin r_1}{\sin i'} \quad \dots\text{(ii)}$$

We know that, $n_{21} = \frac{1}{n_{12}} \quad \dots\text{(iii)}$

From equations (i), (ii) and (iii), we get

$$\frac{\sin i}{\sin r_1} = \frac{\sin i'}{\sin r_1} \quad \text{or} \quad i = i'$$

This shows that a ray of light incident obliquely on the parallel sided glass slab emerges out parallel to the incident ray. However, the incident ray is laterally displaced.

11.8 Lateral Shift (d) :

The perpendicular distance between the direction of incident ray and the emergent ray is known as lateral shift.

From right angled ΔBOL ,

$$\sin(i - r_1) = \frac{BL}{OB} = \frac{d}{OB}$$

or $d = OB \sin(i - r_1) \quad \dots\text{(iv)}$

From right angled ΔBOD ,

$$\cos r_1 = \frac{OD}{OB} = \frac{t}{OB}$$

or $OB = \frac{t}{\cos r_1} \quad \dots\text{(v)}$

From equations (iv) and (v), we get

$$\text{Lateral shift } d = \frac{t \sin(i - r_1)}{\cos r_1}$$

 **EXAMPLES** 

Example: 24 : A ray of light refracted through a glass slab of thickness $2\sqrt{3}$ cm and refractive index $\sqrt{3}$. If angle of incidence is 60° then find the lateral shift?

Solution : $n = \frac{\sin i}{\sin r} \quad \text{or} \quad \sqrt{3} = \frac{\sin 60^\circ}{\sin r}$

or $\sin r = \frac{\sqrt{3}}{2} \times \frac{1}{\sqrt{3}} = \frac{1}{2} = \sin 30^\circ$

or $r = 30^\circ, \quad t = 2\sqrt{3}$ cm

$$d = \frac{t \sin(i - r)}{\cos r} = \frac{2\sqrt{3} \sin(60^\circ - 30^\circ)}{\cos 30^\circ} = \frac{2\sqrt{3} \sin 30^\circ}{\cos 30^\circ}$$

or $d = \frac{2\sqrt{3} \times 1/2}{\sqrt{3}/2} = 2$ cm

Example: 25 : A fish in the pond of a water appears at a depth of 6 cm. What is the actual depth of the fish if refractive index of water is $4/3$?

Solution : $n_{21} = 4/3$; Apparent depth = 6 cm

$$\text{Real depth} = \text{Apparent depth} \times n_{21} = 6 \times \frac{4}{3} = 8 \text{ cm}$$



TRY YOURSELF

4. A container is filled with water 12.5 cm deep. The depth of a needle lying on the bottom of the container appears to be 9.4 cm. Find the refractive index of water.

➤ REFRACTION THROUGH MULTIPLE REFRACTING MEDIA

A compound slab made up of water and glass bounded by parallel faces and placed in air.

At point O,

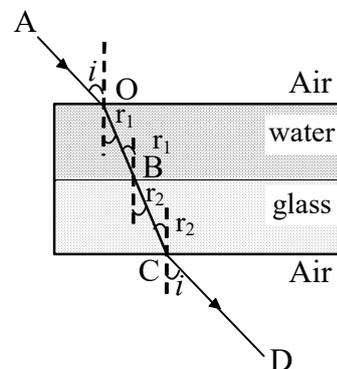
$$n_{wa} = \frac{\sin i}{\sin r_1} \quad \dots(i)$$

At point B,

$$n_{gw} = \frac{\sin r_1}{\sin r_2} \quad \dots(ii)$$

At point C,

$$n_{ag} = \frac{\sin r_2}{\sin i} \quad \dots(iii)$$



Multiplying equations (i), (ii) and (iii), we get

$$n_{wa} \times n_{gw} \times n_{ag} = \frac{\sin i}{\sin r_1} \times \frac{\sin r_1}{\sin r_2} \times \frac{\sin r_2}{\sin i}$$

$$\text{or } n_{wa} \times n_{gw} \times n_{ag} = 1 \quad \text{or } n_{wa} \times n_{gw} = \frac{1}{n_{ag}} \quad \text{or } n_{wa} \times n_{gw} = n_{ga}$$

EXAMPLES

Example: 26 : If refractive index of glass w.r.t. air is $3/2$ and refractive index of water w.r.t. air is $4/3$. Find the refractive index of glass w.r.t. water.

Solution $n_{ga} = 3/2$, $n_{wa} = 4/3$, $n_{gw} = ?$

$$\therefore n_{wa} \times n_{gw} = n_{ga} \quad \text{or } \frac{4}{3} \times n_{gw} = \frac{3}{2} \quad \text{or } n_{gw} = \frac{9}{8}$$



TRY YOURSELF

5. The refractive index of air w.r.t. glass is $2/3$. The refractive index of the diamond w.r.t. air is $12/5$. What is the refractive index of glass w.r.t. the diamond?

12. REFRACTION BY SPHERICAL LENSES

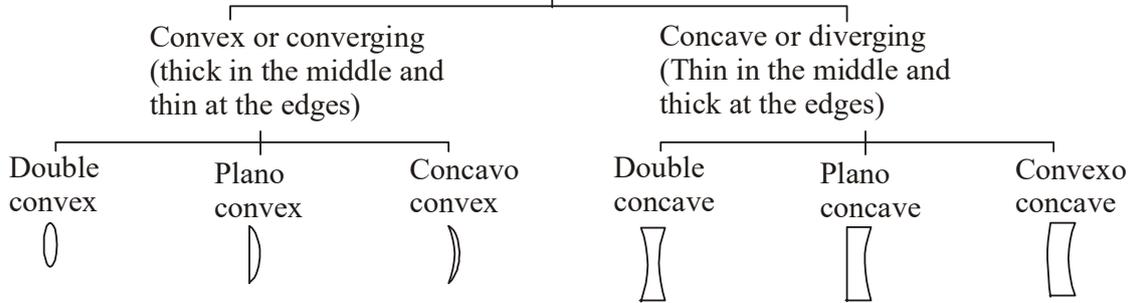
12.1 Lens :

A piece of a transparent medium bounded by at least one spherical surface.

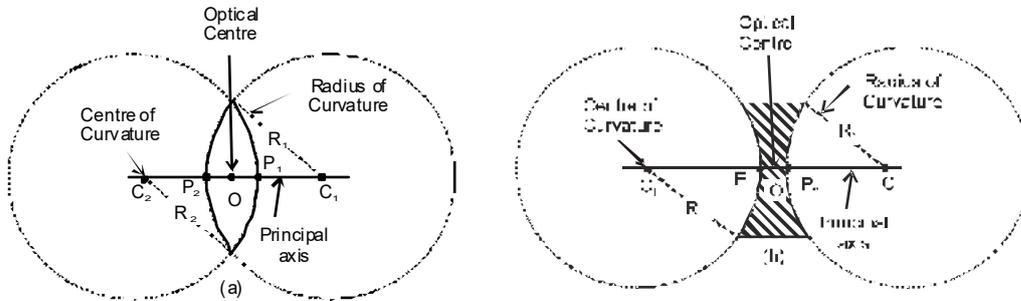
12.1.1 Types of Lens

LENS

(A piece of a transparent medium bounded by at least one spherical surface)



12.1.2 Terms related to thin spherical Lenses



- (a) **Optical centre (O) :** O is a point for a given lens through which any ray passes undeviated.
- (b) **Principal Axis(C₁C₂) :** C₁C₂ is a line passing through optical centre and perpendicular to the lens. The centre of curvature of curved surface always lie on the principal axis (as in a sphere is always perpendicular to surface).



- (c) **Principal Focus (f) :** It is defined as the point where the parallel beam of light converges or appear to diverge i.e. focus.



- (d) **Aperture :** In reference to lens, aperture means to effective diameter of its light transmitting area so that brightness i.e. intensity of image formed by a lens which depends on the light passing through the lens will depend on the square of aperture i.e. $I \propto (\text{aperture})^2$.



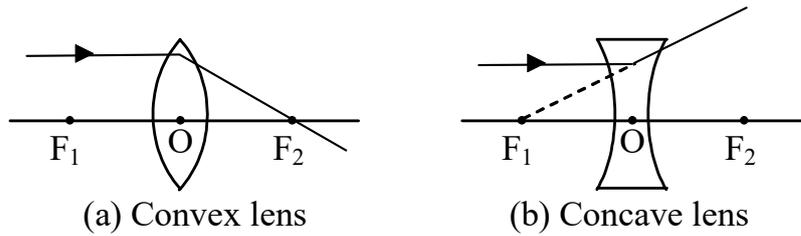
Let's know

Terms related to thin spherical Lenses

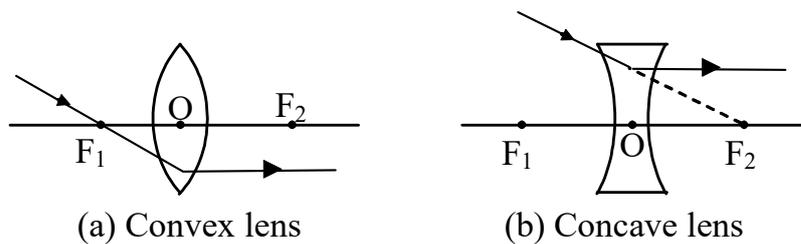
- (i) **Principal axis** : Line passing through the optical centre and joining the centres of curvature of the two curved surface.
- (ii) **Optical centre**: It is a point lying within a lens through which the ray of light pass undeviated.
- (iii) **Principal focus** : It is a point on the principal axis of the lens where all the rays of light coming parallel to the principal axis either converge actually (convex lens) or appear to diverge (concave).
- (iv) **Focal length (f)** : The distance between the optical centre and the principal focus.
For a convex lens : $f = +ve$. For a concave lens : $f = -ve$
- (v) **Focal plane** : A plane passing through the principal focus and perpendicular to the principal axis.
- (vi) **Aperture** : The effective diameter of the light transmitting portion of the lens. Brightness of image is directly proportional to square of aperture of the lens.

12.2 Rules for Image Formation by a Lens :

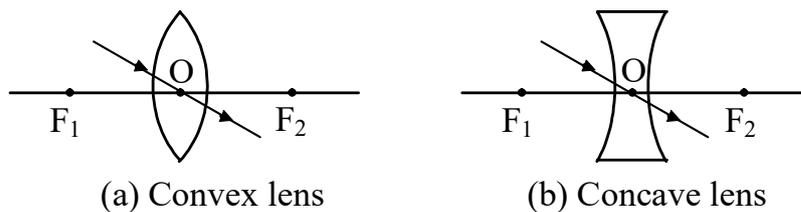
- (i) A ray of light travelling parallel to the principal axis, after refraction passes through (convex lens) or appears to come from (concave lens) its principal focus.



- (ii) A ray of light initially travelling through (convex lens) or along the direction of principal focus after refraction, travels parallel to the principal axis.



- (iii) A ray of light which passes through the optical centre, does not suffer any refraction.



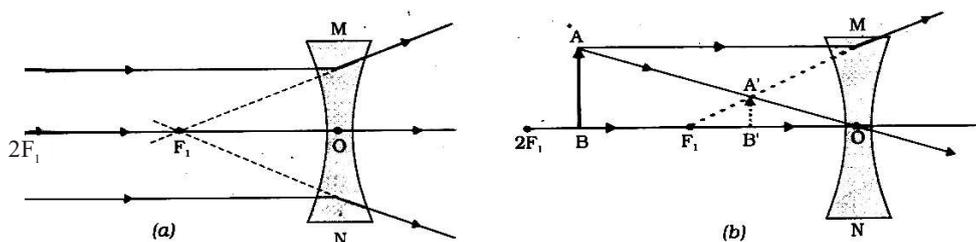
12.3 Image formation in Lenses Using Ray Diagrams :

(a) Image formation by a lens

Position of object	Details of Image	Figure
At infinity	Real, inverted, diminished ($m < -1$), At F	
Between infinity and 2F	Real, inverted, diminished ($m < -1$), between 2F and F	
At 2F	Real, inverted, equal in size ($m = -1$), At 2F	
Between 2F and F	Real, inverted, enlarged ($m > -1$), Between 2F and ∞	
At F	Real, inverted, enlarged ($m \gg -1$), At infinity	
Between Focus and Pole	Virtual, erect, enlarged ($m > +1$), Between ∞ and Object, on same side of object	

(b) Image formed by a concave lens

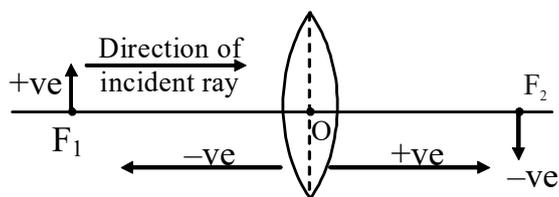
Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity (figure a)	At the focus F_1	Highly diminished, point-sized	Virtual and erect
Between infinity and optical centre O of the lens (figure b)	Between focus F_1 and optical centre O	Diminished	Virtual and erect



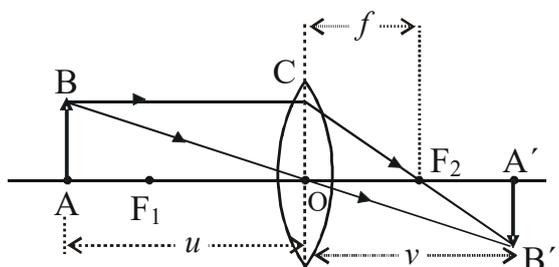
(fig. The position, size and the nature of the image formed by a concave lens for various positions of the object)

12.4 Sign Convention for Spherical Lenses :

- (i) All the distances are measured from the optical centre of the lens.
- (ii) The **distance measured** in the **same direction** as that of **incident light** are taken as **positive**.
- (iii) The **distance measured against the direction of incident light** are taken as **negative**.
- (iv) The **distances measured upward** and perpendicular to the principal axis are taken as **positive**.
- (v) The **distances measured downward** and perpendicular to the principal axis are taken as **negative**.



12.5 The Lens Formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$



12.6 Magnification (m)

It is defined as the ratio of the height of the image and the height of the object

$$m = \frac{\text{Height of the image}}{\text{Height of the object}} = \frac{h_i}{h_o}$$

From equation (i)

$$\frac{A'B'}{AB} = \frac{OA'}{OA} \quad \text{or} \quad \frac{h_i}{h_o} = \frac{v}{u} \quad \text{or} \quad m = \frac{h_i}{h_o} = \frac{v}{u}$$

- (i) If the image is real and inverted (i.e.. I is negative) m is -ve.
- (ii) If the image is virtual and erect (i.e.. I is positive), m is +ve.

$$m = \frac{I}{O} = \frac{v}{u} = \frac{f - v}{f} = \frac{f}{f + u}$$

12.7 Power of Lens (P) :

$$P = \frac{1}{f(\text{in meter})} = \frac{100}{f(\text{in cm})}$$

SI unit of power is diopter (D).

- (i) Power of a convex lens is +ve.
- (ii) Power of a concave lens is -ve.

• Power of a lens is the measure of its degree of convergence or divergence of light rays falling on it.


EXAMPLES


Example: 27 : The image of a needle placed 45 cm from a lens is formed on a screen placed 90 cm on the other side of the lens. Find the displacement of the image, if the object is moved by 5 cm away from the lens. Also find the power of the lens.

Solution : Case I: $u = -45$ cm, $v = 90$ cm, $f = ?$

$$\text{Using, } \frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad \text{or} \quad \frac{1}{f} = \frac{1}{90} + \frac{1}{45} = \frac{3}{90} = \frac{1}{30} \quad \text{or} \quad f = 30 \text{ cm}$$

Case II: $u' = -45 - 5 = -50$ cm

$$\frac{1}{v'} - \frac{1}{u'} = \frac{1}{f} \quad \text{or} \quad \frac{1}{v'} = \frac{1}{f} + \frac{1}{u'} = \frac{1}{30} - \frac{1}{50} \quad \text{or} \quad \frac{1}{v'} = \frac{2}{150}$$

$$\text{or} \quad v' = \frac{150}{2} = 75 \text{ cm}$$

$$\text{or} \quad \text{Displacement of image} = 90 - 75 = 15 \text{ cm}$$

$$\text{Power of lens, } P = \frac{1}{f} = \frac{100}{30} = +3.33 \text{ D}$$

Example: 28 : Two converging lenses with focal lengths 15 cm and 25 cm are placed 18 cm apart. An object is located 8.0 cm in the left of the 15 cm focal length lens. Where will be the final image formed.

Solution: Find the image location for the first lens using the thin lens equation

$$\frac{1}{v_1} = \frac{1}{f_1} + \frac{1}{u_1} = \frac{1}{15 \text{ cm}} + \frac{1}{-8.0 \text{ cm}} \quad \text{which gives } v_1 = -17.14 \text{ cm}$$

This image forms the object of the second lens located $17.14 \text{ cm} + 18 \text{ cm} = 35.14 \text{ cm}$ away. The thin lens equation gives for the second lens

$$\frac{1}{v_2} = \frac{1}{f_2} + \frac{1}{u_2} = \frac{1}{25 \text{ cm}} + \frac{1}{-35.14 \text{ cm}} \quad \text{which gives } v_2 = 86.64 \text{ cm}$$

The final image lies 86.64 cm to the right of the second lens (25 cm) lens

Example: 29 : A converging lens is used to read the small print in a contract. The lens is held 9.0 cm from the print and produces a magnification of +2.5. What is the focal length of the lens?

Solution : The fine print serves as the object for the lens $u = 9.0$ cm. The image distance is then $v = mu = -(2.5 \text{ cm})(9.0 \text{ cm}) = -22.5 \text{ cm}$

$$\text{The thin lens equation gives } \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{-22.5} - \frac{1}{-9} = \frac{1}{f}$$

$$\text{So, } f = +15 \text{ cm}$$



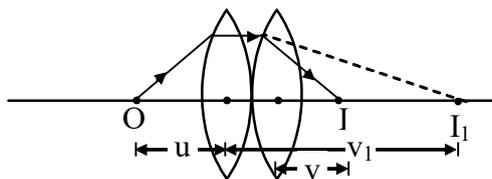
TRY YOURSELF

6. An object 10 cm high is placed at the principal focus of a concave lens of focal length 20 cm. Find the size, position and nature of the image. Also find the power of lens.

13. LENSES IN CONTACT

Consider two thin lens of focal lengths, f_1 and f_2 respectively placed in contact with each other.

Let O be the point object placed on the principal axis of the lenses. If second lens is not present, then the first lens forms an image I_1 of the object O at a distance v_1 from it.



Using lens formula $\frac{1}{v_1} - \frac{1}{-u} = \frac{1}{f_1}$ or $\frac{1}{v_1} + \frac{1}{u} = \frac{1}{f_1}$ (i)

Since second lens is in contact with the first, So I_1 acts as an object for the second lens which forms the image I at a distance v from it.

or $-\frac{1}{v_1} + \frac{1}{v} = \frac{1}{f_2}$ (ii)

Adding equation (i) and (ii), we get

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f_1} + \frac{1}{f_2} \quad \text{or} \quad \frac{1}{u} + \frac{1}{v} = \frac{1}{F}$$

where, $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$

F is equivalent focal length.

The power of the equivalent lens is given by $P = P_1 + P_2$

Magnification, $m = m_1 \times m_2$

➤ ACTIVITY-08

(i) If two thin lens of equal focal length but of opposite nature (i.e. one convergent and other divergent) are put in contact, the resultant focal length of the combination will be

$$\frac{1}{f} = \frac{1}{+f} + \frac{1}{-f} = 0$$

i.e., $F = \infty$ and $P = 0$

i.e., the system will behave as a plane glass plate.

(ii) If two thin lens of the same nature are put in contact then as

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{F} > \frac{1}{f_1} \quad \text{and} \quad \frac{1}{F} > \frac{1}{f_2} \quad \text{i.e., } F < f_1 \quad \text{and} \quad F < f_2$$

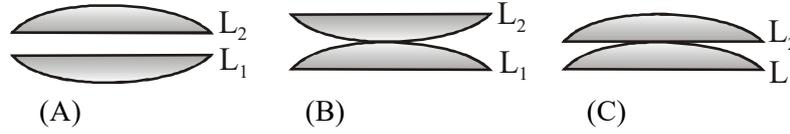
i.e. The resultant focal length will be lesser than smallest individual.

(iii) If two thin lenses of same nature with different focal lengths are put in contact the resultant focal length will be of same nature as that of the lens of shorter focal length but its magnitude will be more than that of shorter focal length. If a lens of focal length f is divided into two equal parts (as shown in figure A)

Each part has focal length f' then as $\frac{1}{f} = \frac{1}{f'} + \frac{1}{f'} \Rightarrow f' = 2f$

i.e. Each part have focal length $2f$ now if these parts are put in contact (as shown in figure B or C), the resultant focal length of the combination will be $\frac{1}{f} = \frac{1}{2f} + \frac{1}{2f}$

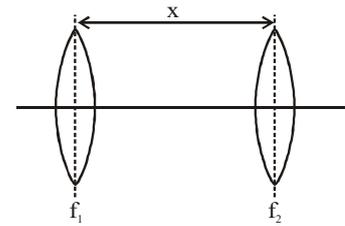
i.e., $F = f$ (= initial value)



Note:

(1) when two lenses of focal lengths f_1 and f_2 are placed co-axially at a distance x from each other, then the equivalent focal length and power is given by

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{x}{f_1 f_2} \text{ and } P = P_1 + P_2 - xP_1P_2$$



13.1 Lens Maker Formula :

This formula gives a relation among the focal length (f) the refractive index of a lens with respect to the medium in which it is placed (${}_m\mu_l - 1$) and its radii of curvatures (R_1 and R_2). This formula is expressed as

$$\frac{1}{f} = ({}_m\mu_l - 1) \times \left(\frac{1}{R_1} - \frac{1}{R_2} \right) \text{ or } \frac{1}{f} = \left(\frac{{}_a\mu_l}{{}_a\mu_m} - 1 \right) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

where ${}_a\mu_l$ = refractive index of lens with respect to air

${}_a\mu_m$ = refractive index of medium with respect to air.

R_1 = radius of curvature of first surface of lens.

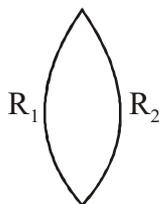
R_2 = radius of curvature of second surface of lens.

If lens is placed in air then

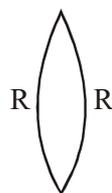
$${}_a\mu_m = 1 \text{ and } {}_a\mu_l = \mu (\text{say}) \quad \therefore \frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

➤ **ACTIVITY-09**

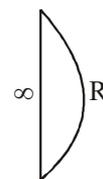
Sign convention for R_1 and R_2 : Observe the sign convention for R_1 and R_2 in following figures.



$$R_1 = +R_1, R_2 = -R_2$$



$$R_1 = R, R_2 = -R$$

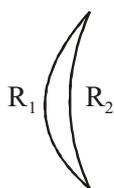


$$R_1 = \infty, R_2 = -R$$

$$\therefore \frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$

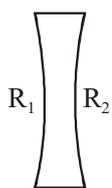
$$\frac{1}{f} = (\mu - 1) \frac{2}{R}$$

$$\frac{1}{f} = (\mu - 1) \left(\frac{1}{\infty} + \frac{1}{R} \right) = \left(\frac{\mu - 1}{R} \right)$$



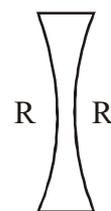
$$R_1 = +R_1, R_2 = +R_2$$

$$\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$



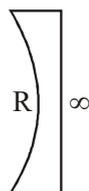
$$R_1 = -R_1, R_2 = +R_2$$

$$\frac{1}{f} = -(\mu - 1) \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$



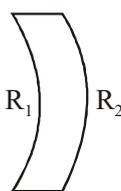
$$R_1 = -R, R_2 = +R$$

$$\frac{1}{f} = -(\mu - 1) \frac{2}{R}$$



$$R_1 = -R, R_2 = \infty$$

$$\frac{1}{f} = -(\mu - 1) \frac{1}{R}$$



$$R_1 = -R_1, R_2 = -R_2$$

$$\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_2} - \frac{1}{R_1} \right)$$

EXAMPLES

Example: 30: A convex lens of focal length 10.0 cm is placed in contact with a convex lens of 15.0 cm focal length. What is the focal length of the combination.

Solution: For combination of lenses

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{10} + \frac{1}{15} = \frac{1}{6}$$

Therefore, $f = 6$ cm

Example: 31: Ten identical converging thin lenses, each of focal length 10 cm, are in contact. What is the power of the combined lens.

Solution: For thin lenses in contact

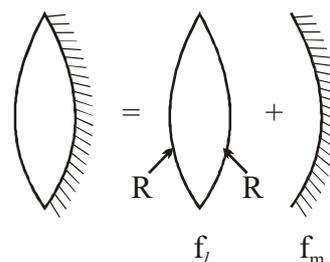
$$P = P_1 + P_2 + \dots + P_{10} = 10 P_1 = \frac{10 \times 100}{10} = 100 \text{ D}$$

➤ **ACTIVITY-10**

A lens has two surface. If one of the surfaces are silvered, the lens behave as a mirror. The mechanism of the image formation can be understood in brief as given below.

Light from the object falls on the lens which produces a virtual image I_1 . This image acts as object for the silvered surface (which acts as a mirror) and a second virtual image I_2 is formed. Finally, this image acts as object for the lens and final image I_3 is formed. Thus, refraction takes place two times at the lens and reflection takes one time at the mirror .

Thus on silvering, the lens behave as a mirror of focal length F given by.



$$\frac{1}{f} = \frac{2}{f_l} + \frac{1}{f_m} \quad \dots(1)$$

Where f_l = focal length of lens from which refraction takes place two times.
 f_m = focal length of mirror from which reflection takes place one time.

Case I : When a double convex lens is silvered.

Clearly, $f_m = \frac{R}{2}$

Also, by lens maker formula

$$\frac{1}{f_l} = (\mu - 1) \left(\frac{1}{R} + \frac{1}{R} \right) = (\mu - 1) \frac{2}{R} \quad \therefore f_l = \frac{R}{2(\mu - 1)}$$

Putting the values of f_m and f_l in (1) we get

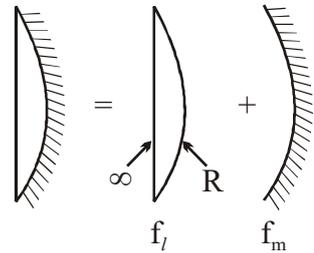
$$\frac{1}{f} = \frac{2 \times 2(\mu - 1)}{R} + \frac{2}{R} = \frac{2(2\mu - 1)}{R} \quad \therefore \boxed{f = \frac{R}{2(2\mu - 1)}}$$

Case II : When a plano convex lens is silvered

(i) If curved surface is silvered

In this case,

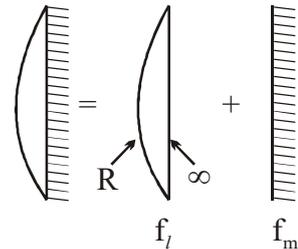
$$f_m = \frac{R}{2} \text{ and } f_l = \frac{R}{(\mu - 1)} \quad \therefore \boxed{f = \frac{R}{2\mu}}$$



(ii) If plane surface is silvered

In this case, $f_m = \infty$ ($\because R = \infty$)

$$\text{and } f_l = \frac{R}{\mu - 1} \quad \therefore \boxed{f = \frac{R}{2(\mu - 1)}}$$



14. APPLICATION OF LENSES

Lenses are used in cameras, telescopes, cinema projectors, search lights and microscopes.

- (i) A convex lens is used from the image of an object on the film of a camera.
- (ii) A convex lens is used in an astronomical telescope to see the heavenly objects like moon, stars, galaxies etc.
- (iii) A convex lens of small focal length is used as a reading glass.
- (iv) A convex lens of small focal length is used in microscopes to study biological specimens.
- (v) A convex lens is used to correct hypermetropia or long - sightedness defect of human eye.
- (vi) A concave lens is used to correct myopia or short - sightedness defect of human eye.

EXAMPLES

Example: 32 : The radius of curvature of a thin plano - convex lens is 10 cm (of curved surface) and the refraction index is 1.5. If the plane surface is silvered then it behaves like a concave mirror of focal length.

- (a) 10 cm (b) 15 cm (c) 20 cm (d) 5 cm

Solution: (a) The silvered plano convex lens behaves as a concave mirror, whose focal length is given by

$$\frac{1}{f} = \frac{2}{f_l} + \frac{1}{f_m}$$

If plane surface is silvered, $f_m = \frac{R_2}{2} = \frac{\infty}{2} = \infty$

$$\therefore \frac{1}{f_1} = (\mu - 1) \left[\frac{1}{R_1} - \frac{1}{R_2} \right] = (\mu - 1) \left[\frac{1}{R} - \frac{1}{\infty} \right] = \frac{\mu - 1}{R}$$

$$\therefore \frac{1}{f} = \frac{2(\mu - 1)}{R} + \frac{1}{\infty} = \frac{2(\mu - 1)}{R} \Rightarrow f = \frac{R}{2(\mu - 1)}$$

Here $R = 10 \text{ cm}$, $\mu = 1.5$

$$\therefore f = \frac{10}{2(1.5 - 1)} = 10 \text{ cm}$$

➤ **ACTIVITY-10**

● **SOME OTHER PROPERTIES OF LIGHT**

As we know light shows dual nature - the nature of a particle in some cases and the nature of a wave in some other. When light behaves as a wave, it shows the following characteristics -

- (A) Interference (B) Diffraction (C) Polarisation

When light behaves as a particle, it performs phenomenon like photoelectric effect.

(A) **Interference of light**

The colour in soap bubbles and oil slicks are due to this property of light. When two light waves of exactly same frequency travels in a medium, in the same direction simultaneously then due to their superposition, the intensity of light is maximum at some points while the intensity is minimum at other points. This phenomenon is called interference of light. It is of two types:

- (i) Constructive interference and (ii) Destructive interference

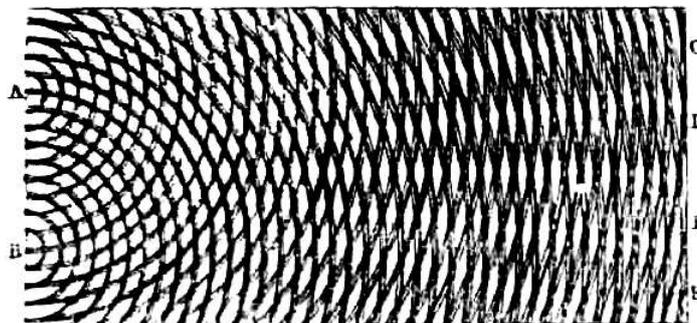
When the waves meet the point with same phase, constructive interference is obtained at that point. Hence, at that point bright spot of light is seen.

But when the waves meet a point with opposite phase, destructive interference is obtained at that point. Hence, at that point dark spot of light is seen.

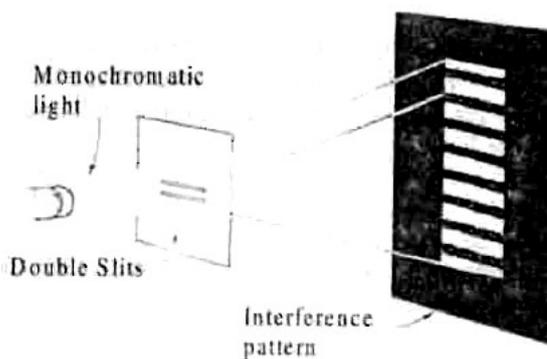
● (A.1) **Young's double slit experiment**

Fringes are produced by interference which we discussed. Constructive and destructive interference is reviewed in figure. We see that the addition, or superposition of a pair of identical waves in phase with each other produces a wave of the same frequency but with twice the amplitude. If the waves are exactly one half wavelength out of phase, their superposition results in complete cancellation. If they are out of phase by order other amounts partial cancellation occurs

In 1801, the wave nature of light was convincingly demonstrated when the British physician Thomas Young performed his now famous interference experiment. Young found that light directed through two closely spaced pinholes recombined to produce fringes of brightness and darkness on a screen behind. The bright fringes of light resulted from light waves from the two holes arriving crest to crest, while the dark area resulted from light waves arriving through to crest. Figure shows Young's drawing of the pattern of superimposed waves from the two sources. His experiment is now done with two closely spaced slits instead of with pinhole, so the fringe patterns are straight lines (as shown in figure below).



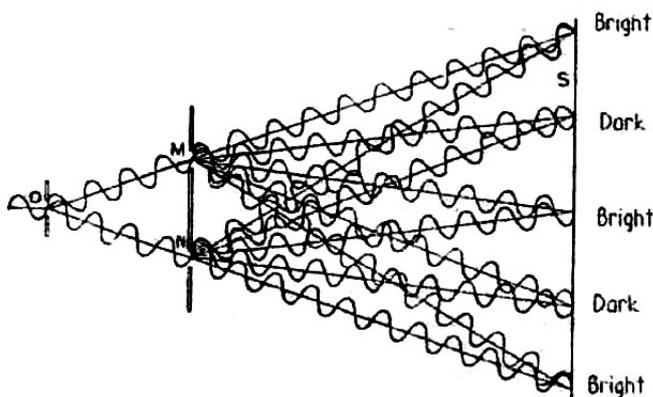
Thomas Young's original drawing of a two-source interference pattern. Letter C, D, E and F mark regions of destructive interference.



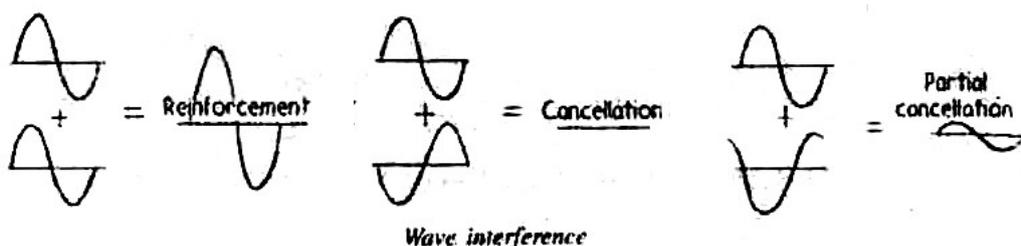
We see in figures and how the series of bright and dark lines results from the different path lengths from the slits to the screen. For the central bright fringe, the path from each slit are the same length, and the waves arrive in phase and reinforce each other. The dark fringes on either side of the central fringe result from one path being longer (or shorter) by one half of wavelength where the wave arrive half a wave length where the wave arrive half wavelength out of phase. The other sets of dark fringes occur where the paths differ by odd multiples of one - half wave length : $3/2, 5/2$ so on.



Bright fringes occur when waves from both slits arrive in phase
 dark areas result from the overlapping of waves that are out of phase.



Light from O passes through slits M and N and produces an interference pattern on the screen S.

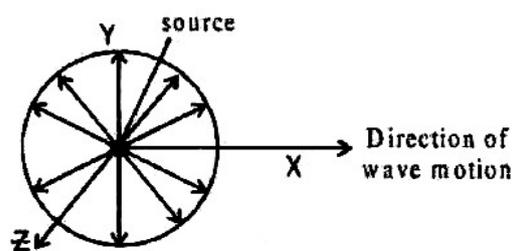


(B) DIFFRACTION OF LIGHT.

The wavelength of light is of the order of an angstroms. So, when light waves encounter obstacles of very small size, the light waves bend around the edges of the obstacle and travel. This is known as diffraction of light. It is due to the diffraction of light that a sharp shadow of an object cannot be obtained on any screen placed behind it. Due to diffraction, light bend and travels into the region of geometrical shadow of the object and thus complete darkness is not found in the shadow. The brightness of light gradually decreases towards complete darkness as we go gradually into the geometrical shadow of the obstacle.

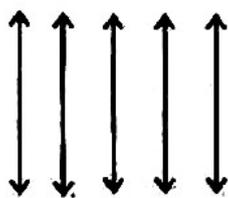
(C) POLARISATION OF LIGHT

An ordinary source of light such as bulb consist of a large number of waves emitted by atoms or molecules in all directions symmetrically. Such light is called unpolarized light (as shown in figure a)



(a) Unpolarised light

If we confine the direction of wave vibration of electric vector in one direction (with the help of polkaroids or Nicol prism) perpendicular to the direction of wave propagation, then such type of light is called plane polarised or linearly polarised. The phenomenon by which, we restrict the vibrations of wave in a particular direction (as shown in figure b). Perpendicular to direction of wave propagation is called polarisation.

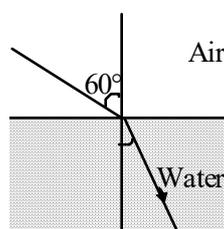


(b) Polarised light

EXAMPLES

Example: 33: A ray of light travelling in air falls on the surface of water. The angle of incidence is 60° with the normal to the surface. The refractive index of water = $4/3$. Calculate the angle of refraction.

Solution :



We know that $\frac{\sin i}{\sin r} = n$

Here, $i = 60^\circ$, $n = 4/3$

$$\therefore \frac{\sin 60^\circ}{\sin r} = \frac{4}{3} \quad \text{or} \quad \frac{\sqrt{3}/2}{\sin r} = \frac{4}{3} \quad \text{or} \quad \sin r = \frac{3\sqrt{3}}{8} = 0.65$$

$$\therefore r = \sin^{-1} 0.65$$

Example: 34: A ray of light is incident on the plane surface of a transparent medium at an angle 60° with the normal. The angle of refraction is 30° . Calculate the refractive index of the transparent material.

Solution :

Here,

Angle of incidence, $i = 60^\circ$

Angle of refraction, $r = 30^\circ$

Refractive index,

$$n = \frac{\sin i}{\sin r} = \frac{\sin 60^\circ}{\sin 30^\circ} = \frac{\sqrt{3}/2}{1/2} = \sqrt{3}$$

Example: 35: The refractive index of diamond is 2.42 and that of carbon disulphide is 1.63. Calculate the refractive index of diamond with respect to carbon disulphide.

Solution : Refractive index of carbon disulphide, $n_1 = 1.63$
 Refractive index of diamond, $n_2 = 2.42$
 \therefore Refractive index of diamond with respect for carbon disulphide,

$${}^1n_2 = \frac{n_2}{n_1} = \frac{2.42}{1.63} = 1.48$$

Example: 36: A coin is placed in a tumbler, water is then filled in the tumbler to a height of 20 cm. If the refractive index of water is $4/3$, calculate the apparent depth of the coin.

Solution : Here,
 Real depth, $h = 20$ cm
 Refractive index, $n = 4/3$

$$\text{Now, } n = \frac{\text{real depth}}{\text{apparent depth}}$$

$$\text{or } \frac{4}{3} = \frac{20}{\text{apparent depth}}$$

$$\text{or Apparent depth} = \frac{20 \times 3}{4} = 15 \text{ cm}$$

Example: 37: There is a black spot on a table. A glass slab of thickness 6 cm is placed on the table over the spot. Refractive index of glass is $3/2$. At what depth from the upper surface will the spot appear when viewed from above?

Solution : Real depth of the spot = 6 cm

$$\text{Refractive index of glass, } n = \frac{3}{2}$$

$$\text{Now, } n = \frac{\text{real depth}}{\text{apparent depth}}$$

$$\text{or } \frac{3}{2} = \frac{6}{\text{apparent depth}}$$

$$\therefore \text{ Apparent depth} = \frac{6 \times 2}{3} = 4 \text{ cm}$$

Example: 38: Refractive index of diamond is 2.42 and that of glass is 1.5. Calculate the critical angle for diamond-glass surface.

Solution : Refractive index of diamond, $n_1 = 2.42$
 Refractive index of glass, $n_2 = 1.5$

$$\text{Now, } \sin i_c = \frac{n_2}{n_1} = \frac{1.5}{2.42} = 0.6198$$

$$\therefore i_c = \sin^{-1} 0.62$$

Example : 39: Refractive index of glass is $3/2$. A ray of light travelling in glass is incident on glass-water surface at an angle 30° with normal. Will it be able to come out into the water. Refractive index of water = $4/3$.

Solution : Refractive index of glass, $n_1 = 3/2$
 Refractive index of water, $n_2 = 4/3$

$$\text{Now, } \sin i_c = \frac{n_2}{n_1} = \frac{4/3}{3/2} = \frac{8}{9} = 0.88$$

$$\therefore i_c = 62^\circ$$

Since, the angle of incidence (30°) is less than the critical angle, the ray will be refracted into the water.

Example : 40: Calculate the speed and wavelength of light (i) in glass and (ii) in air, when light waves of frequency 6×10^{14} Hz travel from air to glass of $\mu = 1.5$.

Solution : Here $v = 6 \times 10^{14}$ Hz, $\mu = 1.5$

(i) In glass speed of light,

$$V_g = \frac{V_a}{\mu} = \frac{3 \times 10^8}{1.5} = 2 \times 10^8 \text{ m/s}$$

$$\text{Wavelength of light, } \lambda_g = \frac{V_g}{v} = \frac{2 \times 10^8}{6 \times 10^{14}} = 3.3 \times 10^{-7} \text{ m.}$$

(ii) In air speed of light $V_a = 3 \times 10^8$ m/s

$$\text{Wavelength of light, } \lambda_a = \frac{V_a}{v} = \frac{3 \times 10^8}{6 \times 10^{14}} = 5 \times 10^{-7} \text{ m.}$$

Example : 41: The depth of water in a tank is 4 meter. If the refractive index of water is $\frac{4}{3}$, by how much distance does the bottom of tank appear to be raised ?

Solution : Actual depth, $d = 4\text{m}$

$$\text{R.I. water, } \mu = \frac{4}{3} ; \mu = \frac{\text{Actual depth}}{\text{Apparent depth}}$$

$$\text{Apparent depth} = \frac{d}{\mu} = \frac{4}{4/3} = 3\text{m}$$

So, bottom of tank appear to be raised by $4 - 3 = 1$ m.

Example : 42: A 2 cm long pin is placed perpendicular to the principal axis of a convex lens of focal length 15 cm at distance of 25 cm from the lens. Find the position of image and its size.

Solution : Here, $u = -25$ cm, $f = +15$

$$\text{Using the lens formula, } \frac{1}{v} - \frac{1}{u} = \frac{1}{f} \text{ we get}$$

$$\text{or } \frac{1}{v} - \frac{1}{-25} = \frac{1}{+15} \text{ or } \frac{1}{v} = \frac{1}{15} - \frac{1}{25} = \frac{2}{75}$$

$$\text{or } v = \frac{75}{2} = 37.5 \text{ cm}$$

The positive sign shows that the image is formed on the right-hand side of the lens.

Magnification is given by

$$m = \frac{h'}{h} = \frac{v}{u} \quad \text{or} \quad \frac{h'}{h} = \frac{37.5}{-25} = -1.5$$

$$\therefore h = -1.5 \times h = -1.5 \times 2 \text{ cm} = -3 \text{ cm}$$

The image of the pin is 3 cm long. The negative sign shows that it is formed below the principal axis, i.e. the image is inverted.

Example : 43: A point object is placed at a distance of 18 cm from a convex lens on its principal axis. Its image is formed on the other side of the lens at 27 cm. Calculate the focal length of the lens.

Solution : According to the sign convention, the object is placed on the left-hand side of the lens, therefore object-distance is negative,

i.e. $u = -18$ cm. Since the image is formed on the other side, the image-distance is positive, i.e., $v = +27$ cm. Using lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}, \text{ we have}$$

$$\frac{1}{+27} - \frac{1}{-18} = \frac{1}{f}$$

$$\text{or} \quad \frac{1}{27} + \frac{1}{18} = \frac{5}{54} = \frac{1}{f} \quad \text{or} \quad f = \frac{54}{5} = 10.8 \text{ cm}$$

Example : 44: A 3 cm high object is placed at a distance of 80 cm from a concave lens of focal length 20 cm. Find the position and size of the image.

Solution : Here, $u = -80$ cm, $f = -20$ cm

Using the lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, we get

$$\text{or} \quad \frac{1}{v} - \frac{1}{-80} = \frac{1}{-20} \quad \text{or} \quad \frac{1}{v} = -\frac{1}{20} - \frac{1}{80} = \frac{-5}{80} = -\frac{1}{16}$$

$$\text{or} \quad v = -16 \text{ cm}$$

$$\text{Magnification, } m = \frac{h'}{h} = \frac{v}{u} = \frac{-16}{-80} = \frac{1}{5}$$

$$\text{or } h' = \frac{h}{5} = \frac{3.0}{5} = 0.6 \text{ cm}$$

Length of image is 0.6 cm. Positive sign shows that the image is erect.

Example : 45: An object is placed on the principal axis of a concave lens at a distance of 40 cm from it. If the focal length of the lens is also 40 cm, find the location of the image and the magnification.

Solution : For a concave lens focal length f is negative, i.e. $f = -40$ cm. Since by convention, object is placed on the left of the lens, so $u = -40$ cm.

Using the lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, we get

$$\text{or } \frac{1}{v} - \frac{1}{-40} = \frac{1}{-40}$$

$$\text{or } \frac{1}{v} = -\frac{1}{40} - \frac{1}{40} = -\frac{1}{20}$$

$$\text{or } v = -20 \text{ cm}$$

The image is formed 20 cm from the lens. Minus sign shows that the image is formed on the same side of the lens as the object.

$$\text{Now, magnification, } m = \frac{h'}{h} = \frac{v}{u} = \frac{-20}{-40} = \frac{1}{2}$$

Positive sign shows that the image is erect.

Example : 46: A beam of light travelling parallel to the principal axis of a concave lens appears to diverge from a point 25 cm behind the lens after refraction. Calculate the power of the lens.

Solution : When a parallel beam after refraction through the lens is incident on a concave lens, it appears to diverge from the focus of the lens. Hence, the focal length of the lens is 25 cm. According to sign convention, focal length of a concave lens is negative.

$$\therefore f = -25 \text{ cm} = -0.25 \text{ m}$$

$$\therefore \text{Power, } P = \frac{1}{f} = \frac{1}{-0.25} = -4\text{D}$$

Example : 47: A convex lens of power 5D is placed at a distance of 30 cm from a screen. At what distance from the lens should the screen be placed so that its image is formed on the screen?

Solution : Power of the lens, $P = +5\text{D}$

$$\therefore \text{Focal length, } f = \frac{1}{5\text{D}} = \frac{1}{5} = 0.20 \text{ m} = 20 \text{ cm}$$

Here, the screen is placed 30 cm from the lens.

$$\therefore v = +30 \text{ cm, } f = +20 \text{ cm, } u = ?$$

Using the lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, we get

$$\frac{1}{30} - \frac{1}{u} = \frac{1}{20} \quad \text{or} \quad \frac{1}{u} = \frac{1}{30} - \frac{1}{20} = -\frac{1}{60}$$

$$\text{or } u = -60 \text{ cm}$$

Therefore, the screen should be placed at 60 cm from the lens.

Example : 48: A concave lens has a focal length of 15 cm. At what distance should the object be from the lens placed so that it forms an image 10 cm from the lens ? Also find the magnification.

Solution : A concave lens always forms a virtual, erect image on the same side as the object.

$$\text{Image distance, } v = -10 \text{ cm}$$

Focal length $f = -15$ cm

Object distance, $u = ?$

Using, the lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, we get

$$\text{or } \frac{1}{-10} - \frac{1}{u} = \frac{1}{-15}$$

$$\text{or } -\frac{1}{10} = \frac{2-3}{30} = -\frac{1}{30}$$

$$\text{or } u = -30 \text{ cm}$$

Thus, the object should be placed 30 cm on the lens.

$$\text{Magnification, } m = \frac{v}{u} = \frac{-10}{-30} = \frac{1}{3} = 0.33$$

The positive sign shows that the image is erect and virtual. The size of the image is one third of that of the object.

Example : 49: Two thin convex lenses of focal lengths 10 cm and 20 cm are placed in contact. Find the effective power of the combination.

Solution :

$$P = P_1 + P_2$$

$$P = \frac{100}{f_1} + \frac{100}{f_2} = \frac{100}{10} + \frac{100}{20} = 10 + 5 = 15 \text{ D}$$

Example : 50: An illuminated object and a screen are placed 90 cm. apart. What is the focal length and nature of the lens required to produce a clear image on the screen, twice the size of the object ?

Solution :

As the image is real, the lens must be a convex lens and it should be placed between the object and the screen.

Let distance between the object & the convex lens be x

$$\text{then } u = -x, v = 90 - x$$

$$\text{Now } m = \frac{v}{u} = -2 \text{ (image is real)}$$

$$\frac{90 - x}{-x} = -2 \quad x = 30$$

$$u = -30 \text{ cm, } v = +60 \text{ cm.}$$

$$\text{Now, } \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{60} - \frac{1}{-30} = \frac{1}{60} + \frac{1}{30} = \frac{3}{60} = \frac{1}{20}$$

$$f = 20 \text{ cm.}$$

Example : 51: Two thin lenses of focal lengths +10 cm and -5 cm are kept in contact. What is the
(a) focal length
(b) power of the combination.

Solution :

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\text{or } \frac{1}{f} = \frac{1}{10} - \frac{1}{5} \quad \text{or } \frac{1}{f} = -\frac{1}{10} \quad \text{or } f = -10 \text{ cm}$$

$$\text{Power, } P = \frac{100}{f} = \frac{100}{-10} = -10D$$



TRY YOURSELF

7. Find the focal length and power of combination of two lenses, one converging of power 8 diopter and the other diverging of power 4 diopter are combined together.

14.1 Defects of Lenses :

- (i) **Chromatic aberration** : Due to dispersion the image has coloured edges.
- (ii) **Spherical aberration** : Due to different focal length for marginal rays and paraxial rays.
- (iii) **Coma** : Comet like tail added to all images.
- (iv) **Astigmatism** : Defect in image shape when the rays from horizontal plane and rays from vertical plane focus at different points.
- (v) **Distortion** : Due to different magnification of a lens for the upper or lower portion and central portion.

14.2 Uses of Lenses :

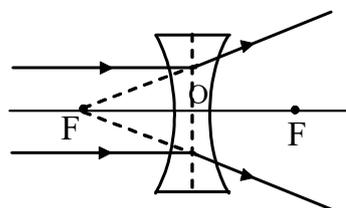
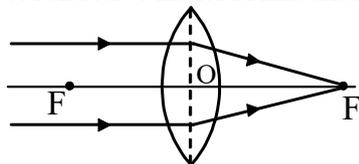
- (i) Concave, convex and other types of lenses are used in spectacles for correcting the defects of vision.
- (ii) Almost all the optical instruments such as projector, telescope, microscope, camera, periscope etc. make use of lenses.
- (iii) Now-a-days powerful lenses of large aperture are used to focus solar energy.

14.3 Behaviour of Lenses in Different Optical Medium :

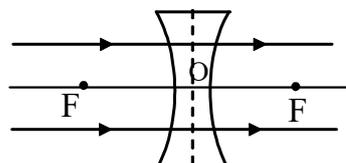
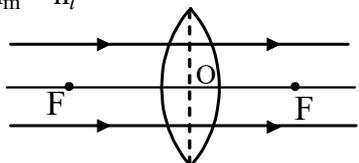
Case I: $n_m < n_l$

where n_m = Absolute refractive index of medium.

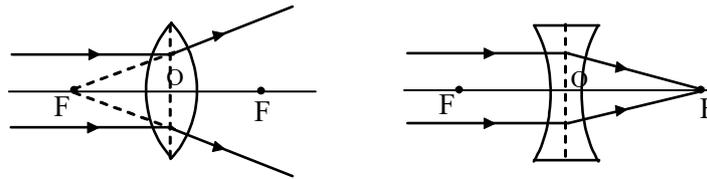
n_l = Absolute refractive index of material of lens



Case II: $n_m = n_l$



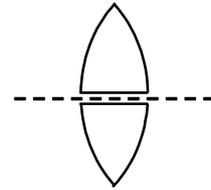
Case III: $n_m > n_l$



➤ **IMPORTANT NOTE**

(1) Intensity or brightness of the image is proportional to the square of the aperture of the lens i.e. Intensity of image \propto (Aperture)².

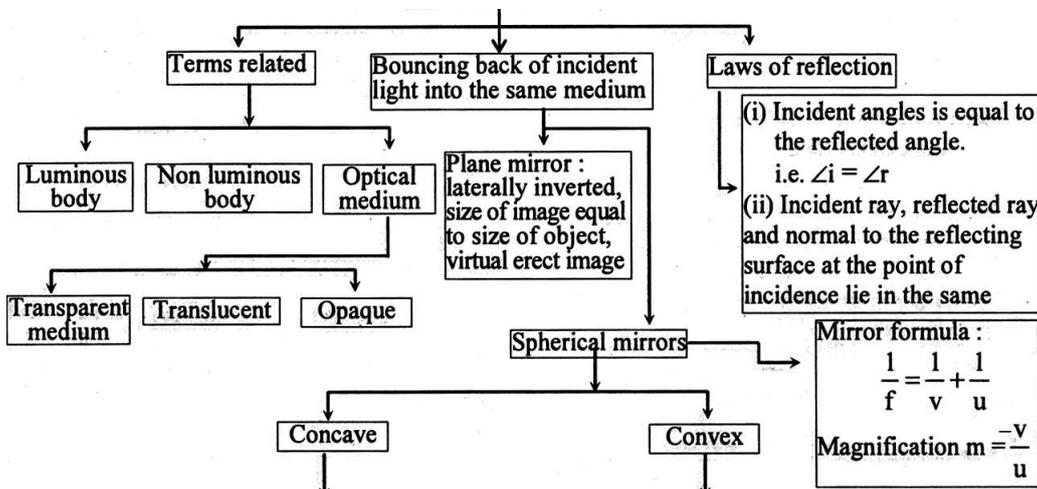
(2) If a lens is cut horizontally into two equal halves as shown in figure, then focal length remains unchanged.



(3) If a lens is cut vertically into two equal halves as shown in figure, then focal length becomes double.



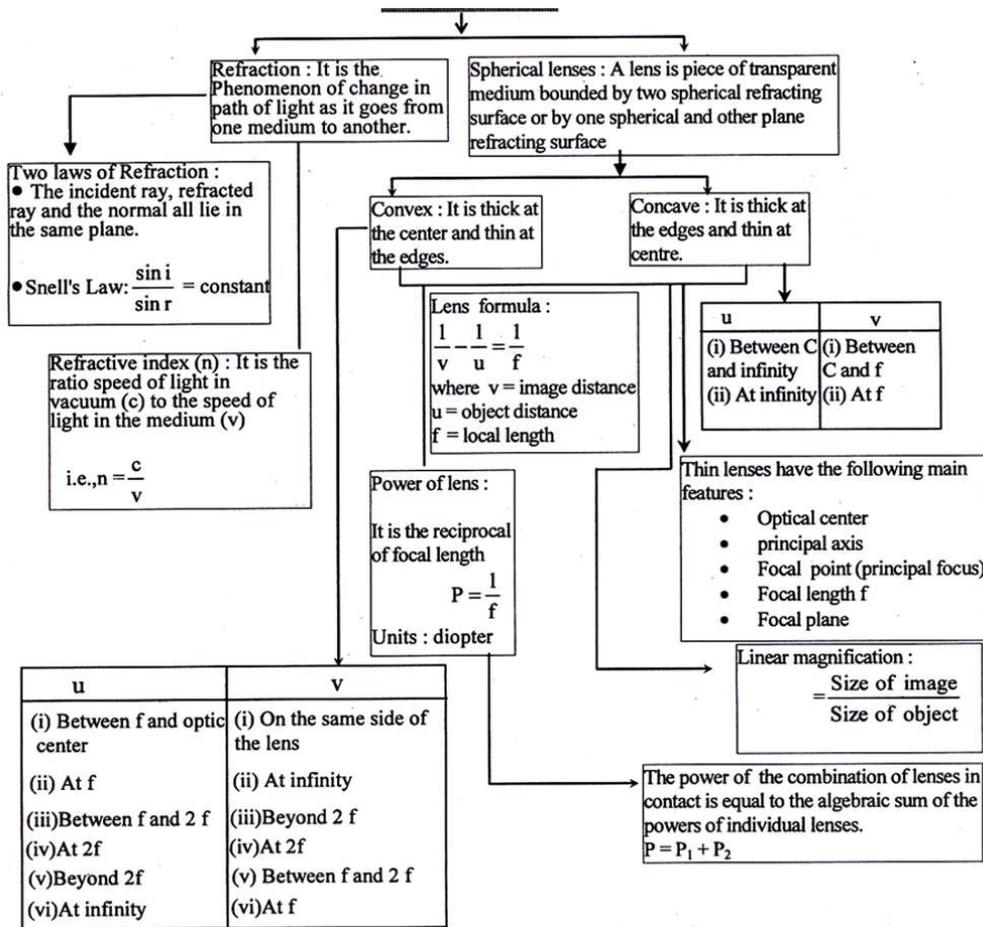
REFLECTION



Object Placed	Image formed
• Between P and F	• Behind mirror, virtual erect
• At F	• At F
• Between F and C	• Between F and C
• At C	• At C
• Beyond C	• Beyond C
• At infinity	• At infinity

Object Placed	Image formed
• Between P and infinity	• Behind mirror, virtual
• At infinity	• Behind mirror at F

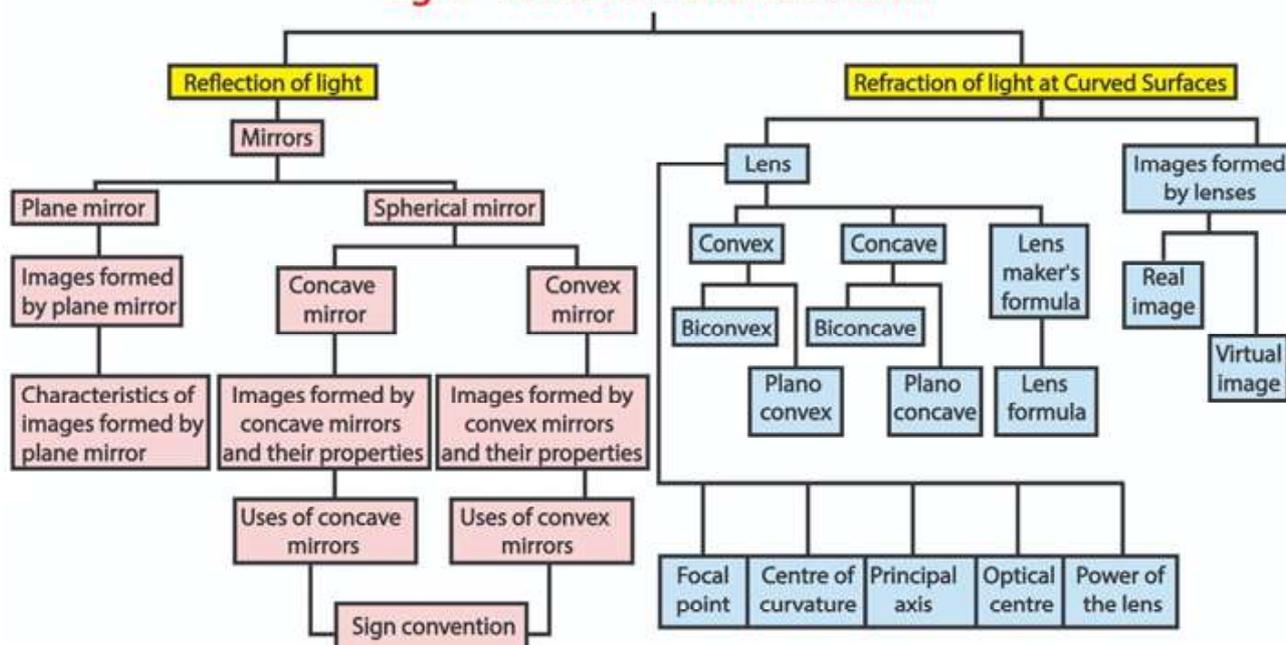
REFRACTION





LET'S RECALL

Light - Reflection and Refraction



- Light** is a form of energy which produces the sensation of sight.
- Speed of light in vacuum / air = $3 \times 10^8 \text{ ms}^{-1}$
- Ray of light** : A line drawn in the direction of propagation of light is called ray of light.
- Beam of light** : A group of parallel rays light emitted by a source of light is called beam of light.
- Reflection of light** : The phenomenon of returning of light in the same medium after striking a surface is called reflection of light.
- Laws of reflection** : The reflection of light from a surface obeys certain laws called laws of reflection.
 - incident angle is equal to reflected angle i.e. $\angle i = \angle r$.
 - Incident ray, reflected ray and normal to the reflecting surface at the point on incident lie in the same plane.
- Concave mirror** : concave mirror is a part of a hollow sphere whose outer part is silvered and the inner part is reflecting surface.
- Convex mirror** : convex mirror is a part of a hollow sphere whose outer part is reflecting surface and inner part is silvered.
- Centre of curvature** : The centre of a hollow sphere of which the spherical mirror forms a part is called centre of curvature. It is denoted by C
- Radius of curvature** : The radius of a hollow sphere of which the spherical mirror forms a part is called radius of curvature. It is denoted by R
- Pole** : The mid point of a spherical mirror is called its pole. It is denoted by P
- Aperture**: The part of spherical mirror exposed to the incident light is called the aperture of the mirror.
- Principal Axis**: A line joining the centre of curvature (C) and pole (P) of a spherical mirror and extend on either side is called principal axis of the spherical mirror.

14. **Principal Focus :** A point on the principal axis of a spherical mirror where the rays of light parallel to the principal axis meet or appears to meet after reflection from the spherical mirror is called principal focus. It is denoted by F.
15. **Focal Plane :** A plane normal or perpendicular to the principal axis and passing through the principal focus (F) of the spherical mirror is called focal plane of the spherical mirror.
16. **Focal length (f):** The distance between the pole (P) and the principal focus (F) of a spherical mirror is called the focal length of the spherical mirror.

17. $f = \frac{R}{2}$, Where R is the radius of the curvature of the mirror.

18. Focal length and radius of curvature of a concave mirror are **negative**.

19. Focal length and radius of curvature of a convex mirror are **positive**.

20. **Sign Conventions for reflection by spherical mirrors**

- (1) All distance are measured from the pole of a spherical mirror.
- (2) Distance measured in the direction of incident light are taken as positive. Distance measured in the direction opposite to that of the incident light are taken negative.
- (3) The upward distance perpendicular to the principal axis are taken as positive, while the downward distance perpendicular to the principal axis are taken as negative.

21. Radius of curvature plane mirror = ∞ (infinite)

22. Focal length of a plane mirror = ∞

23. **Mirror Formula :** The relation between u , v , and focal length (f) of a spherical mirror is known as mirror formula.

That is $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

24. **Linear magnification :** Linear magnification produced by a mirror is defined as the ratio of the size (or height) of the image to the size of the object . It is denoted by m .

That is $m = \frac{h'}{h} = \frac{-v}{u}$

25. Power of mirror (P) = $\frac{-1}{f(\text{in m})} = \frac{-100}{f(\text{in cm})}$

26. Linear magnification produced by a plane mirror = + 1.

27. **Refraction of light:** The bending of light rays when they pass obliquely from one medium to the other medium is called refraction of light .

28. A transparent medium through which light travels fast is known as optically rarer medium.

29. A transparent medium through which light travels slow is known as optically denser medium.

30. **Laws of refraction**

- (i) The incident ray, the refracted ray and the normal to the surface separating two media all lie in the same plane.
- (ii) The ratio of the sine of the incident angle ($\angle i$) to the sine of the refracted angle ($\angle r$) is constant

i.e. $\frac{\sin i}{\sin r} = \text{constant}$

This constant is known as the refractive index of second medium w.r.t the first medium.

31. Absolute refractive index of a medium is defined as the ratio of the speed of light in vacuum (c) to the speed of light in the medium (v)

i.e. $n = \frac{c}{v}$

32. Relative refractive index of medium 2 w.r.t. the medium 1 is defined as the ratio of the speed of light in medium 1 (v_1) to the speed of light in medium 2 (v_2).

i.e.
$$n_{21} = \frac{v_1}{v_2}$$

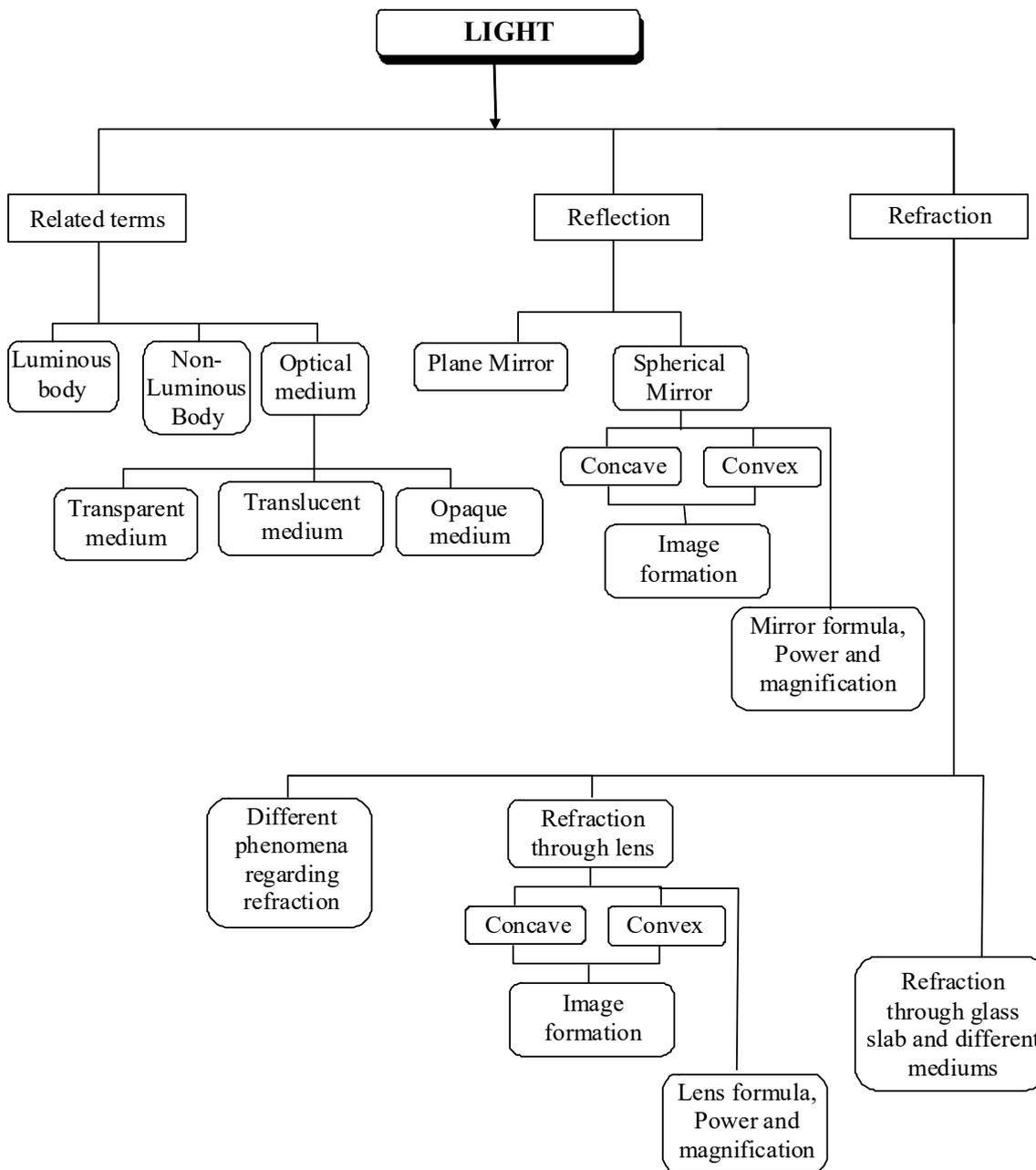
33.
$$n_{21} = \frac{n_2}{n_1}$$

34.
$$n_{21} = \frac{1}{n_{12}}$$

35. A medium whose refractive index is large is known as optically denser medium.
36. A medium whose refractive index is small is known as optically rarer medium.
37. Lateral shift (displacement). The perpendicular distance between the original part of the incident ray and the emergent ray coming out of the glass slab is called lateral shift.
38. Lens is a transparent medium bounded by two spherical refracting surfaces one spherical and other plane refracting surface.
39. Lens are of two types :
- Convex lens or converging lens: it is thick in the middle and thin at the edge.
 - Concave lens or diverging lens: it is thin in the middle and thick at the edge.
40. Convex lens converges the rays of light falling on it and acts as a magnifying glass.
41. Concave lens diverges the rays of light falling on it.
42. Principal axis of a lens is a line joining the centres of curvature of two spherical surfaces forming a lens.
43. Optical centre of a lens is a point inside or outside a lens through which rays of light passes without deviation.
44. Principal focus of a lens is a point on the principal axis where all the rays of light parallel to the principal axis meet or appear to meet after refracting through the lens.
45. Focal length of a lens is the distance between the optical centre and the principal focus of the lens.
46. Focal length of a convex lens is positive.
47. Focal length of a concave lens is negative.
48. Lens formula:
$$-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$
49. Magnification produced by a lens:
$$m = \frac{\text{Size of image}}{\text{Size of object}} = \frac{h'}{h}$$
- Also
$$m = \frac{v}{u}$$
50. Power of lens
$$P = \frac{1}{f(\text{in m})} = \frac{100}{f(\text{in cm})}$$
51. Unit of power is **dioptr** (D).
52. Power of a lens is 1 diopter if its focal length is 1 m or 100 cm.
53. Power of a convex lens is **positive**.
54. Power of concave lens is **negative**.



MIND MAP



EXERCISE-I

NCERT Solutions



TEACHER'S ADVICE:

1. Always take value of u (object distance) $-ve$, in any of the problem either it is of Lens or Mirror directly.
2. Take focal length of convex (either mirror or either lens) $+ve$, each problem directly.
3. Take focal length of the concave (either mirror or lens) $-ve$, each problem directly.

Q.1 Which one of the following materials cannot be used to make a lens?

- (A) Water (B) Glass
(C) Plastic (D) Clay

Sol. (D). This is because clay is opaque (i.e. light cannot pass through it).

Q.2 The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object?

- (A) Between the principal focus and the centre of curvature.
(B) At the centre of curvature.
(C) Beyond the centre of curvature.
(D) Between the pole of the mirror and its principal focus.

Sol. (D)

Q.3 Where should an object be placed in front of a convex lens to get a real image of the size of the object?

- (A) At the principal focus of the lens.
(B) At twice the focal length.
(C) At infinity.
(D) Between the optical centre of the lens and its principal focus.

Sol. (B)

Q.4 A spherical mirror and a thin spherical lens have each a focal length of -15 cm. The mirror and the lens are likely to be

- (A) Both are concave.
(B) Both are convex.
(C) The mirror is concave and the lens is convex.
(D) The mirror is convex but the lens is concave.

Sol. (A)

Q.5 No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be

- (A) Plane only.
(B) Concave only.
(C) Convex only.
(D) Either plane or convex.

Sol. (D)

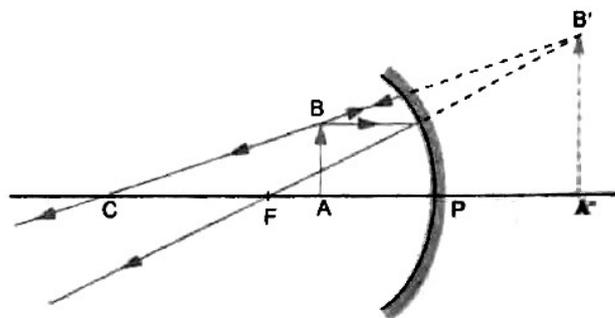
Q.6 Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

- (A) A convex lens of focal length 50 cm.
(B) A concave lens of focal length 50 cm.
(C) A convex lens of focal length 5 cm. (D) A concave lens of focal length 5 cm.

Sol. (D)

Q.7 We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm. What should be the range of distance of the object from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram to show the image formation in this case.

Sol. A concave mirror produces an erect image if the object is placed between the pole and the focus of the concave mirror. Thus, object may be placed at any position whose distance is less than 15 cm from the concave mirror. The image is virtual and erect. The image is larger than the object.



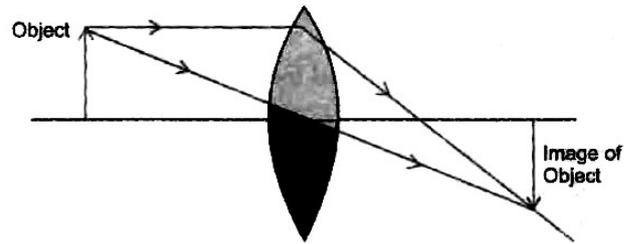
Q.8 Name the type of mirror used in the following situation

- (a) Head lights of a car
(b) Side rear view mirror of a vehicle
(c) Solar furnace

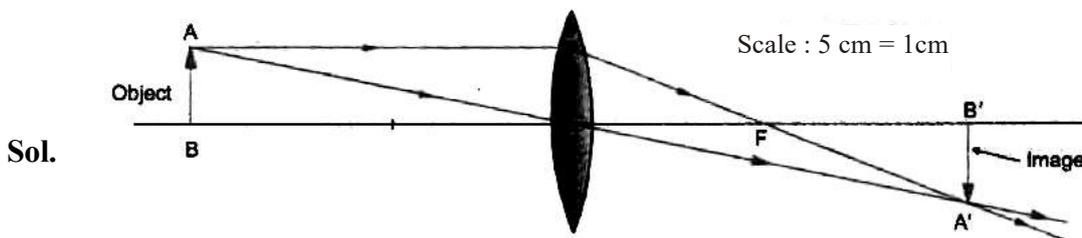
Support your answer with reason.

- Sol.** (a) **Concave mirror :** When a bulb is placed at the focus of a concave mirror, then the beam of light from the bulb after reflection from the concave mirror goes as a parallel beam which lights up the front road.
- (b) **Convex mirror :** Image formed by a convex mirror is erect and small in size. The field of view behind the vehicle is large.
- (c) **Concave mirror :** Concave mirror focuses rays of light coming from the sun at its focus. So, the temperature at the focus is raised.

- Q.9** One-half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object?
- Sol.** A complete image of the object is formed as shown in figure (but with less intensity).



- Q.10** An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and the nature of the image formed.



Here, $u = -25$, $f = 10$ cm

Using $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$, we get

$$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} - \frac{1}{25} = \frac{5-2}{50} = \frac{3}{50}$$

$\therefore v = \frac{50}{3} = 16.67$ cm (position of image)

Size of Image :

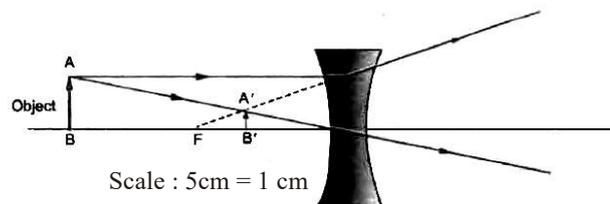
$$m = \frac{h'}{h} = \frac{v}{u} = +\frac{50}{3 \times -25} = -\frac{2}{3}$$

or $h' = -\frac{2}{3} \times h = -\frac{2}{3} \times 5 = -\frac{10}{3} = -3.33$ cm

Image is real and inverted.

- Q.11** A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram.

- Sol.** Here, $f = -15$ cm, $v = -10$ cm, $u = ?$



Using, $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$,

we get $-\frac{1}{u} = -\frac{1}{v} + \frac{1}{f} \Rightarrow \frac{-1}{u} = \frac{1}{10} - \frac{1}{15} = \frac{1}{30}$

$\therefore u = -30$ cm.

Q.12 An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.

Sol. Here, $u = -10$ cm, $f = +15$ cm, $v = ?$

$$\text{Using, } \frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

$$\text{we get, } \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{15} + \frac{1}{10} = \frac{1}{6}$$

$$\therefore v = 6 \text{ cm.}$$

Now, $m = \frac{-v}{u} = \frac{6}{10} = 0.6$. Since, m is positive, so the orientation of both object and image is same. Thus, image is erect and virtual.

Q.13 The magnification produced by a plane mirror is +1. What does this mean?

$$\text{Sol. } m = \frac{h'}{h} = 1 \quad \text{or} \quad h' = h$$

It means, size of the image formed by plane mirror is equal to the size of the object. Positive sign with m tells that both object and image are erect.

Q.14 An object 5.0 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the image, its nature and size.

Sol. $h = 5$ cm, $u = -20$ cm, $R = 30$ cm,

$$\therefore f = \frac{R}{2} = 15 \text{ cm}$$

$$(i) \quad \text{Using, } \frac{1}{u} + \frac{1}{v} = \frac{1}{f}, \quad \text{we get}$$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{15} + \frac{1}{20} = \frac{7}{60}$$

$$\therefore v = \frac{60}{7} = 8.57 \text{ cm (Position of image)}$$

$$(ii) \quad \frac{h'}{h} = -\frac{v}{u} = \frac{60}{7 \times 20} = \frac{3}{7}$$

$$\text{or } h' = \frac{3}{7} \times 5 = \frac{15}{7} = 2.14 \text{ cm}$$

Since h' is positive, so image is erect and virtual.

Q.15 An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed, so that a sharp focussed image can be obtained? Find the size and the nature of the image.

Sol. $h = +7.0$ cm, $u = -27$ cm, $f = -18$ cm

$$(i) \quad \text{Using, } \frac{1}{u} + \frac{1}{v} = \frac{1}{f},$$

$$\text{we get } \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = -\frac{1}{18} + \frac{1}{27} = -\frac{1}{54}$$

$$\therefore v = -54 \text{ cm}$$

So the screen must be placed at distance of 54 cm in front of the concave mirror.

$$(ii) \quad \frac{h'}{h} = -\frac{v}{u} \quad \text{or } h' = -\frac{v}{u} \times h$$

$$= \frac{54}{-27} \times 7 = -14 \text{ cm}$$

Since h' is negative, so image is inverted & real.

Q.16 Find the focal length of a lens of power -2.0 D. What type of lens is this?

$$\text{Sol. } P = \frac{1}{f(\text{in m})}$$

$$\therefore f = \frac{1}{P} = \frac{1}{-2} = -0.5 \text{ m} = -50 \text{ cm}$$

The lens is concave.

Q.17 A doctor has prescribed a corrective lens of power $+1.5$ D. Find the focal length of the lens. Is the prescribed lens diverging or converging?

$$\text{Sol. } f = \frac{1}{P} = \frac{1}{1.5} = +0.67 \text{ m} = +67 \text{ cm}$$

Since focal length is positive, so the lens is converging.

Q.18 Define the principal focus of a concave mirror.

Sol. A point on the principal axis where the parallel rays of light after reflecting from a concave mirror meet.

Q.19 The radius of curvature of a spherical mirror is 20 cm. What is focal length?

Sol. Radius of curvature, $R = 20$ cm

\therefore Focal length,

$$f = \frac{R}{2} = \frac{\pm 20}{2} = \pm 10 \text{ cm}$$

Note : '+' for convex mirror, '-' for concave mirror.

Q.20 Name a mirror that can give an erect and magnified image of an object.

Sol. A concave mirror

Q.21 Why do we prefer a convex mirror as a rear-view mirror in vehicles?

Sol. This because a convex mirror forms an erect and diminished (small in size) images of the objects behind the vehicle and hence the field of view behind the vehicle is also increased.

Q.22 Find the focal length of a convex mirror whose radius of curvature is 32 cm.

Sol. $R = +32$ cm. Therefore, $f = R/2 = +32/2 = +16$ cm

Thus, focal length of the convex mirror is 16 cm.

Q.23 A concave mirror produces three times magnified (enlarged) real image of an object placed at 10 cm in front of it. Where is the image located?

Sol. $m = -3$,

$$\begin{aligned} \text{But } m &= -v/u, & \text{so, } v &= 3u \\ u &= -10 \text{ cm, } & v &= 3(-10 \text{ cm}) \\ & & &= -30 \text{ cm} \end{aligned}$$

Thus, the image is located at a distance of 30 cm to the left side of the concave mirror.

Q.24 A ray of light travelling in air enters obliquely into water. Does the light ray bend towards the normal or away from the normal? Why?

Sol. The ray of light bends towards the normal because the speed of light decreases when it goes from air (rarer medium) into water (denser medium).

Q.25 Light enters from air to glass having refractive index 1.50. What is the speed of light in the glass? The speed of light in vacuum is $3 \times 10^8 \text{ ms}^{-1}$.

Sol. $n = \frac{c}{v}$

$$\therefore v = \frac{3 \times 10^8 \text{ ms}^{-1}}{1.50} = 2 \times 10^8 \text{ ms}^{-1}$$

Thus, speed of light in glass is $2 \times 10^8 \text{ ms}^{-1}$.

Q.26 You are given kerosene, turpentine and water. In which of these does the light travel faster?

Sol. We know, $v = \frac{c}{n}$ Refractive index (n) of water is 1.333, whereas refractive index of kerosene is 1.44 and that of turpentine is 1.47. As refractive index of water is least, so speed of light in water is more than in kerosene and turpentine. Hence, light travels faster in water.

Q.27 The refractive index of diamond is 2.72. What is the meaning of this statement?

Sol. We know, $n = \frac{c}{v}$ or $v = \frac{c}{n} = \frac{1}{2.42} \times c$

Then, speed of light in diamond is $\frac{1}{2.42}$ times the speed a light in vacuum.

Q.28 Define 1 dioptre of power of a lens.

Sol. Power = $1/f$ (in m)

Power of a lens in 1 dioptre if focal length of the lens is 1 metre or 100 cm.

Q.29 A convex lens forms a real and inverted image of a needle at a distance of 50 cm. from it. Where is the needle placed in front of the convex lens if the image is equal to the size of the object? Also find the power of the lens.

Sol. (i) $v = 50$ cm

$m = \frac{h'}{h} = -1$ (\because Image is real and inverted & of same size as that of object)

$$\text{Also, } m = \frac{v}{u} \text{ or } u = -v = -50 \text{ cm}$$

Thus, needle is to be placed at 50 cm in front of the lens.

(ii) Using, $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$, we get $\frac{1}{f}$

$$= \frac{1}{50} + \frac{1}{50} = \frac{2}{50} = \frac{1}{25} \text{ or } f = 25 \text{ cm}$$

$$\therefore P = \frac{100}{f(\text{in cm})} = \frac{100}{25} = +4.0 \text{ D}$$

Q.30 Find the power of a concave lens of focal length 2 m.

Sol. Here $f = -2$ m

$$\therefore P = \frac{1}{f} = -\frac{1}{2} = -0.5 \text{ D}$$

EXERCISE-II

Knowledge Vault



MCQ BASED QUESTIONS:

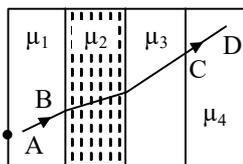
Q.1 When a ray of light enters a glass slab from air.

- (A) Its wavelength decreases.
 (B) Its wavelength increases.
 (C) Its frequency decreases.
 (D) Neither its wavelength nor its frequency changes.

Q.2 An eye specialist prescribe spectacles having combination of convex lens of focal length 40 cm in contact with a concave lens of focal length 25 cm. The power of this lens combination in diopters is

- (A) +1.5 (B) -1.5
 (C) +6.67 (D) -6.67

Q.3 A ray of light passes through four transparent media with refractive indices μ_1, μ_2, μ_3 and μ_4 as shown in the figure. The surfaces of all media are parallel. If the emergent ray CD is parallel to the incident ray AB, we must have



- (A) $\mu_1 = \mu_2$ (B) $\mu_2 = \mu_3$
 (C) $\mu_3 = \mu_4$ (D) $\mu_4 = \mu_1$

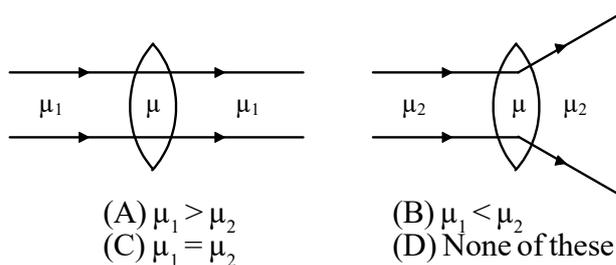
Q.4 A hollow double concave lens is made of very thin transparent material. It can be filled with air or either of two liquids L_1 or L_2 having refractive indices μ_1 and μ_2 respectively ($\mu_2 > \mu_1 > 1$). The lens will diverge a parallel beam of light if it is filled with

- (A) Air and placed in air
 (B) Air and immersed in L_1
 (C) L_1 and immersed in L_2
 (D) L_2 and immersed in L_1

Q.5 A point object is placed at the centre of a glass sphere of radius 6 cm and refractive index 1.5. The distance of virtual image from the surface is

- (A) 6 cm (B) 4 cm
 (C) 12 cm (D) 9 cm

Q.6 What is the relation between the refractive indices μ_1 and μ_2 , if the behaviour of light ray is as shown in the figure.



- (A) $\mu_1 > \mu_2$ (B) $\mu_1 < \mu_2$
 (C) $\mu_1 = \mu_2$ (D) None of these

Q.7 Which of the following lens can form image of an object on screen.

- (A) Concave
 (B) Convex
 (C) Both convex and concave
 (D) none of these

Q.8 To obtain a diminished image of an object, formed by a convex lens, where should the object must be placed?

- (A) between F and 2F
 (B) At F
 (C) between infinity and 2F
 (D) at 2F

Q.9 If object is placed between infinity and 2F of a convex lens, then image will form

- (A) at F
 (B) between F and 2F
 (C) at 2F
 (D) at infinity

Q.10 A convex lens A of focal length 20 cm and a concave lens B of focal length 5 cm are kept along the same axis with a distance 'd' between them. If a parallel beam of light falling on A leaves B as a parallel beam, then d is equal to

- (A) 25 cm (B) 20 cm
 (C) 15 cm (D) 10 cm

Q.11 A thin rod of length $f/3$ is placed along the principal axis of a concave mirror of focal length f such that its image which is real and elongated, just touches the rod. The magnification is

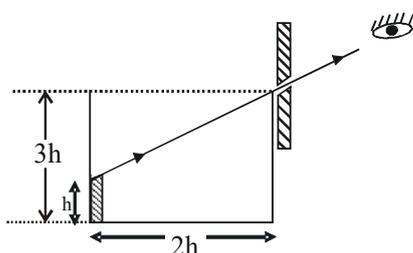
- (A) 2/3 (B) 3/2
 (C) 3/5 (D) 5/3

Q.12 Two thin lenses, when in contact, produce a combination of power +10 diopters. When they are 0.25 m apart, the power reduces to +6 diopters. The focal length of the lenses are

- (A) 0.125 m, 0.5 m (B) 0.25 m, 0.5 m
 (C) 0.25 m, 0.75 m (D) none of these

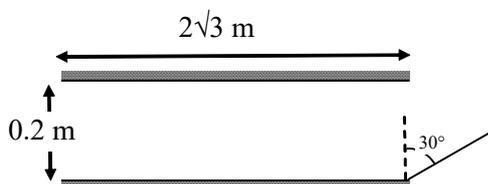
- Q.13** A diminished image of an object is to be obtained on a screen 1.0 m from it. This can be achieved by appropriately placing.
- (A) A convex lens of focal length more than 0.25 m.
 - (B) A convex mirror of suitable focal length.
 - (C) A convex lens of focal length less than 0.25 m.
 - (D) A concave lens of suitable focal length.

- Q.14** An observer can see through a pin-hole the top end of a thin rod of height h , placed as shown in the figure. The beaker height is $3h$ and its radius h . When the beaker is filled with a liquid up to a height $2h$, he can see the lower end of the rod. Then the refractive index of the liquid is



- (A) $\frac{5}{2}$
- (B) $\sqrt{\frac{5}{2}}$
- (C) $\sqrt{\frac{3}{2}}$
- (D) $\frac{3}{2}$

- Q.15** Two plane mirrors A and B are aligned parallel to each other as shown in the figure. A light ray is incident at an angle 30° at a point just inside one end of A. The plane of incidence coincides with the plane of the figure. The maximum number of times the ray undergoes reflections (including the first one) before it emerges out is



- (A) 28
- (B) 30
- (C) 31
- (D) 34

- Q.16** The size of the image of an object, which is at infinity, as formed by a convex lens of focal length 30 cm is 2 cm. If a concave lens of focal length 20 cm is placed between the convex lens and the image at a distance of 26 cm from the convex lens, calculate the new size of the image.

- (A) 1.25 cm
- (B) 1.67 cm
- (C) 1.05 cm
- (D) 2 cm

- Q.17** A convex lens is in contact with concave lens. The magnitude of the ratio of their focal length is $2/3$. Their equivalent focal length is 30 cm. What are their individual focal lengths?
- (A) -15, 10
 - (B) -10, 15
 - (C) 75, 50
 - (D) -75, 50

- Q.18** A short linear object of length 'b' lies along the axis of a concave mirror of focal length f at a distance u from the pole of the mirror. The size of the image is approximately equal to

- (A) $b\left(\frac{u-f}{f}\right)^{1/2}$
- (B) $b\left(\frac{f}{u-f}\right)^{1/2}$
- (C) $b\left(\frac{u-f}{f}\right)$
- (D) $b\left(\frac{f}{f-u}\right)^2$

- Q.19** A concave mirror is placed on a horizontal table, with its axis directed vertically upwards. Let O be the pole of the mirror and C its centre of curvature. A point object is placed at C. It has a real image also located at C. If the mirror is now filled with water, the image will be
- (A) real, and will remain at C
 - (B) real, and located at a point between C and ∞ .
 - (C) virtual, and located at a point between C and O
 - (D) real, and located at a point between C and O.

- Q.20** A converging lens is used to form an image on a screen. When the upper half of the lens is covered by an opaque screen.
- (A) half the image will disappear
 - (B) complete image will be formed
 - (C) intensity of the image will increase
 - (D) intensity of the image will decrease

- Q.21** Which of the following forms a virtual and erect image for all positions of the object?
- (A) convex lens
 - (B) concave lens
 - (C) convex mirror
 - (D) concave mirror

FILL IN THE BLANKS:

Q.22 A light wave of frequency 5×10^{14} Hz enters a medium of refractive index 1.5. In the medium the velocity of light wave is _____ and its wavelength is _____.

MATCH THE COLUMN:

[A] [ONE TO ONE]:

Column-I and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. Only One entries of column-I may have the matching with the same entries of column-II and one entry of column-II Only one matching with entries of column-I

- | Q.23 Column I | Column II |
|--|---|
| (A) Law of reflection | (P) $1/\text{focal length}$ |
| (B) Law of refraction | (Q) $\angle i = \angle r$ |
| (C) Power of lens | (R) $\frac{\sin i}{\sin r} = \text{constant}$ |
| (D) Absolute refractive index of glass | (S) $\frac{\text{Speed of light in air}}{\text{Speed of light in glass}}$ |
- (A) (a)-(p,q), (b)-(q), (c)-(q), (d)-(p,q)
 (B) (a)-(q), (b)-(r), (c)-(p), (d)-(s)
 (C) (a)-(p), (b)-(r), (c)-(q), (d)-(p,s)
 (D) (a)-(p,r), (b)-(q), (c)-(q), (d)-(r)

[B] [ONE TO MANY]:

Column-I and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the same entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I

- | Q.24 Column I | Column II |
|---|--|
| (A) Straight line which is normal to | (P) Will pass through principal focus (F) the mirror at its pole (P) |
| (B) A ray, parallel to the principal axis | (Q) Focal length (f) of concave mirror after reflection |
| (C) The distance between the pole and | (R) Principal axis the principal focus of a mirror |
| (D) A straight line passing through the | (S) Half of radius of curvature |
- (R) pole (P) and the centre of curvature (c)
 (A) (a)-(r), (b)-(p), (c)-(q,s), (d)-(p,r)
 (B) (a)-(p,r), (b)-(s), (c)-(q), (d)-(p,q)
 (C) (a)-(p), (b)-(q,r), (c)-(q), (d)-(p,s)
 (D) (a)-(p,r), (b)-(q), (c)-(p,q), (d)-(p,q,r)

ASSERTION & REASON TYPE QUE.:

Instructions: In the following questions as Assertion (A) is given followed by a Reason (R). Mark your responses from the following options.

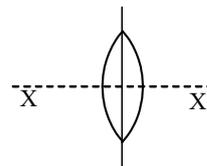
- (A) Both Assertion and Reason are true and Reason is the correct explanation of 'Assertion'
- (B) Both Assertion and Reason are true and Reason is not the correct explanation of 'Assertion'
- (C) Assertion is true but Reason is false
- (D) Assertion is false but Reason is true

Q.25 Assertion: Array of light entering from glass to air suffers from change in frequency.
Reason: Velocity of light in glass is less than that in air.

Q.26 Assertion: A plane mirror has unity magnification.
Reason: In the case of plane mirror the distance of image is equal to the distance of object.

Q.27 Assertion: Convex mirror is used as a driver's mirror.
Reason: Field view of a convex mirror is large.

Q.28 Assertion: Focal length of a lens remain same if it is cut across the axis along XX'.



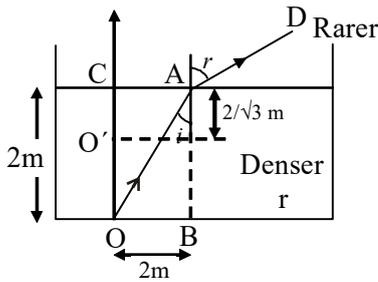
Reason: Both the refracting surfaces remain in contact if the lens is cut along X – X' plane.

Q.29 Assertion: Power of a lens is indirectly proportional to its focal length.
Reason: Units of focal length and power of a lens are same.

COMPREHENSIVE:

An object O is placed in denser medium. A light ray OA travels from denser to rarer medium. Refracted ray AD appears to come from O'. O' is image of the object O.

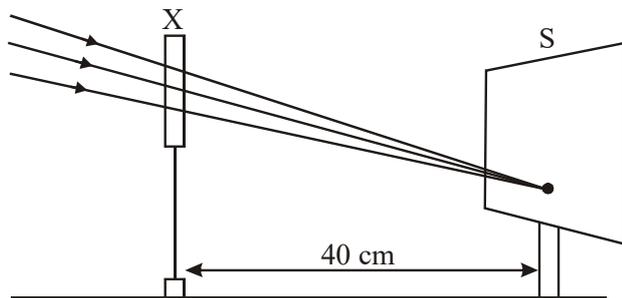
Given that: $OC = 2\text{m}$, $O'C = \frac{2}{\sqrt{3}}\text{m}$ and $OB = 2\text{m}$.



- Q.30** Value of angle i is
 (A) 60° (B) 45° (C) 30°
 (D) None of these
- Q.31** Value of angle r is
 (A) 60° (B) 45° (C) 30°
 (D) None of these
- Q.32** Refractive index of denser medium w.r.t. rarer medium is
 (A) $\frac{\sin i}{\sin r}$ (B) $\frac{\sin r}{\sin i}$
 (C) $\frac{\sin(i - r)}{\sin r}$ (D) None of these

PRACTICAL BASED QUESTIONS :

Q.33 A student focused the image of a distant object using a device 'X' on a white screen 'S' as shown in the figure. If the distance of the screen from the device is 40 cm, select the correct statement about the device.

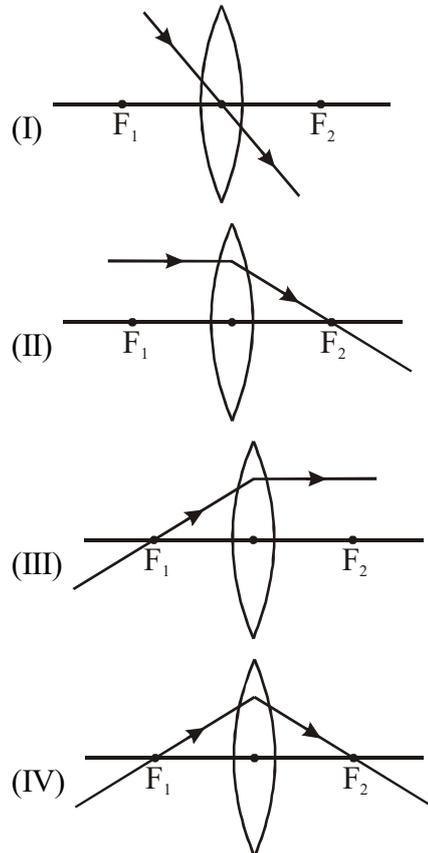


- (A) The device X is a convex lens of focal length 20 cm.
 (B) The device X is a concave mirror of focal length 40 cm.
 (C) The device X is concave mirror of radius of curvature 40 cm.
 (D) The device X is a convex lens of focal length 40 cm.

- Q.34** A student obtained a sharp image of a burning candle, placed at the farther end of a laboratory table, on a screen using a concave mirror. For getting better value of focal length of the mirror, the subject teacher suggested him for focussing a well illuminated distant object. What should the student do?
 (A) He should move the mirror away from the screen.
 (B) He should move the mirror slightly towards the screen.
 (C) He should move the mirror as well as the screen towards the newly selected object.
 (D) He should move only the screen towards the newly selected object.

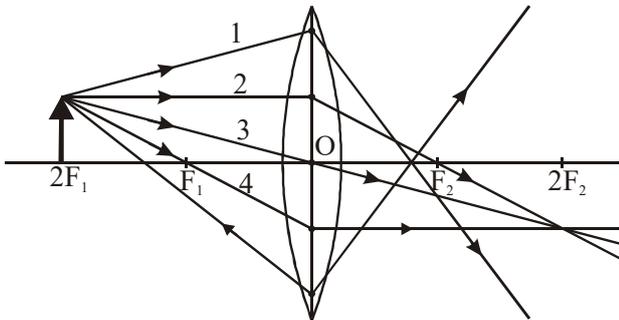
- Q.35** After tracing the path of rays of light through a glass slab for three different angles of incidence, a student measured the corresponding values angle of refraction (r) and angle of emergence (e) and recorded them in the table given below:
- | S.No. | $\angle i$ | $\angle r$ | $\angle e$ |
|-------|------------|------------|------------|
| I | 30° | 20° | 31° |
| II | 40° | 25° | 40° |
| III | 50° | 31° | 49° |
- correct observations are :
 (A) only I (B) only II
 (C) I and III (D) I, II and III

Q.36 Study the following ray diagrams:



The diagrams showing the correct path of the ray after passing through the lens are
 (A) II and III only (B) I and II only
 (C) I, II and III (D) I, II and IV

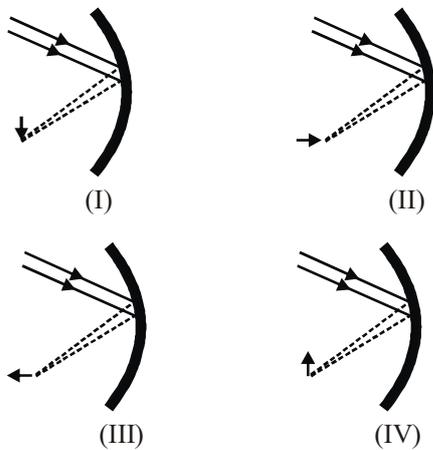
Q.37 Out of the five incident rays shown in the figure find the three rays that are obeying the laws of refraction and may be used for locating the position of image formed by a convex lens.



- (A) 1, 2 and 3 (B) 2, 3 and 4
 (C) 3, 4 and 5 (D) 1, 2 and 4

Q.38 What does the relationship $\angle i = \angle e$ mean ?

Q.39 Four students A, B, C and D carried out focal length of concave mirror as shown in four diagram:



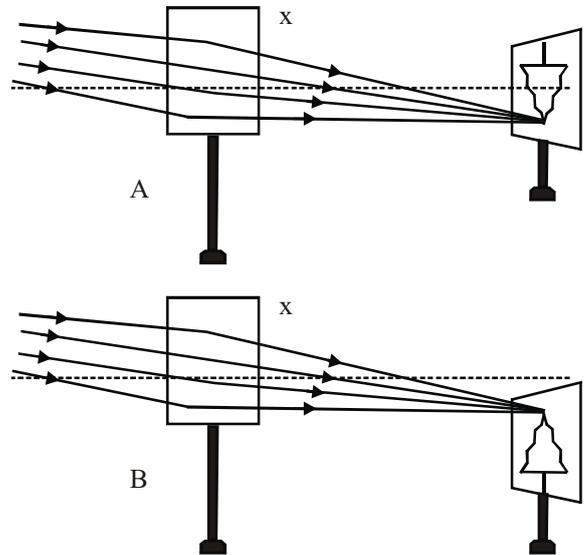
Correct diagram is :

- (A) II (B) I
 (C) III (D) IV

Q.40 A student obtained a sharp image of the grill of a window on a screen, using a convex lens. For getting better results, the teacher suggested focusing of a distant tree instead of the grill. In which direction should the lens be moved for this purpose ?

- (A) away from the screen
 (B) very far away from the screen
 (C) behind the screen
 (D) towards the screen

Q.41 Parallel rays, from a distant tree, incident on the device X, forms its distinct image on a screen as shown. The diagram correctly showing the image of the tree on the screen, is diagram :



- (A) A and the device X is convex lens
 (B) A and the device X is a concave mirror
 (C) B and A the device X is convex lens
 (D) B and the device X is a concave mirror

Q.42 Three students measured the focal length of a convex lens using parallel rays from a distant object. All of them measured the distance between the lens and the inverted image on the screen.

Student A saw a sharp image on the screen and labelled the distance of f_1 .

Student B saw a slightly larger blurred image on the screen and labelled the distance as f_2 .

Student C saw a slightly smaller blurred image on the screen and labelled the distance as f_3 .

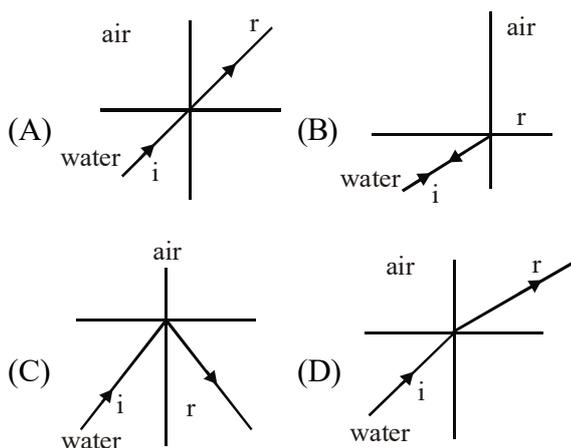
The relation between the three measurements would most likely be :

- (A) $f_1 = f_2 = f_3$ (B) $f_1 < f_2$ and f_3
 (C) $f_3 < f_1 < f_2$ (D) $f_1 < f_2$ and $f_1 = f_3$

Q.43 In an experiment to determine the focal length of a convex lens, a student obtained a sharp inverted image of a distant tree on the behind the lens. She then removed the screen and looked through the lens in the direction of the object. She will see :

- (A) An inverted image of the tree at the focus of the lens
 (B) No image as the screen has been removed
 (C) A blurred image on the wall of the laboratory
 (D) An erect image of the tree on the lens

Q.44 A ray of light is travelling from water to air, which figure shows correct refraction ?



Q.45 Which characteristic of light remains unchanged on refraction ?

- (A) velocity (B) frequency
(C) refractive index (D) wavelength

Q.46 When ray of light enters glass from air, its wavelength :

- (A) decreases (B) Increases
(C) remains same (D) all of them

CASE BASED / NUMERICAL TYPE QUE.:

Q.47 A convex lens of focal length 40 cm is in contact with a concave lens of focal length 25 cm. Find the power of the combination.

Ans.

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{0.4} + \frac{1}{-0.25} = \frac{1}{0.4} - \frac{1}{0.25}$$

$$= \frac{0.25 - 0.4}{0.4 \times 0.25} = \frac{-0.15}{0.4 \times 0.25}$$

or $\frac{1}{f} = \frac{-0.15}{0.4 \times 0.25} = -1.5 \text{ cm}$

or $P = \frac{1}{f} = -1.5 \text{ Dioptre}$

Q.48 The speed of light in water 2.25×10^8 m/s. If the speed of light in vacuum be 3×10^8 m/s, calculate the refractive index of water.

Ans.

Refractive index of water

$$= \frac{\text{Speed of light in vacuum}}{\text{Speed of light in water}}$$

$$= \frac{3 \times 10^8}{2.25 \times 10^8} = \frac{3 \times 100}{225} = 1.33$$

Q.49 A person having a myopic eye uses a concave lens of focal length 50 cm. What is the power of the lens?

Ans. Focal length, $f = -50 \text{ cm}$ (concave lens)
Now, power,

$$P = \frac{1}{f(\text{in metre})} = \frac{1}{-50/100 \text{ m}} = -\frac{100}{50} = -2D$$

Thus, the power of this concave lens is -2 dioptres.

Q.50 A glass slab placed over a page on which VIBGYOR is printed with each letter in its corresponding color.

(i) Will the image of all the letters be at same place

(ii) If not, give reason for your answer

Ans. (i) No, the image of letters of different color will be raised by slightly different heights from each other.

(ii) Violet raised to maximum height because of refractive index of violet is maximum. Its apparent depth will be minimum, hence maximum height.

Q.51 An object is situated at a distance of $f/2$ from a convex lens of focal length f . Find the distance of the image.

Ans. For a spherical lens $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

For convex lens $u = -f/2$ and f is +ve

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{f} - \frac{2}{f} = -\frac{1}{f} \quad \therefore v = -f$$

Therefore distance of image $v = -f$.

Q.52 An object of length 1 cm is placed at a distance of 15 cm from a concave mirror of focal length 10 cm. Find the nature and size of the image.

Ans. Given, $u = -15 \text{ cm}$ $f = -10 \text{ cm}$, $O = 1 \text{ cm}$
By using mirror formula

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}, \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-10} - \frac{1}{-15}$$

$\therefore V = -30 \text{ cm}$

By magnification formula

$$\frac{I}{O} = \frac{-v}{u} = -\frac{-30}{-15} = -2$$

$$I = -2 \times 1 = -2 \text{ cm}$$

Image is real and inverted and placed on the same side of size 2 cm of mirror.

Q.53 A biconvex lens whose both the surfaces have same radii of curvature has a power of 5D. The refractive index of material of lens is 1.5. Find the radius of curvature of each surface.

Ans. $P = \frac{1}{f}$, $\therefore f = \frac{1}{P} = \frac{1}{5} \text{ m} = 20 \text{ cm}$

For an equiconvex lens

$$\frac{1}{f} = \frac{2(\mu - 1)}{R}$$

$$\therefore R = 2(\mu - 1) f = 2 \times 0.5 \times 20 = 20 \text{ cm}$$

Q.54 A lens placed at a distance of 20 cm from an object produces a virtual image $\frac{2}{3}$ the size of the object. Find the position of the image, kind of lens and its focal lens

Ans. Virtual image means I is positive and it is given that $I = (\frac{2}{3})O$. Thus $m = + \frac{2}{3}$

Further because $u = -20 \text{ cm}$ (given), using

$$m = \frac{f}{f + u}$$

we get $\frac{2}{3} = \frac{f}{f + (-20)}$ or $f = -40 \text{ cm}$

Thus f is negative, thus the lens is a concave lens. Again using $m = v/u$

we get $\frac{2}{3} = \frac{v}{-20}$

or $v = -\frac{40}{3} = -13.33 \text{ cm}$

Thus virtual and erect image is formed on the same side of the object.

Q.55 The focal length of a concave mirror is 30 cm. Find the position of the object in front of the mirror, so that the image is three times the size of the object.

Ans. Here image can be real or virtual. If the image is real.

$f = -30 \text{ cm}$, $u = ?$, $m = -3$

$$m = \frac{f}{f - u} \Rightarrow -3 = \frac{-30}{-30 - u}$$

$\Rightarrow u = -40 \text{ cm}$

If the image is virtual

$$m = \frac{f}{f - u} \Rightarrow 3 = \frac{-30}{-30 - u}$$

$\Rightarrow u = -20 \text{ cm}$

Q.56 A square ABCD of side 1 mm is kept at distance 15 cm in front of the concave mirror as shown in the figure. The focal length of the mirror is 10 cm. Find the length of the perimeter of its image.

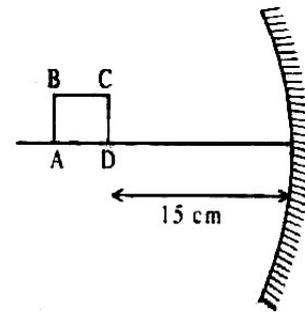
Ans. Given that $u = -15 \text{ cm}$, $f = -10 \text{ cm}$

By using mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\therefore \frac{1}{v} = \frac{-3 + 2}{30}$$

$$\therefore v = -30, m = -\frac{v}{u} = -2$$

$$\therefore A'B' = C'D' = 2 \times 1 = 2 \text{ mm}$$

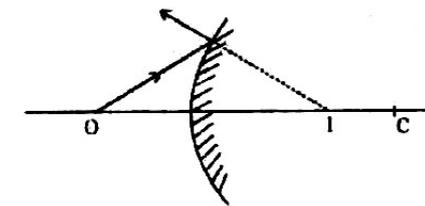


Now, $\frac{B'C'}{BC} = \frac{A'D'}{AD} = \frac{v^2}{u^2} = 4 \text{ mm}$

$\Rightarrow B'C' = A'D' = 4 \text{ mm}$

$\therefore \text{Length} = 2 + 2 + 4 + 4 = 12 \text{ mm}$

Q.57 A convex mirror has its radius of curvature 20 cm. Find the position of the image of object placed at a distance of 12 cm from the mirror.



Ans. The situation is shown in figure above.

Here, $u = -12 \text{ cm}$ and $R = +20 \text{ cm}$. We have

$$\frac{1}{u} + \frac{1}{v} = \frac{2}{R} \text{ or } \frac{1}{v} = \frac{2}{R} - \frac{1}{u}$$

$$\Rightarrow \frac{1}{v} = \frac{2}{20} - \frac{1}{-12} = \frac{11}{60} \text{ cm}$$

$$\Rightarrow v = \frac{60}{11} \text{ cm}$$

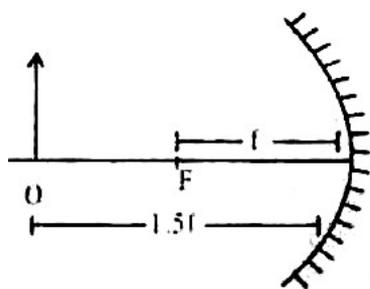
Hence, distance of images 5.45 cm

Q.58 An object of length 2.5 cm is placed at a distance of $1.5f$ from a concave mirror where f is the magnitude of the focal length of the mirror. The length of the object is perpendicular to the principal axis. Find the length of the image. Is the image erect or inverted?

Ans. The given situation is shown in the figure
The focal length $f = -f$ and $u = -1.5f$,
 $h_1 = 2.5$ cm

We know $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

or $\frac{-1}{1.5f} + \frac{1}{v} = -\frac{1}{f}$



or $\frac{1}{v} = \frac{1}{1.5f} - \frac{1}{f} = \frac{-1}{3f}$ or $v = -3f$

Now $m = -\frac{v}{u} = \frac{3f}{1.5f} = -2$.

or $\frac{h_2}{h_1} = -2$.

or $h_2 = -2h_1 = -5.0$ cm

The image is 5.0 cm long. The minus sign shows that it is inverted.

Q.59 Sunlight is incident on a concave mirror, parallel to its principal axis. The image is formed at a distance of 12 cm from the pole. Find the radius of curvature of the mirror.

Ans. As the rays from the sun are parallel to the principal axis, they form the image at the focus. Thus, the focal length of the mirror is 12 cm. The radius of curvature will be twice the focal length, i.e. 24 cm

Q.60 An object is placed at a distance of 20 cm from a convex mirror of focal length 25 cm. Calculate the position of the image. Discuss its nature.

Ans. Here, $u = 20$ cm and $f = 25$ cm

We have $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{25 \text{ cm}} - \frac{1}{-20 \text{ cm}} = \frac{9}{100 \text{ cm}}$

$v = \frac{100}{9} \text{ cm} = 11.11 \text{ cm}$

The positive sign of v shows that the image is formed on the right i.e. behind the mirror. The image is virtual. Also,

$m = -\frac{v}{u} = -\frac{11.11}{-20} = +0.55$

Since the magnification, and hence, the height of the image is positive, the image is erect.

Q.61 A 2.0 cm high object is placed at a distance of 20 cm from a concave mirror. A real image is formed at 40 cm from the mirror. Calculate the focal length of the mirror and the size of the image.

Ans. As the image is real, it is formed on the same side as the reflected rays.

Here, $u = -20$ cm and $v = -40$ cm

Thus, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{-20 \text{ cm}} + \frac{1}{-40 \text{ cm}}$

or $f = -13.3$ cm

The magnification is, $m = -\frac{v}{u} = -\frac{-40 \text{ cm}}{-20 \text{ cm}} = -2.0$ cm

The height of the image is 4.0 cm, and the negative sign of $h_e = -2h_o = -2 \times 2.0$ cm = -4.0 cm

The height of the image is 4.0 cm, and the negative sign of h_e shows that the image is inverted.

Q.62 Find the position, size and the nature of the image formed by a spherical mirror from the following data

$u = -20$ cm, $f = -15$ cm, $h_o = 1.0$ cm

Ans. We have $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

or $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-15} - \frac{1}{-20 \text{ cm}} = \frac{-1}{60 \text{ cm}}$

or $v = -60$ cm

The image is formed at 60 cm from the mirror. Since the sign of u and v are the same, the image is on the same side as the object (to the left of the mirror) and hence, is real. The magnification is

$$m = \frac{h_i}{h_o} = -\frac{v}{u} = -\frac{-60 \text{ cm}}{-20 \text{ cm}} = -3$$

So $h_i = -3h_o = -3 \times 1.0 \text{ cm} = -3.0 \text{ cm}$
The minus sign shows that the image is inverted. Its size is 3.0 cm.

Q.63 A 2 cm high object is placed at a distance of 32 cm from a concave mirror. The image is real, inverted and 3 cm in size. Find the focal length of the mirror and the position of the image.

Ans. We have $m = -\frac{v}{u} = \frac{h_i}{h_o}$

From the question $h_i = -3 \text{ cm}$ and $h_o = 2 \text{ cm}$

$$\therefore m = \frac{h_i}{h_o} = \frac{-3 \text{ cm}}{2 \text{ cm}} = -1.5 \text{ or } -\frac{v}{u} = -1.5$$

$$\text{or } \frac{v}{-32 \text{ cm}} = 1.5 \quad \text{or } v = -48 \text{ cm}$$

$$\begin{aligned} \text{We have } \frac{1}{f} &= \frac{1}{u} + \frac{1}{v} \\ &= \frac{1}{-32 \text{ cm}} + \frac{1}{-48 \text{ cm}} = \frac{-5}{96 \text{ cm}} \end{aligned}$$

$$\text{or } f = \frac{-96 \text{ cm}}{5} = -19.2 \text{ cm}$$

So the focal length of the concave mirror is 19.2 cm, and the image is formed 48 cm in front of it .

Q.64 A concave mirror forms an inverted image of an object placed at a distance of 12 cm from it. If the image is twice as large as the object, where is it formed.

Ans. From the question

$$\frac{h_i}{h_o} = -2 \text{ (inverted image)}$$

$$\text{But } \frac{h_i}{h_o} = -\frac{v}{u}$$

$$\frac{v}{u} = 2$$

$$\text{or } v = 2u = 2(-12 \text{ cm}) = -24 \text{ cm}$$

The image is formed 24 cm in front of the mirror.

Q.65 A concave mirror forms an erect image of an object placed at a distance of 10 cm from it. The size of the image is double that of the object. Where is the image formed ?

Ans. From the question,

$$\frac{h_i}{h_o} = +2 \text{ (erect image)}$$

$$\text{or } -\frac{v}{u} = 2 \quad \text{or } v = -2u$$

$$= -2(-10 \text{ cm}) = +20 \text{ cm}$$

Thus the image is formed 20 cm behind the mirror (from the positive sign of v)

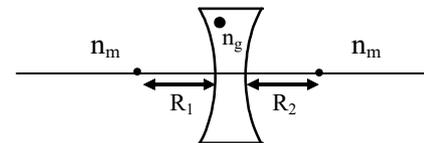
Q.66 A concave lens of glass, refractive index 1.5 has both surfaces of same radius of curvature R . On immersion in a medium of refractive index 1.75, it will behave as a
(A) convergent lens of focal length 3.5 R
(B) convergent lens of focal length 3.0 R
(C) divergent lens of focal length 3.5 R
(D) divergent lens of focal length 3.0 R

Ans. According to lens maker's formula

$$\frac{1}{f} = (n_{gm} - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

$$\text{Now, } n_{gm} = \frac{n_g}{n_m} = \frac{1.5}{1.75}$$

For concave lens as shown in figure in this case $R_1 = -R$ and $R_2 = R$



$$\therefore \frac{1}{f} = \left(\frac{1.5}{1.75} - 1 \right) \left(-\frac{1}{R} - \frac{1}{R} \right) = +\frac{0.25 \times 2}{1.75R}$$

$$\text{or } f = +3.5 R$$

The positive sign shows that the lens behaves as convergent lens.

Q.67 A ray of light travelling in air falls on the surface of a rectangular slab of a plastic material whose refractive index is 1.6. If the incident ray makes an angle of 53° with the normal, find the angle made by the refractive ray with the normal ($\sin 53^\circ = 4/5$).

Ans. The angle of incidence is 53° and the refractive index is $n = 1.6$.

$$\text{We have, } \frac{\sin i}{\sin r} = n \quad \text{or } \sin r = \frac{\sin i}{n}$$

$$\text{or } \frac{\sin 53^\circ}{1.6} = \frac{4}{5 \times 1.6} \Rightarrow \sin r = \frac{1}{2}$$

$$\text{or } r = 30^\circ$$

Q.68 Find the refractive index of glass with respect of water. The refractive indices of these with respect to air are $\frac{3}{2}$ and $\frac{4}{3}$ respectively.

Ans. We have $n_{21} = \frac{n_2}{n_1}$. Here, glass is the second medium

$$\text{Here } n_2 = \frac{3}{2}, n_1 = \frac{4}{3}, \text{ So, } n_{21} = \frac{9}{8}$$

Q.69 A point object is placed at a distance of 12 cm from a convex lens on its principal axis. Its image is formed on the other side of the lens at a distance of 18 cm from the lens. Find the focal length of the lens.

Ans. According to convention, let the object be on the left of the lens. Therefore u is negative, i.e. $u = -12$ cm. Since the image is on the other side, it is formed on the right of the lens. Thus v is positive, i.e. $v = +18$ cm. (you can also say that since u is measured opposite to the direction of the incident ray, it is negative. And since v is measured along the direction of the incident rays, it is positive)

$$\text{We have, } \frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\text{or } \frac{1}{f} = \frac{1}{18 \text{ cm}} - \frac{1}{-12 \text{ cm}} = \frac{5}{36 \text{ cm}}$$

$$\text{or } f = \frac{36}{5} \text{ cm} = 7.2 \text{ cm}$$

Q.70 The image of an object formed by a convex lens is of the same size as the object. If the image is formed at a distance of 40 cm, find the focal length of the lens. Also find the power of the lens. At what distance from the lens is the object placed?

Ans. A same sized image is formed when an object is placed at a distance of $2f$ from the convex lens. The image is formed at a distance of $2f$ from the lens. Here this distance is given as 40 cm. So

$$2f = 40 \text{ cm} \quad \text{or} \quad f = 20 \text{ cm}$$

$$\text{Power } p = \frac{1}{f} = \frac{1}{0.2 \text{ m}} = 5 \text{ D}$$

The object is placed at a distance of $2f = 40$ cm from the lens.

Q.71 An object is placed on the principal axis of a concave lens at a distance of 20 cm from it. If the focal length of the lens is also 20 cm, find the location of the image.

Ans. Given $u = -20$ cm, $f = -20$ cm

$$\text{We have } \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\text{or } \frac{1}{v} - \frac{1}{-20 \text{ cm}} = \frac{1}{-20 \text{ cm}}$$

$$\text{or } \frac{1}{v} = \frac{1}{-20 \text{ cm}} + \frac{1}{-20 \text{ cm}} = \frac{-1}{10} \quad \text{or} \\ v = -10 \text{ cm.}$$

Thus, the image is formed at a distance of 10 cm from the lens. As v has turned out to be negative, the image just be on the left of the lens.

Q.72 A beam of light travelling parallel to the principal axis of a concave lens appears to diverge from a point 20 cm behind the lens after passing through the lens. Find the power of the lens.

Ans. By definition, the point from where the beam appears to diverge is the focus of the lens. Thus the focal length is 20 cm. As it is a concave lens, f is negative

$$f = -20 \text{ cm} = -0.2 \text{ m}$$

$$\text{The power is } P = \frac{1}{f} = \frac{1}{-0.2 \text{ m}} = -5 \text{ D}$$

Q.73 A convex lens of power 4 D is placed at a distance of 40 cm from a wall. At what distance from the lens should a candle be placed so that its image is formed on the wall?

Ans. Here, $f = \frac{1}{P} = \frac{1}{4 \text{ D}} = \frac{1}{4} \text{ m} = 25 \text{ cm}$,
and $v = +40$ cm

$$\text{We have } \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\text{or } \frac{1}{u} = \frac{1}{v} - \frac{1}{f} = \frac{1}{40} - \frac{1}{25} = -\frac{3}{200 \text{ cm}}$$

So the candle should be placed $\frac{-200}{3}$ cm from the lens

Q.74 A pin which is 2 cm long is placed at a distance of 16 cm from a convex lens. Assuming it to be perpendicular to the principal axis, find the position, size and the nature of the image if the focal length of the lens is 12 cm.

Ans. Here $u = -16$ cm and $f = +12$ cm

We have $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ or $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$

$$= \frac{1}{-16 \text{ cm}} + \frac{1}{12 \text{ cm}} = \frac{1}{48}$$

or $v = +48$ cm

The image is formed 48 cm from the lens on the side of the transmitted rays. The image is therefore real.

The magnification is

$$m = \frac{v}{u} = \frac{48 \text{ cm}}{-16 \text{ cm}} = -3 \text{ or } \frac{h_i}{h_o} = -3$$

or $h_i = -3h_o = -3 \times 2 \text{ cm} = -6 \text{ cm}$

The image is inverted and is 6 cm in size. So an inverted and real image of size 6 cm is formed 48 cm from the lens.

Q.75 A 4.0 cm high object is placed at a distance of 60 cm from a concave lens of focal length 20 cm. Find the size of the image.

Ans. We have $f = -20$ cm and $u = -60$ cm

For a lens $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\text{or } \frac{1}{v} = \frac{1}{u} + \frac{1}{f} = \frac{1}{-60 \text{ cm}} + \frac{1}{-20 \text{ cm}}$$

$$= -\frac{1}{15 \text{ cm}}$$

or $v = -15$ cm

The magnification is

$$m = \frac{h_i}{h_o} = \frac{v}{u} = \frac{-15 \text{ cm}}{-60 \text{ cm}} = \frac{1}{4}$$

or $h_i = \frac{h_o}{4} \Rightarrow \frac{4.0 \text{ cm}}{4} = 1.0 \text{ cm}$

So the image is 1.0 cm high. The positive sign shows that it is erect.

Q.76 A convex lens of focal length 20 cm is placed in contact with a concave lens of focal length 12.5 cm in such a way that they have the same principal axis. Find the power of combination.

Ans. $P = P_1 + P_2$

Here $P_1 = +\frac{1}{20 \text{ cm}} = +\frac{1}{0.20 \text{ m}} = 5\text{D}$

and $P_2 = \frac{1}{125 \text{ cm}} = -\frac{1}{0.125 \text{ m}} = -8\text{D}$

So the power of the combination is

$$P_1 + P_2 = -3 \text{ D.}$$

Q.77 A plane mirror is approaching you at 10 cm/sec. You can see your image in it. At what speed will your image approach you.

Ans. Relative speed of image with respect to person/observer = $2 \times$ Speed of object with respect to mirror
 $= 2 \times 10 \text{ cm/sec} = 20 \text{ cm/sec.}$

Q.78 Two mirrors are kept at 72° to each other and a body is placed at middle. Find the total number of images formed?

Ans. Here, $\frac{360}{\theta} = \frac{360}{72} = 5$

$\therefore \frac{360}{\theta}$ is odd integer and placement is symmetrical.

So, number of images = $\frac{360}{\theta} - 1 = 5 - 1 = 4.$

Q.79 An object is placed in front of a concave mirror of radius of curvature 40 cm at a distance of 10 cm. Find the position, nature and magnification of the image.

Ans. Here, $R = -40$ cm, $u = -10$ cm
 Focal length of concave mirror,

$$f = \frac{R}{2} = -\frac{40}{2} = -20 \text{ cm}$$

Using $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$,

we get $\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$

$$= -\frac{1}{20} - \frac{1}{(-10)} = -\frac{1}{20} + \frac{1}{10} = \frac{-1+2}{20} = \frac{1}{20}$$

$\therefore v = +20$ cm

Thus position of the image is at 20 cm to the right side of the pole of the mirror.

Since v is positive, so virtual image is formed.

$$m = -\frac{v}{u} = \frac{-20}{(-10)} = 2 \text{ Since, } m = \frac{I}{O} = 2$$

$\therefore I = 2 \times O$

Therefore, size of image is double than the size of the object, Moreover image is erect.

Q.80 An object is situated at a distance of 15 cm from a convex lens of focal length 30 cm. Find the position of the image formed by it.

Ans. $u = -15$ cm, $f = 30$ cm, $v = ?$

$$\therefore \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{30} - \frac{1}{15} = \frac{1-2}{30}$$

or $\frac{1}{v} = -\frac{1}{30}$ or $v = -30$ cm

Q.81 Find the time taken by light in travelling a water column of length 1000 m if the refractive index of water is $4/3$.

Ans. $n_{aw} = \frac{v_a}{v_w}$

$$\therefore v_w = \frac{v_a}{n_{aw}} = \frac{3 \times 10^8}{4/3}$$

or $v_w = 2.25 \times 10^8$ m/s

or $t = \frac{d}{v_w} = \frac{1000}{2.25 \times 10^8}$

or $t = 4.4 \times 10^{-6}$ sec.

Q.82 A rectangular glass slab of thickness 8 cm is placed on a figure. Eye is kept exactly above this slab. If the refractive index of glass is 1.6, then the figure will appear to be raised by

- (A) 8 cm (B) 2.4 cm
(C) 4.2 cm (D) 3 cm

Ans. Let the figure get raised by d cm on placing the slab, then its apparent depth will be $(8-d)$ cm

$$n_{ag} = \frac{\text{real depth}}{\text{apparent depth}}$$

$$1.6 = \frac{8}{8-d}$$

or $1.6(8-d) = 8$ or $12.8 - 1.6d = 8$

or $d = \frac{4.8}{1.6} = 3$ cm

Q.83 The focal length of a convex lens is 10 cm and its refractive index is 1.5. If the radius of curvature of one surface is 7.5 cm. Find the radius of curvature of the second surface.

Ans. We know,

$$\frac{1}{f} = (n-1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

$f = 10$ cm, $R_1 = 7.5$ cm, $n = 1.5$

$$\text{or } \frac{1}{10} = (1.5-1) \left(\frac{1}{7.5} - \frac{1}{R_2} \right)$$

or $R_2 = -15$ cm

Q.84 Find the size, nature and position of image formed when an object of size 1 cm is placed at a distance of 15 cm from a concave mirror of focal length 10 cm.

Ans. Given that :

Object size = 1 cm

Object distance $u = -15$ cm

Focal length $f = -10$ cm

By using mirror formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$\Rightarrow \frac{-1}{10} + \frac{1}{15} = \frac{-3+2}{30} = \frac{-1}{30}$$

$\therefore v = -30$ cm

Magnification $m = \frac{-v}{u} = \frac{h_i}{h_0}$

$$\Rightarrow \frac{-(-30)}{-15} = \frac{h_i}{h_0}$$

$$\Rightarrow h_i = \frac{-30}{15} \times 1 = -2 \text{ cm}$$

Image distance is at 30 cm in same side of mirror which is real and inverted. Image size is larger than object.

Q.85 A concave mirror of focal length 10 cm is placed at a distance of 25 cm from a wall. How far from the wall an object be placed so that its image formed by the mirror falls on the wall?

Ans. Given that focal length (f) = -10 cm

image distance (v) = -25 cm

object distance (u) = ?

by using mirror formula

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{u} = \frac{1}{f} - \frac{1}{v}$$

$$\Rightarrow \frac{1}{u} = -\frac{1}{10} - \left(-\frac{1}{25} \right) =$$

$$\frac{1}{10} + \frac{1}{25} = \frac{-5+2}{50}$$

$$\therefore u = \frac{-50}{3} \text{ cm} = -16.66 \text{ cm}$$

Object distance is 16.66 cm from the mirror.

Q.86 An object is placed at a distance of 15 cm from a convex mirror of focal length 30 cm. Find the position and the nature of the image.

Ans. Given that object distance $u = -15$ cm
focal length $f = +30$ cm

By mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} - \frac{1}{15} = \frac{1}{30}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{30} + \frac{1}{15} = \frac{1+2}{30} = \frac{3}{30}$$

$$\therefore v = +10 \text{ cm}$$

Therefore image distance is 10 cm behind the mirror.

Q.87 A convex mirror used for rear-view on an automobile has a radius of curvature of 3 m. If a bus is located at 5 m from this mirror, find the position, nature and size of the image.

Ans. Given that radius of curvature (R) = 3 m

$$\therefore \text{Focal length} = \frac{R}{2} = \frac{3}{2} = 1.5 \text{ m}$$

object distance = -5 cm

Position of image (v) = ?

By using mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{2}{3} - \left(\frac{-1}{5}\right) = \frac{2}{3} + \frac{1}{5}$$

$$= \frac{10+3}{15} = \frac{13}{15}$$

$$\therefore v = \frac{15}{13} = 1.15 \text{ cm}$$

Thus, Image is placed at a distance of 1.15 cm behind the mirror which is virtual & erect

$$\text{New magnification } m = -\frac{v}{u} = \frac{-1.15}{-5}$$

$$= 0.23$$

Then image size is a factor of 0.23 by the object size.

Q.88 An object 4 cm in size is placed at 25 cm in front of a concave mirror of focal length 15 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Find the nature and the size of this image.

Ans. Given that size of object $h_0 = 4$ cm
object distance = -25 cm = u
focal length $f = -15$ cm

By using mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$\Rightarrow \frac{-1}{15} - \left(\frac{-1}{25}\right) = \frac{-1}{15} + \frac{1}{25} = \frac{-5+3}{75} = \frac{-2}{75}$$

$$\therefore v = \frac{-75}{2} = -37.5 \text{ cm}$$

This image is formed at a distance of 37.5 cm from the mirror which is same side of object. It is real and inverted.

By using magnification

$$m = \frac{-v}{u} = \frac{h_i \text{ (height of image)}}{h_0 \text{ (height of object)}}$$

$$\Rightarrow \frac{h_i}{h_0} = \frac{-v}{u}$$

$$h_i = \frac{-v}{u} \times h_0 = \frac{-(-37.5)}{-25} \times 4 = 6 \text{ cm}$$

Image size is larger than the object size.

Q.89 Light of wavelength 6000 Å in air enters a medium of refractive index 1.5. What will be the frequency in the medium?

Ans. Given that wavelength $\lambda = 6000 \text{ \AA}$
refractive index $\mu = 1.5$
frequency = ?

By using formula,

$$\therefore C = f \cdot \lambda \text{ where } c \text{ is speed of light.}$$

$$\therefore f = \frac{c}{\lambda} = \frac{3 \times 10^8}{6 \times 10^{-7}} = 0.5 \times 10^{15}$$

$$\text{Frequency (f)} = 5 \times 10^{14} \text{ Hz}$$

Q.90 If the refractive index of water for light going from air to water be 1.33, what will be the refractive index for light going from water to air?

Ans. Refractive index of water with respect to air

$$\mu_w^a = 1.33 = \frac{4}{3}$$

$$\therefore \mu_a^w = \frac{1}{\mu_w^a} = \frac{1}{\frac{4}{3}} = \frac{3}{4} = 0.75$$

Q.91 Refractive index of water is 4/3 and glass is 3/2 with regard to air. What is the refractive index of glass with respect to water?

Ans. Refractive Index of water = $\frac{4}{3} = \mu_g$

Refractive index of glass = $\frac{3}{2} = \mu_w$

∴ R.I of glass with respect to water

$$= \frac{\mu_w}{\mu_g} = \frac{3/2}{4/3} = \frac{9}{8}$$

Q.92 Light of wavelength of 500 nm in air, enters a glass plate of refractive index 1.5. Find (i) speed (ii) frequency and (iii) wavelength of light in glass. Assume that the frequency of light remains the same in both media.

Ans. Given that wavelength (λ) = 500×10^{-9} m
Refractive index of glass plate (μ) = 1.5
To find speed, frequency & wavelength.

(i) $\mu = \frac{c}{v} \frac{(\text{speed of light in air / vaccum})}{(\text{speed of light in medium})}$

$$1.5 = \frac{3 \times 10^8}{v} \Rightarrow v = \frac{3 \times 10^8}{1.5}$$

$$= 2 \times 10^8 \text{ m/s.}$$

(ii) Since, velocity = frequency \times wavelength

$$\Rightarrow f = \frac{v}{\lambda} = \frac{2 \times 10^8}{500 \times 10^{-9}} = 0.4 \times 10^{15} \text{ Hz}$$

(iii) Refractive index (μ) = $\frac{f(\lambda_a)}{f(\lambda_g)}$

$$1.5 = \frac{500 \times 10^{-9}}{\lambda_g}$$

$$\Rightarrow \lambda_g = \frac{500 \times 10^{-9}}{1.5} = 333.33 \text{ nm}$$

Q.93 A needle placed 45 cm from the lens forms an image on a screen placed 98 cm on the other side of the lens. Identify the type of the lens and determine its focal length.

Ans. Given that object (needle) distance (u) = -45 cm
Screen placed or image formed at a distance (v) = 98 cm
focal length (f) = ?

By using lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{1}{98} + \frac{1}{45} = \frac{45 + 98}{98 \times 45}$$

∴ $f = +30.8 \text{ cm}$

Focal length positive then lens is convex in nature.

Q.94 A concave lens has a focal length of 10 cm. An object 2.5 cm high is placed at 30 cm from the lens. Determine the position and size of the image.

Ans. Given that focal length (f) = -10 cm
object height (h_0) = 2.5 cm
object distance $u = -30 \text{ cm}$
by using lens formula

$$\Rightarrow \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{-1}{10} - \frac{1}{30} = \frac{-4}{30}$$

$$\therefore v = \frac{-30}{4} = -7.5 \text{ cm}$$

magnification (m) = $\frac{v}{u} = \frac{h_i (\text{image size})}{h_0 (\text{object size})}$

$$\Rightarrow \frac{-7.5}{-30} = \frac{h_i}{2.5} \Rightarrow h_i = \frac{5}{8} \text{ cm}$$

Q.95 A real image 4/5 size of the object is formed 18 cm from a lens. Calculate the focal length of the lens.

Ans. Given that image size = $\frac{4}{5}$ times of object size.

$$\Rightarrow h_i = \frac{4}{5} h_0 \Rightarrow \frac{h_i}{h_0} = \frac{4}{5}$$

∴ magnification (m) = $\frac{v}{u} = \frac{h_i}{h_0}$

$$\Rightarrow \frac{4}{5} = \frac{18}{-u} \Rightarrow u = \frac{-18 \times 5}{4} = -22.5 \text{ cm}$$

u is object distance

Now by using lens formula

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{18} - \left(\frac{-1}{22.5} \right) = \frac{1}{f}$$

(∵ Image distance $v = 18 \text{ cm}$)

$$\Rightarrow \frac{1}{f} = \frac{1}{18} + \frac{1}{22.5} = \frac{1}{10}$$

∴ focal length = 10 cm

Q.96 A 5 cm tall object is placed on the principal axis of a convex lens of focal length 50 cm at a distance of 40 cm from it. Find the nature, position and size of the image.

Ans. Given that : Object height $h_0 = 5 \text{ cm}$

Focal length $f = 50 \text{ cm}$

Object distance $v = -40 \text{ cm}$

By using lens formula, Image height = $h_i = ?$

Image distance = v ?

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$

$$\Rightarrow \frac{1}{50} + \left(\frac{-1}{40}\right) = \frac{1}{50} - \frac{1}{40} = \frac{4-5}{200}$$

$$= \frac{-1}{200}$$

∴ v = -200 cm

Therefore image formed at a distance of 200 cm from the lens.

by magnification $m = \frac{v}{u} = \frac{h_i}{h_o}$

$$\Rightarrow \frac{v}{u} = \frac{h_i}{h_o} = \frac{h_i}{5}$$

$$\Rightarrow h_i = 5 \times 5 = +25 \text{ cm}$$

Image is 25 cm tall which is virtual & erect.

Q.97 A 5 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20 cm. The distance of the object from the lens is 30. Find the (i) position and (ii) nature of the image formed.

Ans. Given that Object height $h_o = 5 \text{ cm}$
 Focal length $f = 20 \text{ cm}$
 Object distance $u = -30 \text{ cm}$

To find (i) Position of image $v = ?$
 (ii) Nature of image = ?

(i) By using lens formula,

$$\Rightarrow \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{20} + \left(\frac{-1}{30}\right)$$

$$= \frac{3-2}{60} = \frac{1}{60}$$

$$\frac{1}{v} = \frac{1}{60}$$

The image is situated 60 cm on the other side of the lens.

(ii) Image formed real and Inverted.

Q.98 A 2 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 10 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image. Also find its magnification.

Ans. Given that : Object height $h_o = 2 \text{ cm}$
 (f) focal length = + 10cm
 (u) object distance = -15 cm

By using lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} - \frac{1}{15} = \frac{3-2}{30}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{30} \quad \therefore v = 30 \text{ cm}$$

Image is formed at a distance of 30 cm behind the lens.

Now, magnification = $\frac{v}{u} = \frac{h_i}{h_o}$

$$\Rightarrow \frac{30}{-15} = \frac{h_i}{2} \Rightarrow h_i = -4 \text{ cm}$$

The image size is 4 cm which is real and inverted.

Magnification $m = \frac{v}{u} \Rightarrow m = -2$

Q.99 A convex lens has focal length of 20 cm. Calculate at what distance from the lens should the object be placed so that the image is formed at 40 cm on the other side of the lens? Also state the nature of the image formed.

Ans. Here, $f = 20 \text{ cm}$, $v = 40 \text{ cm}$, $u = ?$

Step 1: Using $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$,

we have $-\frac{1}{u} = \frac{1}{f} - \frac{1}{v} = \frac{1}{20} - \frac{1}{40}$

or $-\frac{1}{u} = \frac{1}{40}$ or $u = -40 \text{ cm}$

Thus, the object should be placed at a distance of 40 cm in front of the convex lens.

Step 2: $m = \frac{v}{u} = \frac{40}{-40} = -1$

Negative sign shows that the image is real and inverted (Nature of image).

Q.100 An object 4 cm high is placed at a distance of 27 cm in front of a convex lens of focal length 18 cm. Find the position, nature and size of the image formed.

Ans. Here, $u = -27$ cm (sign convention),
 $f = 18$ cm, $h = 4$ cm

Step 1: Determination of 'v'

Using $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$,

we get $\frac{1}{(-27)} + \frac{1}{v} = \frac{1}{18}$

or $\frac{1}{v} = \frac{1}{18} - \frac{1}{27} = \frac{1}{54}$

$\therefore v = 54$ cm (Position of image)

Step 2 : Determination of h'

Using, $\frac{h'}{h} = \frac{v}{u}$

we get, $h' = \frac{v}{u} \times h = \frac{54}{-27} \times 4 = -8.0$ cm

Thus, size of image is 8 cm. Negative sign shows that the image is **inverted**.

Q.101 A 4.0 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20 cm. If the distance of the object is 30 cm from the lens, find the position, nature and size of the image. Also find its magnification.

Ans. Here, $h = 4.0$ cm, $f = 20$ cm;
 $u = -30$ cm, $h' = ?$, $v = ?$, $m = ?$

Step 1: Determination of v

Using lens formula $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

we have $-\frac{1}{(-30)} + \frac{1}{v} = \frac{1}{20}$

or $\frac{1}{v} = \frac{1}{20} - \frac{1}{30}$ or $\frac{1}{v} = \frac{1}{60}$

or $v = +60$ cm

Thus, the image is formed at 60 cm on other side (i.e. right side) of the lens.

Step 2: Determination of h'

Using, $\frac{h'}{h} = \frac{v}{u}$

We have $h' = \frac{v}{u} h = \frac{60}{-30} \times 4 = -8.0$ cm

Thus, size of the image is 8.0 cm. Negative sign shows that the image is inverted.

So, a real and inverted image of large size is formed.

Step 3: Determination of Magnification

Using, $m = \frac{h'}{h}$

we get, $m = \frac{-8.0 \text{ cm}}{4.0 \text{ cm}} = -2$

Q.102 A concave lens of focal length 20 cm forms an image at a distance of 10 cm from the lens. What is the distance of the object from the lens? Also draw ray diagram.

Ans. Here, $f = -20$ cm (Sign convention),
 $v = -10$ cm

(\therefore image formed by concave lens is virtual)

Step 1: Using lens formula $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

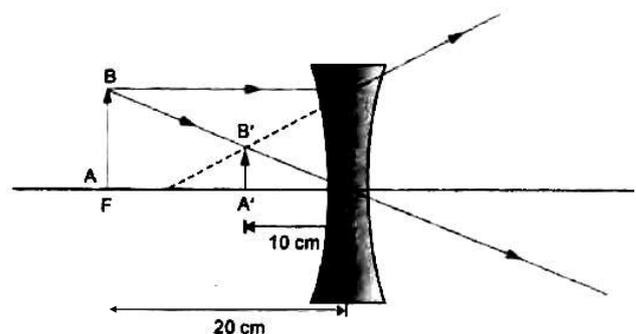
We have, $-\frac{1}{u} - \frac{1}{10} = -\frac{1}{20}$

$\Rightarrow -\frac{1}{u} = \frac{-1}{20} + \frac{1}{10}$

or $u = -20$ cm

Thus, the object is placed at 20 cm from the concave lens.

Step 2:



Q.103 What will be the focal length of a lens whose power is given as +2.0 D?

Ans. Here, $P = 2.0$ D

Using $P = \frac{1}{f(\text{in m})}$

we get, $f = \frac{1}{P} = \frac{1}{2} = 0.5 \text{ m} = 50 \text{ cm}$

Q.104 What is the power of a convex lens of focal length 40 cm?

Ans. Here, $f = 40$ cm

Using $P = \frac{100}{f(\text{in cm})}$

we get, $f = \frac{100}{40} = +2.5$ D

Q.105 (a) Two lenses have power of (i) +2D, (ii) –4D. What is the nature and focal length of each lens?

(b) An object is kept at a distance of 100 cm from each of above lenses. Calculate (i) image distance, (ii) magnification in each of the two cases.

Ans. (a) (i) $P = +2D$. Since power is positive, so the lens is convex lens.

Focal length, $f = \frac{1}{P} = \frac{1}{2} = 0.5 \text{ m} = 50 \text{ cm}$

(ii) $P = -4D$. Since power is negative. So the lens is concave lens.

Focal length,

$f = \frac{1}{P} = \frac{1}{-4} = -0.25 \text{ m} = -25 \text{ cm}$

(b) (i) Here, $u = -100 \text{ cm}$ (sign convention)

1st case : $f = 50 \text{ cm}$

Using $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

We get, $\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{50} - \frac{1}{100} = \frac{1}{100}$

or $v = 100 \text{ cm}$

2nd case : $f = -25 \text{ cm}$

Using $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

We get, $\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = -\frac{1}{25} - \frac{1}{100} = \frac{-5}{100} = \frac{-1}{20}$

or $v = -20 \text{ cm}$

(ii) $m = \frac{v}{u}$

1st case : $u = -100 \text{ cm}$, $v = 100 \text{ cm}$

$\therefore m = \frac{100 \text{ cm}}{-100 \text{ cm}} = -1$

2nd case : $u = -100 \text{ cm}$, $v = -20 \text{ cm}$

$\therefore m = \frac{-20 \text{ cm}}{-100 \text{ cm}} = \frac{1}{5} = 0.2$

Q.106 An object of size 5 cm is kept at a distance 25 cm from the optical centre of a converging lens of focal length 10 cm. Calculate the distance of the image from the lens and size of the image.

Ans. Here, size of object, $h = 5 \text{ cm}$, $u = -25 \text{ cm}$ (sign convention), $f = 10 \text{ cm}$ (sign convention)

Step 1: Using $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

We get, $\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} - \frac{1}{25} = \frac{3}{50}$

$\therefore v = \frac{50}{3} = 16.67 \text{ cm}$

Thus, image distance = 16.67 cm

Step 2: $m = \frac{h'}{h} = \frac{v}{u}$

$h' = \frac{v}{u} \times h = \frac{50}{3 \times (-25)} \times 5 = -\frac{10}{3} = -3.33 \text{ cm}$

Thus, size of image = 3.33 cm. Negative sign show that image is inverted.

Q.107 A concave lens has focal length of 20 cm. At what distance from the lens, a 5 cm tall object be placed so that it formed an image at 15 cm from the lens? Also calculate the size of the image formed.

Ans. Here, $f = -20 \text{ cm}$ (sign convention), $h = 5 \text{ cm}$, $v = -15 \text{ cm}$ (sign convention), $u = ?$, $h' = ?$

Step 1: Using $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

We get, $-\frac{1}{u} - \frac{1}{15} = -\frac{1}{20} = \frac{1}{u} = \frac{1}{20} - \frac{1}{15} = \frac{3-4}{60}$

or $\frac{1}{u} = -\frac{1}{60} \therefore -u = 60 \text{ cm}$

Thus, object should be placed at a distance of 60 cm from the lens to the left side.

Step 2: Using $m = \frac{h'}{h} = \frac{v}{u}$

$h' = \frac{v}{u} \times h = \frac{-15}{-60} \times 5 \text{ cm} = 1.25 \text{ cm}$

\therefore Size of image = 1.25 cm

Q.108 An object 50 cm tall is placed on the principal axis of a convex lens. A 20 cm tall image is formed on the screen placed at a distance of 10 cm from the lens. Calculate the focal length of the lens.

Ans. Here, $h = 50 \text{ cm}$, $h' = -20 \text{ cm}$ (sign convention), $v = 10 \text{ cm}$, $f = ?$

Step 1: Using $\frac{h'}{h} = \frac{v}{u}$

we get $\frac{-20}{50} \times \frac{10}{u}$ or $u = -\frac{10 \times 50}{20} = -25 \text{ cm}$

Step 2: Using $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

we get, $\frac{1}{25} + \frac{1}{10} = \frac{1}{f}$

or $\frac{1}{f} = \frac{2+5}{50} = \frac{7}{50}$ or $f = \frac{50}{7} = 7.14 \text{ cm}$

Thus, focal length of the convex lens = 7.14 cm

EXERCISE - III

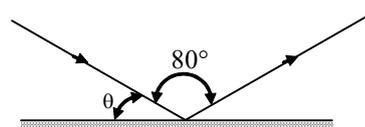
Subjective Stuff



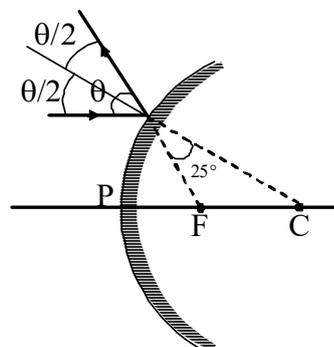
VERY SHORT TYPE QUESTIONS:

- Q.1** What type of waves are light waves?
Ans. Light waves are electromagnetic waves.
- Q.2** What is the radius of a plane mirror?
Ans. The radius of a plane mirror is infinity.
- Q.3** What is the angle of reflection if a ray falls normally on a plane mirror?
Ans. The angle of reflection is 0° .
- Q.4** Relate the focal length f and radius of curvature R .
Ans. Focal length = $\frac{\text{Radius of curvature}}{2}$
 or $f = R/2$
- Q.5** What is a real image?
Ans. If the rays of light after reflection or refraction actually meet at a point, the image is known as real image.
- Q.6** What is a virtual image?
Ans. If the rays do not actually meet but appear to meet when produced backwards, then the image is known as virtual image.
- Q.7** What type of image is formed:
 (i) In a plane mirror
 (ii) On a cinema screen?
Ans. (i) Virtual image (ii) Real image
- Q.8** Write the mirror formula.
Ans. $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ (u = object distance, v = image distance and f = focal length)
- Q.9** Name the type of mirror which always forms a virtual and diminished image.
Ans. Convex mirror
- Q.10** Which mirror convex or concave has more field of view?
Ans. Convex mirror
- Q.11** For what position of an object, a concave mirror forms a real image equal in size to the object?
Ans. At C , centre of curvature.

- Q.12** What should be the position of the object when a concave mirror is to be used?
 (i) As a shaving mirror and
 (ii) As a doctor's mirror?
Ans. (i) Between pole P and focus F .
 (ii) Between pole P and focus F .
- Q.13** Differentiate between virtual image of a concave mirror and of a convex mirror.
Ans. The virtual image of a concave mirror is always magnified whereas the virtual image of a convex mirror is diminished.
- Q.14** The angle between an incident ray and the mirror is θ . The total angle turned by the ray of light is 80° . What is the value of θ ?
Ans. Since angle of incidence is equal to angle of reflection, $\theta = 90^\circ - 40^\circ = 50^\circ$.



- Q.15** What is the value of θ in the following ray diagram?



- Ans.** 50°
- Q.16** What is a rarer medium?
Ans. A medium, in which the speed of light is more, is known as optically rarer medium.
- Q.17** What is the unit of refractive index?
Ans. Refractive index has no units as it is a ratio of two similar quantities.
- Q.18** Name a point inside a lens through which the light passes undeviated.
Ans. Optical centre.

Q.19 Distinguish between real and virtual image.

	Real Image		Virtual Image
Ans.	(i) It is formed by the actual meeting of reflected (or refracted) rays.	(i)	It is formed when reflected (or refracted) rays appear to meet when produced backwards.
	(ii) It can be obtained on the screen.	(ii)	It cannot be obtained on the screen.
	(iii) It is always inverted.	(iii)	It is always erect.
	(iv) It is always formed by concave mirror and convex lens.	(iv)	It is formed by concave, convex and plane mirrors, concave and convex lens.

Q.20 Define the power of a lens. Give its SI unit. State whether the power of a converging lens is positive or negative.

Ans. Power of a lens is defined as the reciprocal of its focal length f (in metres)

$$P = \frac{1}{f \text{ (in m)}}$$

The SI unit of a lens is dioptre. The power of a converging lens is positive.

Q.21 A spherical mirror and a lens both have focal length of -20 cm. What type of mirror and lens are these?

Ans. A concave mirror and concave lens have negative focal length.

Q.22 What is dioptre?

Ans. One dioptre is the power of a lens whose focal length is 1 metre.

Q.23 What is the nature of light?

Ans. Light is an electromagnetic wave which does not require a material medium for propagation.

Q.24 What is a ray?

Ans. The path of light is called a ray.

Q.25 If the angle of incidence (i) for a light ray in air be 45° and the angle of refraction (r) in glass be 30° . Find the refractive index

Ans. Refractive index of glass,

$$n = \frac{\sin 45^\circ}{\sin 30^\circ} = \frac{1/\sqrt{2}}{1/2} = \sqrt{2}$$

Q.26 A point object is 24 cm above the surface of water ($\mu = 4/3$) in a lake. A fish inside the water will observe the image to be at distance.

- (A) 32 cm above the water surface
 (B) 18 cm above the water surface
 (C) 6 cm above the water surface
 (D) 6 cm below the water surface

Ans. Apparent depth = $n_{dr} \times$ Real depth = $\frac{4}{3} \times 24$
 $= 32$ cm

Q.27 State two effects caused by the refraction of light

Ans. Two effects caused by the refraction of light
 (i) A stick partly immersed in water appears to be bent at the water surface.
 (ii) A pool of water appears less deeper than its actual position.

Q.28 If you are driving a car, what type of mirror would you prefer to use for observing traffic at your back and why?

Ans. Convex mirror, because it forms virtual, erect and diminished image of an object. Thus have larger field of view.

Q.29 Define Snell's law of Refraction.

Ans. The second law of refraction is called Snell's law of refraction. According to Snell's law "The ratio of sine of the angle of incidence to the sine of the angle of refraction is a constant for a pair of medium"

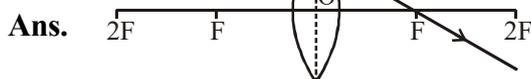
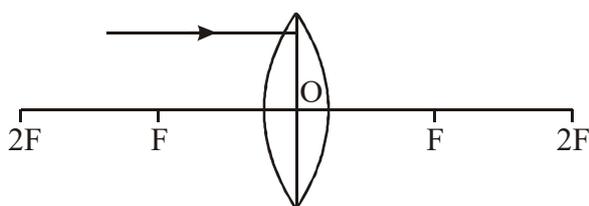
$$\frac{\sin i}{\sin r} = \text{constant}$$

This constant is called refractive index.

Q.30 Why does a ray of light bend when it travels from one medium to another medium?

Ans. When a ray of light travels from one medium into another medium, its speed (wavelength) changes so it bends.

Q.31 Draw the given diagram in your answer book and complete it for the path of ray of light beyond the lens.



Q.32 Explain why a ray of light passing through the centre of curvature of a concave mirror gets reflected along the same path.

Ans. The normal of concave mirror at any point passes through centre, so incident angle ($\angle i$) is equal to zero.

Q.33 What is the nature of the image formed by a concave mirror if the magnification produced by the mirror is +3?

Ans. Magnification = +3
so that nature of image virtual, erect and magnified.

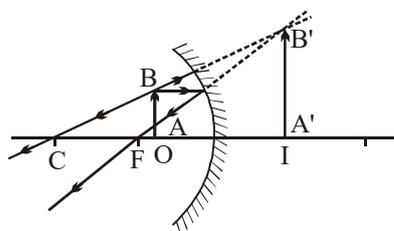
Q.34 State one function of iris in human eye.

Ans. Functions of iris :
To control the amount of light entering the eye.

SHORT TYPE QUESTIONS:

Q.35 What is the minimum number of rays required for location of the image formed by a concave mirror of an object. Draw a ray diagram to show the formation of a virtual image by a concave mirror.

Sol. Two (minimum)



Q.36 At what distance should an object be placed from a convex lens of focal length 18 cm to obtain an image at 24 cm from it on the other side. What will be the magnification produced in this case?

Sol. Given : $f = 18$ cm; $v = 24$ cm; $u = ?$; $m = ?$
By using len's formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{24} - \frac{1}{u} = \frac{1}{18} \quad \Rightarrow \frac{1}{u} = \frac{1}{24} - \frac{1}{18}$$

$$\Rightarrow \frac{1}{u} = \frac{3-4}{72} \quad \Rightarrow \frac{1}{u} = -\frac{1}{72}$$

$$\Rightarrow u = -72 \text{ cm}$$

Object distance is 72 cm in front of mirror.

Magnification :

$$m = \frac{v}{u} = \frac{24}{-72} = -\frac{1}{3}$$

Hence, final image is 3 times smaller than the object.

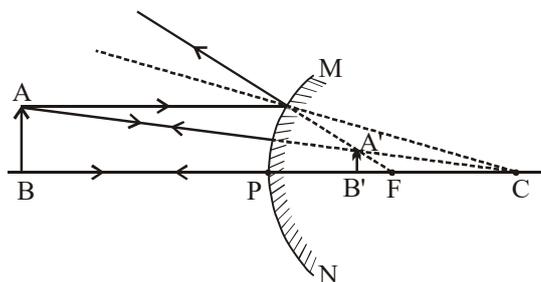
Negative sign shows image is real & inverted.

Q.37 State any four characteristics of the image of an object formed by a plane mirror.

- Sol.**
- (i) Distance of object from mirror is equal to distance of image from mirror.
 - (ii) The image is laterally inverted.
 - (iii) The line joining the object point with its image is normal to the reflecting surface.
 - (iv) The size of the image is same as that of the object.

Q.38 An object is placed between infinity and the pole of a convex mirror. Draw a ray diagram and also state the position, the relative size and the nature of the image formed.

Sol.



Position of the image – Between P and F, behind the mirror.

Size of the image – Diminished.

Nature of the image - Virtual and erect.

Q.39 What is the principal of reversibility of light? Show that the incident ray of light is parallel to the emergent ray of light when light falls obliquely on a side of a rectangular glass slab.

OR

“A ray of light incident on a rectangular glass slab immersed in any medium emerges parallel to itself.” Draw labelled ray diagram to justify the statement.

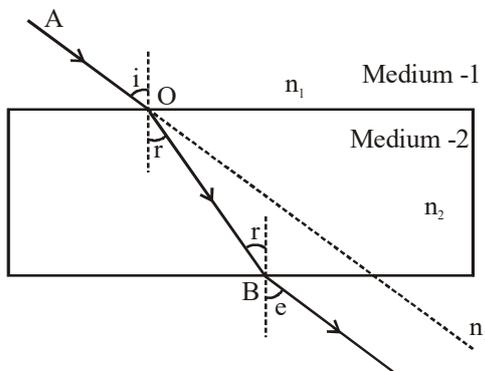
Sol. Path of ray of light is reversible.
or

Light traces back its path while travelling in reverse direction.

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} \quad \dots (1)$$

$$\frac{\sin r}{\sin e} = \frac{n_1}{n_2} \quad \dots (2)$$

on multiplying eq. (1) and (2)

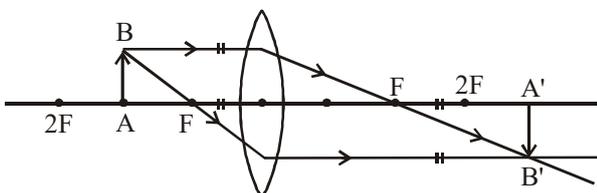


$$\frac{\sin i}{\sin r} \times \frac{\sin r}{\sin e} = \frac{n_2}{n_1} \times \frac{n_1}{n_2}$$

$$\Rightarrow \frac{\sin i}{\sin e} = 1 \Rightarrow \angle i = \angle e$$

Q.40 To construct ray diagram we use two light rays which are so chosen that it is easy to know their directions after refractions from the lens. List these two rays and state the path of these rays after refraction. Use these rays to locate the image of an object placed between centre of curvature and focus of a convex lens.

Sol. (i) Any ray parallel to the principal axis after reflection will pass through the focus.
(ii) Any ray passing through the focus after refraction will go parallel to the principle axis.



Q.41 A 4 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 24 cm. The distance of the object from the lens is 16 cm. Find the position, size & nature of the image formed by using lens formula.

Sol. A 4 cm tall object is given
So object height $h_0 = 4$ cm
focal length $f = +24$ cm
object distance $u = -16$ cm
To find : image height $h_i = ?$
image distance $v = ?$

using lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$$\Rightarrow \frac{1}{f} + \frac{1}{u} = \frac{1}{v} \quad \dots (1)$$

put the value of u and f in equation (1)

$$\frac{1}{v} = \frac{1}{24} - \frac{1}{16} = \frac{2-3}{48} = -\frac{1}{48}$$

$$\therefore v = -48 \text{ cm}$$

(-ve) sign shows that the image formed is same side of the object.

Now, magnification

$$m = \frac{h_i}{h_0} = \frac{v}{u}$$

$$\frac{h_i}{4} = \frac{-48}{-16} \Rightarrow h_i = 3 \times 4 = 12 \text{ cm}$$

Hence, image is formed at a distance of 48 cm in front of lens which is virtual and erect. Height of image is 12 cm.

Q.42 Draw a diagram and only these conventions for calculating the focal length and nature of a spherical mirror which forms a $\frac{1}{3}$ times magnified virtual image of an object placed 18 cm in front of it.

Sol. Given that $u = -18$ cm
If object size is h_0 and image size is h_i ,

then $h_i = \frac{1}{3}h_0 \Rightarrow \frac{h_i}{h_0} = \frac{1}{3}$

magnification $m = \frac{h_i}{h_0} = \frac{1}{3}$

$$\therefore \frac{h_i}{h_0} = \frac{1}{3} \Rightarrow -\frac{v}{u} = \frac{1}{3}$$

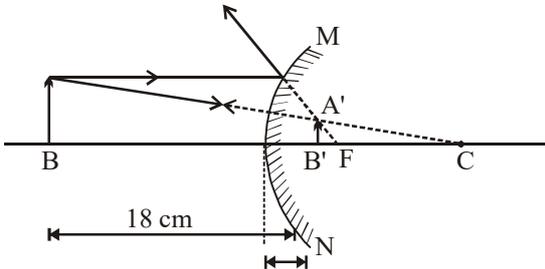
$$\Rightarrow v = \frac{-u}{3} = -\left(\frac{-18}{3}\right) = \frac{+18}{3} = +6 \text{ cm}$$

By using mirror formula

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{6} - \frac{1}{18} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{f} = \frac{3-1}{18} = \frac{2}{18} \Rightarrow \frac{1}{f} = \frac{1}{9}$$

$$\Rightarrow f = 9 \text{ cm}$$



Hence, focal length is 9 cm behind the mirror and mirror is convex in nature. Image is virtual & erect and size of image is smaller than object.

Q.43 An object of height 6 cm is placed perpendicular to the principal axis of a concave lens of focal length 5 cm. Use lens formula to determine the position, size of nature of the image if the distance of the object from the lens is 10 cm.

Sol. Given that $h_o = 6 \text{ cm}$
 $f = -5 \text{ cm}$
 $u = -10 \text{ cm}$

by using lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{-5} + \frac{1}{-10} = \frac{-2-1}{10} = \frac{-3}{10}$$

$$v = \frac{-10}{3} \text{ cm} = -3.33 \text{ cm}$$

Distance of image from the lens is 3.33 cm.

Now magnification $m = \frac{h_i}{h_o} = \frac{v}{u}$

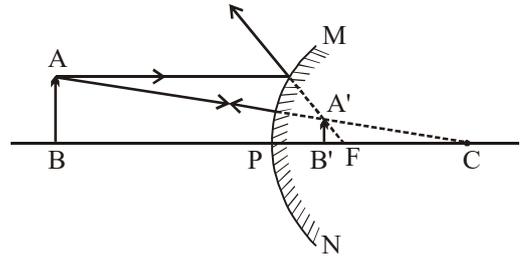
$$\Rightarrow \frac{h_i}{h_o} = \frac{v}{u} \Rightarrow \frac{h_i}{6} = \frac{-10/3}{-10} = \frac{1}{3}$$

$$h_i = 2 \text{ cm}$$

Hence, image formed at a distance of 3.33 cm in front of lens which is virtual & erect size of image is larger than the object i.e. image size is 3 times less than object size.

Q.44 If the image formed by the mirror for all positions of the object placed in front of it is always erect and diminished, what type of mirror it is? Draw a ray diagram to justify your answer. Where and why do we generally use this type of mirror.

Sol. A convex mirror always produces an erect and diminished image of the object placed in front of it irrespective of the position of the object.



A virtual, erect and diminished image is formed behind the mirror between the pole and focus as shown in figure. As a convex mirror gives a wide field of view, it is used as a rear view mirror in vehicles. It enables the driver to view a much larger area of the traffic behind, it is also used as shop security cameras.

Q.45 An object of height 5 cm is placed perpendicular to the principal axis of a concave lens of focal length 10 cm. If the distance of the object from the optical centre of the lens is 20 cm, determine the position, nature & size of the image formed using the lens formula.

Sol. Given:
 Height of object = 5 cm
 Focal length of concave lens = -10 cm
 Object distance $u = -20 \text{ cm}$

Using lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{-10} = \frac{1}{v} + \frac{1}{20} = \frac{1}{-10} - \frac{1}{20} = \frac{-2-1}{20} = \frac{-3}{20}$$

$$\therefore v = -6.67 \text{ cm}$$

Hence image is formed 6.67 in front of the lens on the same side as the object because v is negative, we can say that the image is virtual.

Now, magnification $m = \frac{h_i}{h_o} = \frac{v}{u}$

$$h_i = \frac{v}{u} \times h_o = -\frac{6.67 \times 5}{-20} = 1.67 \text{ cm}$$

Hence, the size of the image is $h_i = 1.67 \text{ cm}$ Because the height of the image is positive and smaller than the height of the object, the image is erect and diminished. So, we can conclude that image is virtual, erect and diminished.

Q.46 The image of a candle flame placed at a distance of 45 cm from a spherical lens is formed on a screen placed at a distance of 90 cm from the lens. Identify the type of lens and calculate its focal length. If the height of the flame is 2 cm, find the height of its image.

Sol. Given that object distance $u = -45$ cm
Image distance $v = 90$ cm
The image of a candle flame is formed on the screen, so a convex lens is used.

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\Rightarrow \frac{1}{f} = \frac{1}{90} - \left(\frac{1}{-45} \right)$$

$$= \frac{1}{90} + \frac{1}{45} = \frac{1+2}{90} = \frac{3}{90} = \frac{1}{30}$$

$$\Rightarrow f = +30 \text{ cm}$$

Hence, it is convex lens of focal length 30 cm
Now, height of image $h_i = ?$

$$\text{Magnification } m = \frac{h_i}{h_o} = \frac{v}{u}$$

$$\Rightarrow h_i = \frac{v \times h_o}{u}$$

$$\therefore h_i = \frac{2 \times 90}{-45} = -4 \text{ cm}$$

Height of image $h_i = -4$ cm

Thus, height is 4 cm which is image minus (-1) sign indicates that the image is formed below the principal axis. So image is real & inverted.

Q.47 The image formed by a spherical mirror is real, inverted and is of magnification-2. If the image is at a distance of 30cm from the mirror, where the object placed? Find the focal length of the mirror. List two characteristic of the image formed if the object is moved 10 cm towards the mirror.

Sol. Given that $m = -2$
Distance of the image, $v = -30$ cm

$$\text{magnification } m = -\frac{v}{u}$$

$$u = \frac{-v}{m} = -\frac{(-30)}{(-2)} = -15 \text{ cm}$$

Now using mirror formula

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{(-30)} + \frac{1}{(-15)} = \frac{-1}{30} - \frac{1}{15}$$

$$= \frac{-1-2}{30} = \frac{-3}{30}$$

$$f = -10 \text{ cm}$$

When object is moved 10 cm towards the mirror the new position of the object is
 $u' = -(15 - 10) = -5$ cm

$$\text{Again, using } \frac{1}{f} = \frac{1}{v'} + \frac{1}{u'}$$

$$\frac{1}{v'} = \frac{1}{f} - \frac{1}{u'} = \frac{1}{-10} - \left(\frac{1}{-5} \right) = \frac{-1}{10} + \frac{1}{5}$$

$$\frac{1}{v'} = \frac{1}{10} \Rightarrow v' = 10 \text{ cm}$$

Thus, the image formed 10 cm behind the mirror.

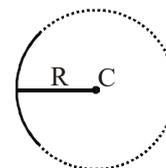
$$\text{magnification } m' = \frac{v'}{u'} = \frac{10}{(-5)} = -2$$

Since, magnification is positive the image is erect and virtual.

Thus, the image is erect, virtual and magnified in nature.

Q.48 Define the radius of curvature of spherical mirror. Find the nature and focal length of a spherical mirror whose radius of curvature is +24 cm.

Sol. Radius of curvature : Radius of sphere from which a mirror is cut. It is denoted by R.



The radius of curvature of a spherical mirror is the radius of the sphere of which the reflecting surface of the spherical mirror is a part and it represented by 'R'.

Given that $R = 24$ cm

$$\therefore \text{focal length } f = \frac{R}{2} = 12 \text{ cm}$$

LONG TYPE QUESTIONS:

- Q.49** (a) What is meant by 'Power of a lens'?
(b) State and define the S.I. unit of power of a lens.
(c) A convex lens of focal length 25 cm and a concave lens of focal length 10cm are placed in close contact with each other. Calculate the lens power of this combination.

Sol. (a) It is the ability of lens to converge or diverge the incident light rays.
Power of a lens is the reciprocal of the focal length of a lens.

$$P = \frac{1}{f(\text{in m})} = \frac{100}{f(\text{in cm})}$$

(b) S.I. unit of power of a lens is dioptre (D)
Power of a lens in 1 dioptre if focal length of the lens is 1 metre or 100 cm.

(c) Given $f_1 = 25 \text{ cm}$; $f_2 = -10 \text{ cm}$;

$$p_1 = \frac{100}{25} = 4D; p_2 = \frac{100}{-10} = -10D$$

$$p = p_1 + p_2 = (4 - 10) D = -6 D$$

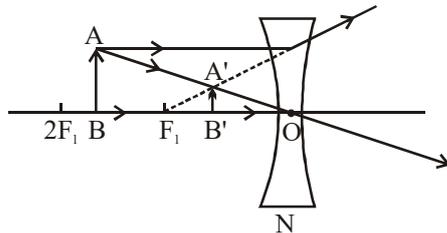
Q.50 (a) Draw a ray diagram to show the formation of image of object placed between infinity and the optical centre of a concave lens.

(b) A concave lens of focal length 15 cm forms an image 10 cm from the lens.

Calculate :

- (i) The distance of the object from the lens.
- (ii) The magnification for the image formed.
- (iii) The nature of the image formed.

Sol.



(b) $f = -15 \text{ cm}$
 $v = -10 \text{ cm}$

$$(i) \frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{-10} - \frac{1}{u} = \frac{1}{-15}$$

$$\frac{1}{u} = \frac{1}{-10} + \frac{1}{15} \Rightarrow u = -30 \text{ cm}$$

Object distance is 30 cm from lens.

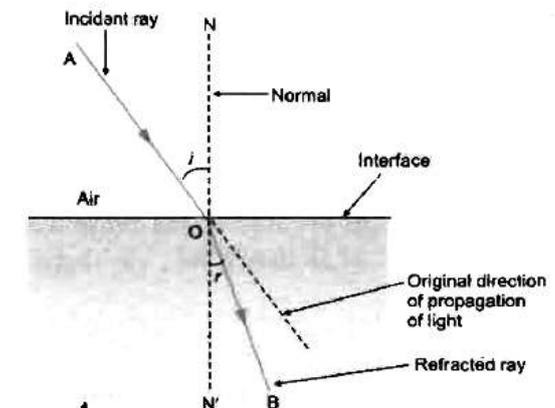
$$(ii) m = \frac{v}{u} = \frac{-10}{-30} = \frac{1}{3}$$

Hence magnification is 1/3

(iii) Nature of image – virtual and erect.

Q.51 With the help of ray diagram, state what is meant by refraction of light. State snell's law of refraction of light and also express it mathematically. The refractive index of air with respect to glass is $\frac{2}{3}$ and the refractive index of water with respect to air is $\frac{4}{3}$. If the speed of light in glass is $2 \times 10^8 \text{ m/s}$. Find the speed of light in (a) air (b) water.

Sol. Refraction of light :
The bending of light rays when they pass obliquely from one medium to another medium is called refraction of light.



Snell's law :

The ratio of the sine of the incident angle ($\angle i$) to the sine of the refracted angle ($\angle r$) is constant for a pair of two media

$$\text{i.e. } \frac{\sin i}{\sin r} = \text{constant}$$

This constant is known as the refractive index of the medium in which refracted ray travels with respect to the medium in which incident ray travels.

$$\text{Given that } {}^a\mu_g = \frac{2}{3} \Rightarrow {}^g\mu_a = \frac{3}{2} \text{ and } {}^w\mu_a = \frac{4}{3}$$

Let velocity of light in glass is v_g & water is v_w then $v_g = 2 \times 10^8 \text{ m/s}$

To find: $v_a = ?$ $v_w = ?$

$$\text{Refractive index } (\mu) = \frac{\text{speed of light in air}}{\text{speed of light in medium}}$$

$$(a) {}^g\mu_a = \frac{\text{speed of light in glass}}{\text{speed of light in air}}$$

$$\Rightarrow \frac{2}{3} = \frac{2 \times 10^8}{V_a} \Rightarrow V_a = 3 \times 10^8 \text{ m/s}$$

Hence, speed of light in air is $3 \times 10^8 \text{ m/s}$.

$$(b) {}^a\mu_w = \frac{\text{speed of light in air}}{\text{speed of light in water}}$$

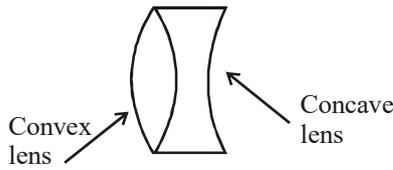
$$\frac{4}{3} = \frac{3 \times 10^8}{V_w}$$

(\because Speed of light in air = $3 \times 10^8 \text{ m/s}$)

$$\Rightarrow V_w = \frac{4}{9} \times 10^8 = 2.25 \times 10^8 \text{ m/s}$$

Q.52 A convex lens of focal length 25 cm and a concave lens of focal length 10 cm are placed in close contact with each other. Calculate the lens power of this combination.

Sol. Focal length of convex lens $f_1 = 25$ cm
 Focal length of concave lens $f_2 = -10$ cm



$$\therefore \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{25} - \frac{1}{10} = \frac{2-5}{50} = \frac{-3}{50}$$

$$\therefore f = -\frac{50}{3} = -16.66 \text{ cm}$$

Focal length of combination of lens is $-\frac{50}{3}$ cm

$$\therefore \text{Power} = \frac{100}{f}, \text{ where } f \text{ is in cm}$$

$$= \frac{-100 \times 3}{50} = -6 \text{ D}$$

Q.53 A concave lens of focal length 15 cm forms an image 10 cm from the lens. Calculate
 (i) The distance of the object from the lens.
 (ii) The magnification for the image formed.
 (iii) The nature of the image formed.

Sol. Given that $f = -15$ cm, $v = -10$ cm,
 To find, $u = ?$, $m = ?$

(i) By using lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$-\frac{1}{u} = \frac{1}{f} - \frac{1}{v} = -\frac{1}{15} + \frac{1}{10} = \frac{-2+3}{30} = \frac{1}{30}$$

$$\Rightarrow u = -30 \text{ cm}$$

(ii) Magnification, $m = \frac{v}{u} = \frac{-10}{-30} = \frac{1}{3}$

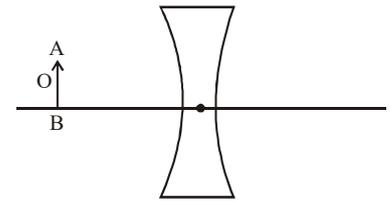
(iii) $m = \frac{1}{3}$, and $m = \frac{h_i}{h_0} = \frac{\text{image size}}{\text{object size}}$

$$\therefore \frac{h_i}{h_0} = \frac{1}{3} \Rightarrow h_i = \frac{1}{3} h_0$$

Hence image size is $\frac{1}{3}$ times of the object size. Image formed at the same side of object which is virtual and erect.

Q.54 (a) An object of size 7.6 cm is placed at 24 cm in front of a concave mirror of focal length 16 cm. At what distance from the mirror should a screen be placed, so that a sharp focused image can be obtained? Find the size and nature of the image.

(b) The diagram given below shows an object O. Copy the diagram and draw a suitable ray to locate the image. Name the type of lens used in this case.



Sol. (a) Given that object height $h_0 = 7.6$ cm = -24 cm; $f = -16$ cm; $v = ?$

By using mirror formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = -\frac{1}{16} - \left(-\frac{1}{24}\right)$$

$$\frac{-1}{16} + \frac{1}{24} = \frac{-3+2}{48} = \frac{-1}{48}$$

$$v = 48 \text{ cm}$$

Image distance with (-ve) sign shows that image formed at the same side of the object and screen also placed at that point.

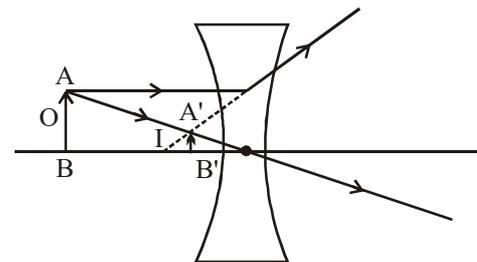
$$\text{Now, } m = \frac{h_i}{h_0} = \frac{-v}{u} \Rightarrow \frac{h_i}{h_0} = \frac{-v}{u}$$

$$\Rightarrow \frac{h_i}{7.6} = \frac{-(-48)}{-24} = 2$$

$$h_i = 2 \times 7.6 = 15.2 \text{ cm}$$

Image size is 15.2 cm which is larger than the object. Image is real and inverted.

(b)



AB = object

A'B' = Image

Lens used here is concave.

Q.55 (a) Name the lens which can be used as a magnifying glass. For which position of the object a convex lens forms:

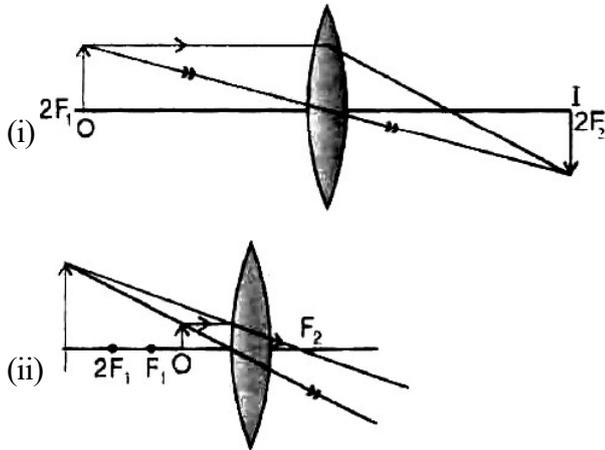
- (i) A real & inverted image of the same size as that of the object.
- (ii) A virtual & erect image.

Draw the ray diagram to justify your answer in each case.

(b) One half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object?

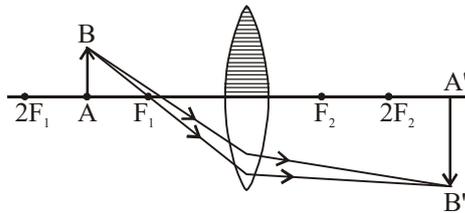
Draw ray diagram to justify your answer.

Sol. (a) Convex lens is used as a magnifying glass.



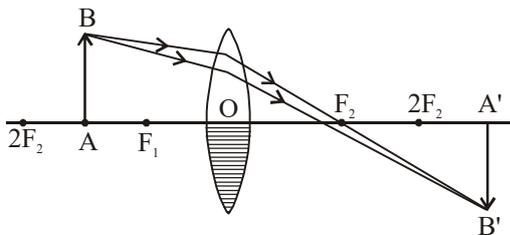
(b) The convex lens will form a complete image of an object, even if its one-half is covered with black paper. It can be understood by the following two cases :

Case I - When upper half of lens is covered



In this case, the ray of light coming from the object will be refracted by lower half of the lens. These rays meet at the other side of the lens to form the image of the given object.

Case-II - When the lower half of the lens is covered.



In this case, a ray of light coming from the object is refracted by the upper half of the lens. These rays meet at the other side of the lens to form the image of the given object, as shown in figure given above.

Note : The only difference between these two images will be that they will have less intensity.

Q.56 An object 4 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 20 cm. The mirror formula to find the position, nature and size of image. Also draw a ray diagram for the above situation and mark the position of pole, focus and centre of curvature on it.

Sol. Given that :

Object distance $u = -20$ cm
Object height $h_0 = 4$ cm
Radius of curvature $R = 20$ cm

$$\therefore f = \frac{R}{2}$$

$$\therefore \text{Focal length } f = \frac{20}{2} = 10 \text{ cm}$$

According to mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$\frac{1}{v} = \frac{1}{10} - \left(\frac{1}{-20} \right) = \frac{1}{10} + \frac{1}{20} = \frac{2+1}{20} = \frac{3}{20}$$

$$\therefore v = \frac{20}{3} = 6.67 \text{ cm}$$

The positive value of v indicates that the image is formed behind the mirror. So, it is virtual in nature

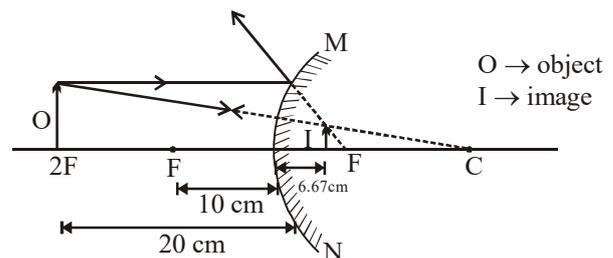
$$\text{magnification } m = -\frac{v}{u}$$

$$m = -\frac{v}{u} = -\frac{6.67}{-20} = 0.33$$

$$\text{and } m = \frac{h_i}{h_0} \Rightarrow h_i = m \times h_0$$

$$= 0.33 \times 4 = 1.32 \text{ cm}$$

The positive value of the image height indicates that the image formed is erect.



EXERCISE-IV

Competitive Edge

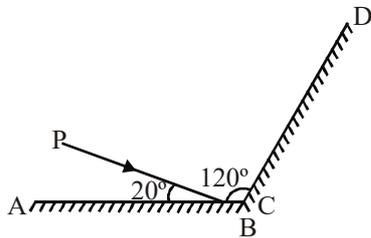


PREVIOUS YEAR NSO QUESTIONS:

Q.1 Optical density of a medium depends on _____ . [NSO 2010]

- (A) Density of the medium
- (B) thickness of the medium
- (C) Velocity of light in that medium
- (D) None of these

Q.2 Figure shows a ray of light P striking a mirror AB. The mirror AB and the mirror CD make an angle of 120° with each other. The angle of reflection of ray P at CD is _____ [NSO 2010]

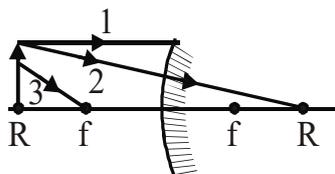


- (A) 20°
- (B) 30°
- (C) 50°
- (D) 70°

Q.3 Two plane mirrors are placed parallel to each other at distance L apart. A point object O is placed between them, at a distance $\frac{L}{3}$ from one mirror. Both mirrors form multiple images. The distance between any two images cannot be _____ . [NSO 2010]

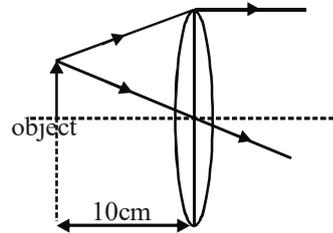
- (A) $\frac{3L}{2}$
- (B) $\frac{2L}{3}$
- (C) 2L
- (D) None of these

Q.4 Which pairs of rays from the object in the drawing are used to construct the image location produced by the convex spherical mirror of focal length f and radius R? [NSO 2010]



- (A) 1 and 3
- (B) 1 and 2
- (C) 2 and 3
- (D) any pair of rays of shown will work

Q.5 The diagram shows the paths of two rays of light from an object. The object is 10 cm in front of a lens as shown in the diagram. [NSO 2010]



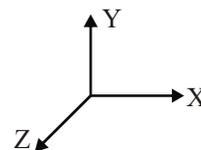
Which of the following statements is true about the given diagram ?

- (A) The lens is converging and focal length of lens is greater than 10 cm.
- (B) The lens is converging and focal length of lens is less than 10 cm.
- (C) The lens is diverging and focal length of lens is greater than 10 cm.
- (D) The lens is diverging and focal length of lens is less than 10 cm

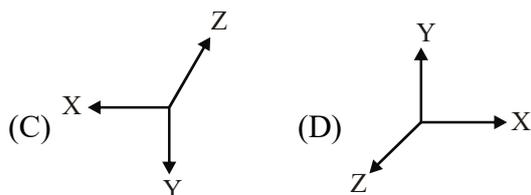
Q.6 A fisherman is standing on the bank of a lake. To a fish under water, viewing obliquely the man looks _____ [NSO 2015]

- (A) Taller than what he actually is
- (B) Shorter than what he actually is
- (C) The same height as he actually is
- (D) Depends on the obliquity

Q.7 A coordinate axis as shown in figure is kept in front of a converging lens at a distance 2f from it, where f is the focal length of the lens. Which of the following shows the approximate shape of the image ? Assume that X-axis is the principal axis of the lens. [NSO 2015]



- (A)
- (B)



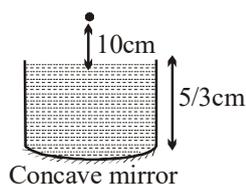
Q.8 Read the given statements and select the correct option. **[NSO 2015]**

Statement 1 : A concave mirror and a convex lens both have the same focal length in air. When they are submerged in water, they will still have the same focal length.

Statement 2 : The refractive index of water is greater than the refractive index of air.

- (A) Both statements 1 and 2 are true and statement 2 is the correct explanation of statement 1.
- (B) Both statements 1 and 2 are true but statement 2 is not the correct explanation of statement 1.
- (C) Statement 1 is true but statement 2 is false.
- (D) Statement 1 is false but statement 2 is true.

Q.9 A concave mirror of focal length 10 cm is dipped in water as shown in the given figure.

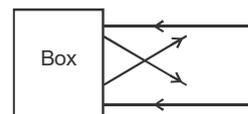


Given that the refractive index of water is $\frac{4}{3}$ and object S is placed on the principal axis of the concave mirror. The final image formed by the system is at **[NSO 2015]**

- (A) $\frac{85}{4}$ cm from water surface
- (B) $\frac{85}{4}$ cm from mirror surface
- (C) $\frac{94}{3}$ cm from water surface
- (D) $\frac{94}{3}$ cm from mirror surface.

PREVIOUS YEAR NTSE QUESTIONS:

Q.10 In the given diagram the reflecting surface inside the box will be : **(Raj./NTSE Stage-I/2005)**



- (A) Plane mirror
- (B) Concave mirror
- (C) Convex mirror
- (D) Two inclined plane mirrors

Q.11 On passing white light through a glass prism. Which colour ray will deviate maximum towards its base ?

(Raj./NTSE Stage-I/2005)

- (A) Red
- (B) Yellow
- (C) Blue
- (D) Violet

Q.12 On immersing a glass lens in water its focal length **(Raj./NTSE Stage-I/2005)**

- (A) will become zero
- (B) will decrease
- (C) will increase
- (D) will become infinite

Q.13 The intensities of two interfering waves are I_1 and I_2 . The best contrast in the interference pattern will be, when -

(Raj./NTSE Stage-I 2005)

- (A) $I_1 = I_2$
- (B) $I_1 \gg I_2$
- (C) $I_1 > I_2$
- (D) I_1 or $I_2 = 0$

Q.14 A point object is placed in the middle of two concave mirrors. The focal length of each mirror is 10 cm. to obtain single image of point object, the distance between two mirrors in cm will be:

(Raj./NTSE Stage-I/2006)

- (A) 10
- (B) 40
- (C) 30
- (D) 20

Q.15 If a ray of light is incident normally on the glass slab, then angle of refraction will be :

(Raj./NTSE Stage-I/2006)

- (A) 0°
- (B) 45°
- (C) 60°
- (D) 90°

Q.16 The lens used in the Camera is :

(Raj./NTSE Stage-I/2007)

- (A) Biconcave Lens
- (B) Concave lens
- (C) Biconvex lens
- (D) Both (A) and (C)

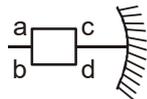
Q.17 While obtaining the image of a candle by a convex lens, if lower half portion of the lens is blackened to make it opaque completely, then the intensity of the image will be:
(Raj./ NTSE Stage-I 2007)
 (A) constant (B) decreased
 (C) increased (D) zero

Q.18 When a light wave of frequency 5×10^{14} Hz is passed through a medium of refractive index 1.5 then its wavelength will become:
(Raj./ NTSE Stage-I 2007)
 (A) 4000 Å (B) 4500 Å
 (C) 6000 Å (D) 9000 Å

Q.19 The minimum distance between an object and its real image in convex lens is :
 (f = focal length of the lens)
(West Bengal./NTSE Stage-I/2013)
 (A) 2.5 f (B) $2f$
 (C) $4f$ (D) f

Q.20 The relation among u , v and f for mirror is:
(Mizoram/NTSE Stage-I/2013)
 (A) $f = uv / (u + v)$
 (B) $v = fu (u + f)$
 (C) $u = fv (f + v)$
 (D) all of these

Q.21 An object is placed in front of a concave mirror of focal length ' f ' as shown in figure. Choose the correct shape of image.
(Haryana/ NTSE Stage-I 2013)



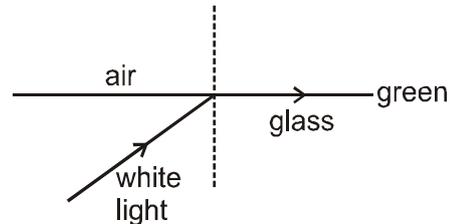
- (A) (B)
- (C) (D)

Q.22 Match the following
(Haryana/ NTSE Stage-I 2013)

- | | |
|----------------------------------|---------------------|
| Column I | Column II |
| (i) Convex mirror, real object | p. Real image |
| (ii) Concave mirror, real object | q. Virtual image |
| (iii) Concave lens real object | r. Magnified image |
| (iv) Convex lens, real object | s. Diminished image |
- (A) (i)-q,s (ii) p,q,s (iii) q,r (iv)-p,q,r, s
 (B) (i)-q (ii) p,q,s (iii) q,r (iv)-p,q,r
 (C) (i)-s (ii) p,q,s (iii) q,s (iv)-p,q,r,s
 (D) (i) q,s (ii) p,q,r,s (iii) q,s (iv)-p,q,r,s

Q.23 The frequency of light of wave length 5000 Å is **(West Bengal/ NTSE Stage-I 2013)**
 (A) 1.5×10^5 Hz (B) 6×10 Hz
 (C) 6×10^{14} Hz (D) 7.5×10^{15} Hz

Q.24 White light is incident on the interface of glass and air as shown in the figure. If green light is just totally internally reflected then the emerging ray in air contains :
(Haryana./ NTSE Stage-I 2014)



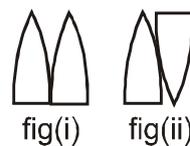
- (A) Yellow, orange , red
 (B) Violet, indigo, blue
 (C) All colours except green
 (D) All colours

Q.25 A concave mirror is placed in a horizontal table with its axis directed vertically upwards. Let O be pole of the mirror and C its centre of curvature. A point object is placed at C. If the mirror is now filled with water, the image will be :
(Raj./ NTSE Stage-I/2014)
 (A) Real and located at a point between C and O.
 (B) Real and will remain at C.
 (C) Real and located at point between C and ∞ (infinity).
 (D) Virtual and located at a point between C and O.

Q.26 If a lens of focal length ' f ' is cut in two equal parts shown as :



are put in contact as shown in figure (i) and (ii)



the resulting focal length of fig (i) and (ii) will be- **(Haryana/ NTSE Stage-I/2014)**
 (A) $f/2, 0$ (B) $0, f/2$
 (C) f, f (D) $f/2, (\infty)$

Q.27 If sum of velocities of light in two media is 3.25×10^8 m/s and their difference is 0.75×10^8 m/s, find the refractive index of the second medium with respect to one :
(MAHARASHTRA/ NTSE Stage-I/2014)

- (A) 1.25 (B) 1.6
(C) 1.5 (D) 1.3

Q.28 The ability of a lens to converge or diverge light rays depends on :

(MAHARASHTRA/ NTSE Stage-I/2014)

- (A) Principal axis (B) Focal length
(C) Object distance (D) Image distance

Q.29 The correct relation between u, v and r for a mirror will be : (symbols represent traditional meaning)

(Raj./NTSE Stage-I/2014)

- (A) $r = \frac{2uv}{u+v}$ (B) $r = \frac{uv}{2(u-v)}$
(C) $r = \frac{1}{u+v}$ (D) $\frac{1}{r} = \frac{1}{u} + \frac{1}{v}$

Q.30 The mirror used by a dentist to examine the teeth of a person is :

(M.P./NTSE Stage-I/2014)

- (A) Convex (B) Concave
(C) Plane (D) Plano convex

Q.31 The twinkling of stars is due to atmospheric: (M.P./NTSE Stage-I/2014)

- (A) Reflection of light
(B) Dispersion of light
(C) Interference of light
(D) Refraction of light

Q.32 The blue colour of sky is due to :

(M.P./NTSE Stage-I/2014)

- (A) Reflection of light
(B) Dispersion of light
(C) Diffraction of light
(D) Scattering of light

Q.33 For magnification in spherical mirrors object height is :

(Maharashtra/NTSE Stage-I/2014)

- (A) Negative
(B) Positive
(C) For real images positive
(D) For virtual image negative

Q.34 After refraction of light through a glass slab, incident ray and refracted are :

(Maharashtra/NTSE Stage-I/2014)

- (A) perpendicular (B) parallel
(C) in a straight line (D) (A) and (C)

Q.35 Convex lens is not used in :

(Maharashtra/NTSE Stage-I/2014)

- (A) simple microscope
(B) spectacles
(C) telescope
(D) flood lights

Q.36 As the thickness of the atmosphere increases colour of scattered light is found in the

(Maharashtra/NTSE Stage-I/2014)

- (A) blue, violet, yellow, red
(B) violet, blue, yellow, red
(C) red, yellow, blue, violet
(D) violet, blue, red, yellow

Q.37 The resultant focal length of the lenses as shown in the figure is :

(Delhi/NTSE Stage-I/2014)



- (A) $2f$ (B) $\frac{f}{2}$
(C) $\frac{f}{4}$ (D) f

Q.38 White colour of the cloud is due to :

(Delhi/NTSE Stage-I/2014)

- (A) reflection of seven colours of light
(B) refraction of seven colours of light
(C) scattering of seven colors of light
(D) absorption of seven colors of light

Q.39 If a part of a convex lens is covered, its focal length will be :

(West Bengal/NTSE Stage-I/2014)

- (A) remain unchanged
(B) become twice
(C) become half
(D) depend on the covered area

Q.40 The minimum distance between an object and its real image in a convex lens is :

(West Bengal/NTSE Stage-I/2014)

- (A) 2.5 times its focal length
(B) 2 times its focal length
(C) 4 times its focal length
(D) equal to its focal length

Q.41 A real and enlarged image can be formed by using a

(Jharkhand/NTSE Stage-I/2014)

- (A) convex mirror
- (B) plane mirror
- (C) concave mirror
- (D) either convex or a plane mirror

Q.42 Magnification produced by a convex lens is always

(Jharkhand/NTSE Stage-I/2014)

- (A) More than 1
- (B) Less than 1
- (C) Equal to 1
- (D) More or less than 1

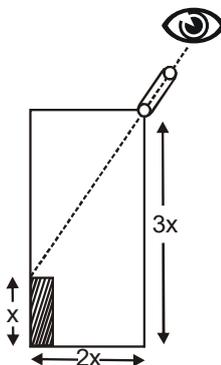
Q.43 Amount of light entering into the camera depends upon:

(Delhi/NTSE Stage-I/2014)

- (A) Focal length of objective lens
- (B) Product of focal length & diameter of objective lens.
- (C) Distance of objective from camera.
- (D) Aperture setting of the camera.

Q.44 A man can see through a hole, the top end of a thin rod of height x , the height of beaker is $3x$, If the beaker is filled with a liquid of refractive index μ upto height $2x$, he can now see the lower end of rod. The value of μ is:

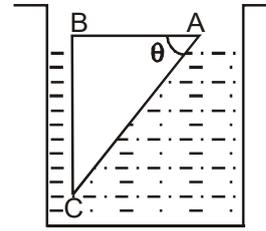
(Haryana/NTSE Stage-I/2014)



- (A) $\frac{5}{2}$
- (B) $\sqrt{\frac{5}{2}}$
- (C) $\sqrt{\frac{3}{2}}$
- (D) $\frac{3}{2}$

Q.45 A glass prism of refractive index $\frac{3}{2}$ is immersed in water of refractive index $\frac{4}{3}$. A light beam incident normally on the face AB is totally reflected to reach the face BC if:

(Haryana/NTSE Stage-I/2014)



- (A) $\sin \theta > \frac{8}{9}$
- (B) $\frac{2}{3} < \sin \theta < \frac{8}{9}$
- (C) $\sin \theta < \frac{2}{3}$
- (D) $\sin \theta > \frac{3}{2}$

Q.46 The focal length of a concave mirror in air is f . If it is immersed in water $\left(n = \frac{4}{3}\right)$, then the focal length will be :

(Raj./NTSE Stage-I/2015)

- (A) f
- (B) $\frac{4}{3}f$
- (C) $\frac{3}{4}f$
- (D) $4f$

Q.47 A student was asked to draw a ray diagram for formation of image by a convex lens for the following positions of the object :

(Raj./NTSE Stage-I/2015)

- (I) between F and $2F$
- (II) at F
- (III) at $2F$
- (IV) between F and optical centre the position for which virtual image can be formed among these is
- (A) I
- (B) II
- (C) III
- (D) IV

Q.48 The far point of a myopic person is 75 cm in front of the eye. The nature and power of the lens required to correct the problem, will be:

(Raj./NTSE Stage-I/2015)

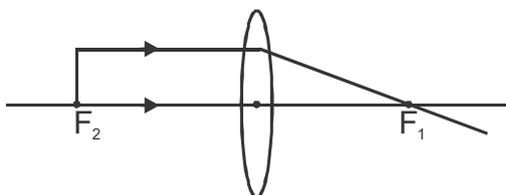
- (A) convex lens, -1.33 D
- (B) concave lens, -1.33 D
- (C) concave lens, $+1.33$ D
- (D) convex lens, $+1.33$ D

Q.49 Find the wrong statement related to convex lens
(Maharashtra/NTSE Stage-I/2015)
 (A) Two spherical surfaces bulging outward
 (B) Converging lens
 (C) Positive focal length
 (D) Image is always virtual and diminished

Q.50 Velocity of light travelling from rarer medium to denser decreases by 30 %. Find the refractive index of the denser medium with respect to rarer medium?
(Maharashtra/NTSE Stage-I/2015)
 (A) 1.35 (B) 1.5
 (C) 1.4 (D) 1.428

Q.51 Object when placed at in front of concave mirror magnification of -1 is obtained :
(Maharashtra/NTSE Stage-I/2015)
 (A) infinity
 (B) Centre of curvature
 (C) Between focus and centre of curvature
 (D) Principal focus

Q.52 The position of image of the object in the ray diagram will be at :
(Uttarakhand/NTSE Stage-I/2015)



- (A) Focal point F_2
- (B) Focal point F_1
- (C) Infinity
- (D) None of these

Q.53 If two plane mirror are kept together at an angle of 30° then number of images of object will be:
(Uttarakhand/NTSE Stage-I/2015)
 (A) 10 (B) 11
 (C) 13 (D) 11.5

Q.54 A mirror which can produce a magnification of $+1$ is :
(Delhi/NTSE Stage-I/2015)
 (A) Convex mirror
 (B) Concave mirror
 (C) Plane mirror
 (D) Both concave mirror & plane mirror

Q.55 A light ray enters from denser medium to rarer medium. What is the angle of incidence called that has 90° angle of reflection? **(Gujrat/NTSE Stage-I/2015)**
 (A) angle of reflection
 (B) critical angle
 (C) angle of deviation
 (D) angle of refraction

Q.56 Due to which motion of light does the tyndall effect occur ?
(Gujrat/NTSE Stage-I/2015)
 (A) incidence (B) refraction
 (C) scattering (D) dispersion

Q.57 The absolute refractive index of any medium is : **(Gujrat/NTSE Stage-I/2015)**
 (A) 1 (B) > 1
 (C) < 2 (D) 0

Q.58 A lens have power $+5D$. This lens will be :
(U.P./NTSE Stage-I/2015)
 (A) a convex lens of focal length 0.05 m.
 (B) a concave lens of focal length 0.20m.
 (C) a convex lens of focal length 0.20m.
 (D) a concave lens of focal length 0.05 m

Q.59 The refractive index of glass is maximum for:
(U.P./NTSE Stage-I/2015)
 (A) red colour (B) yellow colour
 (C) violet colour (D) green colour

Q.60 Most of the refraction takes place at when light enter the eye :
(Haryana/NTSE Stage-I/2015)
 (A) Pupil
 (B) Iris
 (C) Outer surface of cornea
 (D) Crytalline lens

Q.61 For an incident ray directed towards centre of curvature of a spherical mirror, the reflected ray
(Bihar/NTSE Stage-I/2015)
 (A) retraces its path
 (B) passes through focus
 (C) passes through pole
 (D) becomes parallel to the principal axis

Q.62 A convex lens of suitable focal length can correct man's eye problem of :
(Bihar/NTSE Stage-I/2015)
 (A) Short sightedness
 (B) Long sightedness
 (C) Presbyopia
 (D) Astigmatism

Q.63 The focal length of a spherical mirror is 20 cm. The radius of curvature of this mirror will be :

(M.P./NTSE Stage-I/2015)

- (A) 10 cm (B) 20 cm
(C) 40 cm (D) 80 cm

Q.64 If λ_R , λ_V are wavelengths of light rays of red and violet colours respectively then :

(M.P./NTSE Stage-I/2015)

- (A) $\lambda_R < \lambda_V$ (B) $\lambda_R > \lambda_V$
(C) $\lambda_R = \lambda_V$ (D) none of these

Q.65 Which of the following colours is not a primary colour ?

(M.P./NTSE Stage-I/2015)

- (A) White (B) Green
(C) Red (D) Blue

Q.66 You are provided with a concave lens having focal length 15 cm. If it diminishes the image by one-third, calculate the distance of image from lens ?

(Chandigarh/NTSE Stage-I/2015)

- (A) 5 cm (B) 0 cm
(C) 5 m (D) 10 m

Q.67 Refractive index of a medium with respect to air is $\mu = \sqrt{2}$, find the critical angle between the two medium :

(West Bengal/NTSE Stage-I/2015)

- (A) 30° (B) 90°
(C) 45° (D) 60°

Q.68 What will be the colour the sky as seen from the earth if there is no atmosphere ?

(West Bengal/NTSE Stage-I/2015)

- (A) Black (B) Blue
(C) Orange (D) Red

Q.69 A convex lens of glass has power P in air. If it is immersed in water, its power will be :

(West Bengal/NTSE Stage-I/2015)

- (A) More than P
(B) less than P
(C) P
(D) More the P for some colours and less than P for others

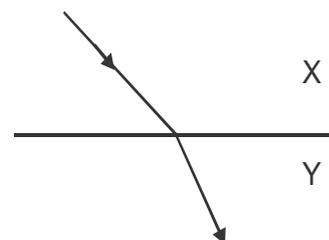
Q.70 Colour of scattered light depends :

(Maharashtra/NTSE Stage-I/2016)

- (A) only on size of scattering particle
(B) only on length of travelling light
(C) both size of scattering particle and length of travelling light
(D) on colour of incident light

Q.71 When light travels from medium X to medium Y as shown :

(Raj./NTSE Stage-I/2016)



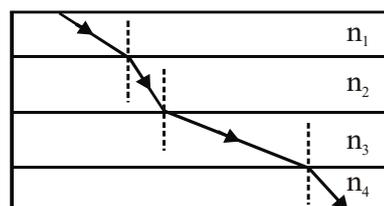
- (A) both the speed and the frequency decrease
(B) both the speed and the frequency increase
(C) both the speed and the wavelength decrease
(D) both the wavelength and the frequency are unchanged.

Q.72 The image formed by a concave mirror is observed to be real, inverted and larger than the object. Where should be the position of the object?

[NTSE Stage 1 2016]

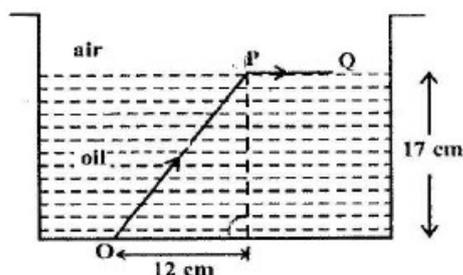
- (A) At the centre of curvature
(B) Between the principal focus and centre of curvature
(C) Beyond the centre of curvature
(D) Between the pole of the mirror and its principal focus.

Q.73 The path of ray of light in different media of refractive indices n_1 , n_2 , n_3 and n_4 is shown in figure. The velocity of light will be maximum in the medium whose refractive index is [NTSE Stage 1 2016]



- (A) n_1 (B) n_2 (C) n_3 (D) n_4

Q.74 A vessel is filled with oil as shown in the diagram. A ray of light from point O at the bottom of vessel is incident on the oil - air interface at point P and grazes the surface along PQ. The refractive index of the oil is close to – [NTSE Stage II 2017]



- (A) 1.41
- (B) 1.50
- (C) 1.63
- (D) 1.73

Q.75 The focal length of concave lens is 25 cm. Then its power will be : (Chattis./NTSE Stage-I/2017)

- (A) 4D
- (B) $\frac{1}{4}D$
- (C) - 4D
- (D) All of these

Q.76 A ray passing through which part of a lens emerges undeviated? (Gujrat/NTSE Stage-I/2017)

- (A) Focus
- (B) Centre of curvature
- (C) Optical centre
- (D) Between focus and centre of curvature

Q.77 A swimming pool appears less deeper than its real depth : (U.P./NTSE Stage-I/2017)

- (A) due to reflection
- (B) due to refraction
- (C) due to dispersion
- (D) due to lateral displacement

Q.78 If 'p' and 'q' are distance of object and image from principal focus of a concave mirror then what is the relation between 'p', 'q' and 'f' ? (Haryana/NTSE Stage-I/2017)

- (A) $q = \sqrt{f}$
- (B) $pq = f$
- (C) $pq = f^2$
- (D) $pq = \frac{1}{f}$

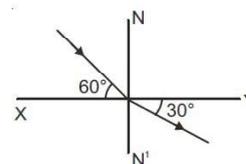
Q.79 For the definite colour of light absolute refractive index of water is $\frac{4}{3}$ and absolute refractive index of glass is $\frac{3}{2}$, then will be the refractive index of glass with respect to water ?

- (West Bengal/NTSE Stage-I/2017)
- (A) 1.125
 - (B) 1.33
 - (C) 1.56
 - (D) 2

Q.80 Two lenses of focal length f_1 and f_2 are kept in contact coaxially. The power of the combination will be : (Delhi/NTSE Stage-I/2017)

- (A) $\frac{f_1 f_2}{f_1 + f_2}$
- (B) $\frac{f_1 + f_2}{f_1 f_2}$
- (C) $\frac{f_1 f_2}{f_1 - f_2}$
- (D) $f_1 + f_2$

Q.81 In figure, a ray of light undergoes refraction from medium A to medium B. If the speed of light in medium A is v, then the speed of light in medium B will be : (Delhi/NTSE Stage-I/2017)



- (A) $\sqrt{3}v$
- (B) $\frac{v}{\sqrt{3}}$
- (C) 2 v
- (D) $\frac{v}{2}$

Q.82 A convex lens has focal length 30 cm. If an object is placed at a distance of 15 cm from it then the magnification produced by the lens is: (Raj./NTSE Stage-I/2018)

- (A) 6.66
- (B) 0.5
- (C) 1
- (D) 2

Q.83 Two plane mirrors P & Q are kept at θ with respect to each other. Light falls on P is reflected and then fall on Q and is reflected. The emergent ray is opposite to incident ray direction. The θ is equal to (Haryana/NTSE Stage-I/2018)

- (A) 40°
- (B) 30°
- (C) 60°
- (D) 90°

Q.84 Focal length of convex lens is +40 cm. The power of this lens will be :

(Raj./NTSE Stage-I/2019)

- (A) + 4 dioptre (B) + 2.5 dioptre
(C) + 40 dioptre (D) + 25 dioptre

Q.85 Focal length of a lens is 25 cm. In dioptre power of lens will be

(Raj./NTSE Stage-I/2019)

- (A) 0.04 (B) 0.4
(C) 4 (D) 2.5

Q.86 Find the power of a concave lens of focal length 2 m ?

(Gujrat/NTSE Stage - I/2019)

- (A) -0.5 D (B) +0.5 D
(C) - 4D (D) 4 D

Q.87 The central point of lens is known as

(Gujrat/NTSE Stage - I/2019)

- (A) Centre of curvature
(B) Principal focus
(C) Optical centre
(D) Pole

Q.88 A spherical mirror and a thin spherical lens each of focal length -10 cm are given. The mirror and lens are likely to be :

(Karnataka/NTSE Stage - I/2019)

- (A) The mirror is concave mirror and the lens is concave lens.
(B) The mirror is convex mirror and the lens is convex lens.
(C) The mirror is convex mirror and the lens is concave lens.
(D) The mirror is concave mirror and the lens is convex lens.

Q.89 A ray of light passes from glass ($\mu = \frac{3}{2}$)

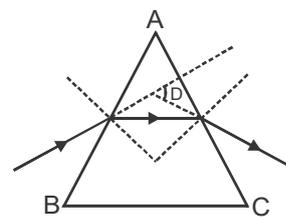
to water ($\mu = \frac{4}{3}$). The value of critical angle will be :

(UP/NTSE Stage - I/2019)

- (A) $\sin^{-1}\left(\frac{1}{2}\right)$ (B) $\sin^{-1}\left(\sqrt{\frac{8}{9}}\right)$
(C) $\sin^{-1}\left(\frac{8}{9}\right)$ (D) $\sin^{-1}\left(\frac{5}{7}\right)$

Q.90 The refraction of light by a prism is shown in the following figure. The angle $\angle D$ is -

(UP/NTSE Stage - I/2019)



- (A) Angle of prism
(B) Angle of refraction
(C) Angle of emergence
(D) Angle of deviation

Q.91 The absolute refractive indices of water and glass are $\frac{4}{3}$ and $\frac{3}{2}$ respectively.

Which is the refractive index of glass with respect to water ?

(West Bengal/NTSE Stage - I/2019)

- (A) 1.125 (B) 1.5
(C) 1.25 (D) 1.52

Q.92 When electromagnetic wave propagates, the angle between the electric field and the magnetic field is given by :

(West Bengal/NTSE Stage - I/2019)

- (A) 0° (B) 90°
(C) 45° (D) 135°

Q.93 If a plane mirror is rotated by an angle 15° then the reflected light will be rotated by :

(Assam/NTSE Stage - I/2019)

- (A) 15° (B) 30°
(C) 45° (D) 7.5°

Q.94 At total internal reflection the angle between the reflected ray and the incident ray is:

(Assam/NTSE Stage - I/2019)

- (A) Two times the angle of incidence
(B) Equal to the angle of incidence
(C) zero 0°
(D) 90°

Q.95 The correct sequence in the increasing order of frequency is :

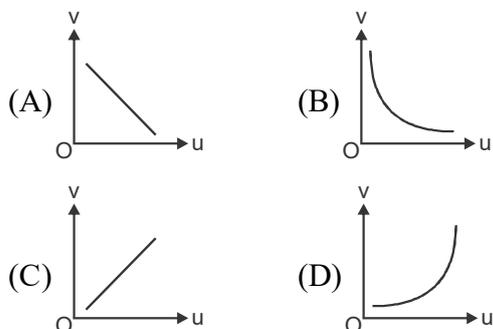
(Assam/NTSE Stage - I/2019)

- (A) violet, yellow, orange
(B) red, orange, violet
(C) blue, yellow, violet
(D) blue, red, orange

Q.96 A concave lens of focal length 30 cm placed in contact with a plane mirror acts as a: **(Bihar/NTSE Stage - I/2019)**
 (A) convex mirror of focal length 60 cm.
 (B) concave mirror of focal length 15 cm.
 (C) convex mirror of focal length 15 cm.
 (D) concave mirror of focal length 60 cm.

Q.97 Rainbow is formed due to a combination of: **(Bihar/NTSE Stage - I/2019)**
 (A) Dispersion and total internal reflection.
 (B) Refraction and absorption.
 (C) Dispersion and interference.
 (D) Scattering and dispersion.

Q.98 In an experiment to find the focal length of a concave mirror, a graph is drawn between magnitude of u and v . The graph looks like : **(Chandigarh/NTSE Stage - I/2019)**



Q.99 A person cannot clearly see objects at a distance more than 40 cm. He is advised to use lens of power : **(Delhi/NTSE Stage - I/2019)**
 (A) -2.5 D (B) 2.5 D
 (C) -1.5 D (D) 1.5 D

Q.100 An observation moves towards a stationary plane mirror at a speed of 4 m/s the speed with which his image move towards him ? **(Delhi/NTSE Stage - I/2019)**
 (A) 2 m/s (B) 4m/s
 (C) 8 m/s
 (D) Image will stay at rest

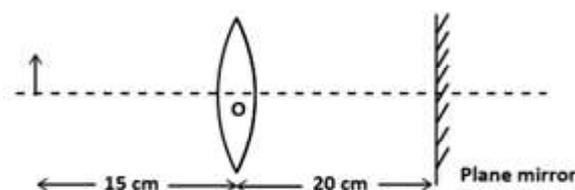
Q.101 A concave mirror of focal length 15 cm forms an image. The position of the object when the image is virtual and linear magnification is 2 is : **(Delhi/NTSE Stage - I/2019)**
 (A) 22.5 cm (B) 7.5 cm
 (C) 30 cm (D) 4.5 cm

Q.102 Focal length of a lens is 50 cm. In diopter power of lens will be **(Raj./NTSE Stage - I/2020)**
 (A) 0.02 (B) 2
 (C) 0.2 (D) 50

Q.103 A convex mirror of focal length f produces an image $(1/n)^{\text{th}}$ the size of the object. Calculate the distance of the object from the mirror in terms of f and n . **(Raj./NTSE Stage - I/2020)**
 (A) $(n + 1) f$ (B) nf
 (C) $(n - 1) f$ (D) $\frac{n}{f}$

Q.104 Sir CV raman announced the discovery of Raman Effect on February 28, 1928. He received 1930 Nobel prize in Physics for this discovery. Raman Effect is the discovery of **(NSE JS 2022)**
 (A) Dispersion of light
 (B) Total Internal Reflection of light
 (C) Refraction of light
 (D) Inelastic scattering of light

Q.105 Focal length of a thin convex lens is 10 cm. An object is placed at a distance 15 cm in front of the lens and a plane mirror is kept at 20 cm on the other side as shown in figure. **(NSE JS 2022)**



(A) The final image is formed at distance 10 cm from lens towards the mirror
 (B) The final image is formed at a distance 30 cm from lens means 10 cm behind the mirror.
 (C) The final image has magnification $m = -2$
 (D) The final image has magnification $m = +2$

Q.106 The refractive index of glass is 1.50. If the speed of light in air is $3 \times 10^8 \text{ ms}^{-1}$, then the speed in glass will be-
(STSE SAT 2022)

- (A) $3 \times 10^8 \text{ ms}^{-1}$
 (B) $2 \times 10^8 \text{ ms}^{-1}$
 (C) $1.5 \times 10^8 \text{ ms}^{-1}$
 (D) $4.5 \times 10^8 \text{ ms}^{-1}$

Q.107 Correct relation between object distance (u), image distance (v) and focal length (f) of a mirror is (STSE SAT 2022)

- (A) $v - u = f$ (B) $\frac{1}{v} = \frac{1}{u} = \frac{1}{f}$
 (C) $v + u = f$ (D) $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

Q.108 Nature and focal length of a lens of power +2.0 D will be-

(STSE SAT 2022)

- (A) Concave lens, +50 cm
 (B) Concave lens, -50 cm
 (C) Convex lens, +50 cm
 (D) Convex lens, -50 cm

Q.109 The image formed by a concave mirror is of the same size, real and inverted when the object is placed (STSE SAT 2022)

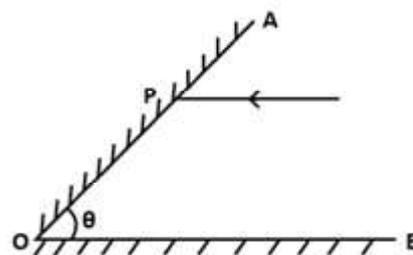
- (A) Between P and F (B) At infinity
 (C) At C (D) At F

Q.110 Twinkle of stars is due to-

(STSE SAT 2022)

- (A) scattering (B) dispersion
 (C) reflection (D) Atmospheric

Q.111 Two plane mirrors OA and OB are inclined at an angle θ as shown in figure. A ray of light incident parallel to BO strikes the mirror OA at point P. It gets reflected from mirror OA and then reflected from the mirror OB, the ray finally emerges parallel to OA. The value of angle θ is (NSEJS 2022)



- (A) 90° (B) 60°
 (C) 45° (D) 30°

EXERCISE-V

Board Navigator



Q.1 An object of height 4.0 cm is placed at a distance of 30 cm from the optical centre 'O' of a convex lens of focal length 20 cm. Draw a ray diagram to find the position and size of the image formed. Mark optical centre 'O' and principal focus 'F' on the diagram. Also find the approximate ratio of size of the image to the size of the object. [2018]

Q.2 A concave mirror has a focal length of 20 cm. At what distance from the mirror should a 4 cm tall object be placed so that it forms an image at a distance of 30 cm from the mirror? Also calculate the size of the image formed. [2019]

OR

A real image $\frac{2}{3}$ rd of the size of an object is formed by a convex lens when the object is at a distance of 12 cm from it. Find the focal length of the lens.

Q.3 (a) A 5 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20 cm. The distance of the object from the lens is 30 cm. Find the position, nature and size of the image formed. [2019]

(b) Draw a labelled ray diagram showing object distance, image distance and focal length in the above case.

Q.4 A teacher gives a convex lens and concave mirror of focal length of 20 cm each to his student and asks him to find their focal lengths by obtaining the image of a distant object. The student uses a distant tree as the object and obtains its sharp image, one by one, on a screen. The distances d_1 and d_2 between the lens/mirror and the screen in the two cases and the nature of their respective sharp images are likely to be [2019]

- (a) (20 cm, 40 cm) and (erect and erect)
 (b) (20 cm, 40 cm) and (inverted and inverted)
 (c) (20 cm, 20 cm) and (inverted and inverted)
 (d) (20 cm, 40 cm) and (erect and inverted)

Give reason for your answer.

Q.5 Draw a ray diagram in each of the following cases to show the formation of image, when the object is placed : [2020]

- (i) between optical centre and principal focus of a convex lens.
 (ii) anywhere in front of a concave lens.
 (iii) at 2F of a convex lens.

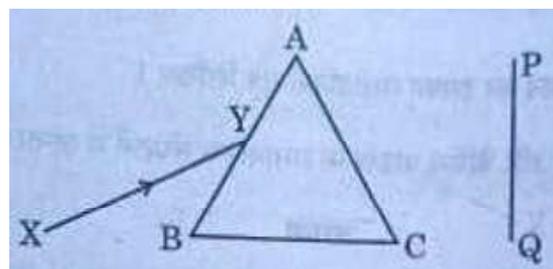
State the signs and values of magnifications in the above mentioned cases (i) and (ii).

OR

An object 4.0 cm in size, is placed 25.0 cm in front of a concave mirror of focal length 15.0 cm.

- (i) At what distance from the mirror should a screen be placed in order to obtain a sharp image?
 (ii) Find the size of the image.
 (iv) Draw a ray diagram to show the formation of image in this case.

Q.6 (a) A narrow beam XY of white light is passing through a glass prism ABC as shown in the diagram : [2023]



Trace it on your answer sheet and show the path of the emergent beam as observed on the screen PQ.

Name the phenomenon observed and state its cause.

Q.7 (a) The image of an object formed by a lens is of same size but inverted. If the object distance is 30 cm, calculate [2023]

- (i) The distance between the object and its image.
 (ii) Focal length of the lens.
 (b) Draw a ray diagram to show the image formed in above case.

Q.8 Hold a concave mirror in your hand and direct its reflecting surface towards the sun. Direct the light reflected by the mirror on to a white card - board back and forth gradually until you find a bright, sharp spot of light on the board. This spot of light is the image of the sun on the sheet of paper; which is also termed as "Principal Focus" of the concave mirror.

[2023]

- (a) List two applications of concave mirror.
- (b) If the distance between the mirror and the principal focus is 15 cm, find the radius of curvature of the mirror.

- (c) Draw a ray diagram to show the type of image formed when an object is placed between pole and focus of a concave mirror.

OR

- (c) An object 10 cm in size is placed at 100 cm in front of a concave mirror. If its image is formed at the same point where the object is located, find:
 - (i) Focal length of the mirror, and
 - (ii) Magnification of the image formed with sign as per Cartesian sign convention.

ANSWER KEY

TRY YOURSELF:

1. (C) 2. (i) 7/9 m (ii) 2/9 (iii) Virtual, erect and diminished
 3. $n_g = 3/2$
 4. 1.32
 5. 5/8
 6. (i) $h_i = 5$ cm (ii) $v = -10$ cm (iii) virtual, erect & diminished (iv) -5 D
 7. $f = 25$ cm, $P = 4D$

EXERCISE-II

MCQ BASED QUESTIONS:

- Q.1** A **Q.2** B **Q.3** D **Q.4** C **Q.5** B **Q.6** B **Q.7** B
Q.8 C **Q.9** B **Q.10** A **Q.11** B **Q.12** A **Q.13** C **Q.14** B
Q.15 C **Q.16** B **Q.17** A **Q.18** D **Q.19** D **Q.20** BD **Q.21** BC

FILL IN THE BLANKS:

- Q.22** 2×10^8 m/s, 0.4×10^{-6} m

MATCH THE COLUMN:

- Q.23** (B) (a)-(q), (b)-(r), (c)-(p), (d)-(s)
Q.24 (A) (a)-(r), (b)-(p), (c)-(q,s), (d)-(p,r)

ASSERTION & REASON TYPE QUESTIONS:

- Q.25** D **Q.26** A **Q.27** A **Q.28** A **Q.29** C

COMPREHENSIVE:

- Q.30** B **Q.31** A **Q.32** B

PRACTICAL BASED QUESTIONS:

- Q.33** D **Q.34** B **Q.35** B **Q.36** C **Q.37** B
Q.38 It means that the incident ray and emergent ray are parallel to each other. **Q.39** B
Q.40 D **Q.41** A **Q.42** A **Q.43** A **Q.44** D **Q.45** B **Q.46** A

EXERCISE-IV

NSO :

- Q.1** C **Q.2** C **Q.3** A **Q.4** B **Q.5** A **Q.6** A **Q.7** A
Q.8 D **Q.9** A

NTSE :

- Q.10** B **Q.11** D **Q.12** C **Q.13** A **Q.14** B **Q.15** A **Q.16** A
Q.17 B **Q.18** A **Q.19** C **Q.20** A **Q.21** C **Q.22** D **Q.23** C
Q.24 A **Q.25** A **Q.26** D **Q.27** B **Q.28** B **Q.29** A **Q.30** B
Q.31 D **Q.32** D **Q.33** B **Q.34** B **Q.35** D **Q.36** D **Q.37** B
Q.38 C **Q.39** A **Q.40** C **Q.41** C **Q.42** D **Q.43** D **Q.44** B

Q.45	A	Q.46	A	Q.47	D	Q.48	B	Q.49	D	Q.50	D	Q.51	B
Q.52	C	Q.53	B	Q.54	C	Q.55	B	Q.56	C	Q.57	B	Q.58	C
Q.59	C	Q.60	C	Q.61	A	Q.62	B	Q.63	C	Q.64	B	Q.65	A
Q.66	B	Q.67	C	Q.68	A	Q.69	B	Q.70	D	Q.71	C	Q.72	B
Q.73	C	Q.74	D	Q.75	C	Q.76	C	Q.77	B	Q.78	C	Q.79	A
Q.80	B	Q.81	A	Q.82	D	Q.83	D	Q.84	B	Q.85	C	Q.86	A
Q.87	C	Q.88	A	Q.89	C	Q.90	D	Q.91	A	Q.92	B	Q.93	B
Q.94	A	Q.95	B	Q.96	C	Q.97	A	Q.98	B	Q.99	A	Q.100	C
Q.101	B	Q.102	B	Q.103	A	Q.104	D	Q.105	B	Q.106	B	Q.107	D
Q.108	C	Q.109	C	Q.110	D	Q.111	B						

1. INTRODUCTION

Chemistry is defined as the branch of science which deals with the study of matter, dealing with the composition, structure, properties and changes occurring in matter.

There are so many situations of daily life, where we can observe various changes. Like,

- (i) Conversion of tea into vapours from a cup of hot tea.
- (ii) Corrosion of iron articles (rusting) if exposed to humid atmosphere.
- (iii) Cooking of food.
- (iv) Digestion of food in our body.
- (v) Breaking of any article like glass
- (vi) Combustion of fuel in our vehicle.
- (vii) A piece of paper is burnt
- (viii) Curdling of milk
- (ix) Burning of candle wax
- (x) Fermentation of grapes

➤ **Scientists classify these changes as :**

- ⇒ Physical changes
- ⇒ Chemical changes.

(1) **Physical changes :** A change in which physical properties of the substance changes but the chemical composition does not change.

Examples

Freezing, melting, boiling, condensation etc.

➤ **Characteristic features of physical changes :**

- (i) The identity of the substances is maintained.
- (ii) The change may or may not take place.
- (iii) Heat change may or may not take place.
- (iv) Only the physical state or some of the physical properties of the substances are changed.

(2) **Chemical Changes :** A change in which one or more substances changes into new substances with a different chemical composition.

Examples.

Burning of candle, rusting of iron, curdling of milk etc.

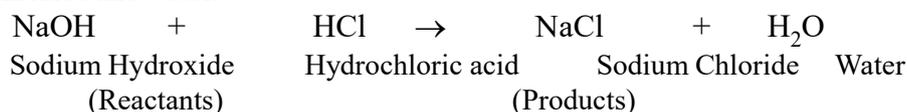
➤ **Characteristic features of chemical changes :**

- (i) The identity of original substance is completely lost.
- (ii) The change is permanent.
- (iii) The change is generally accompanied by energy change.
- (iv) The change cannot be reversed.

In this chapter, we will discuss chemical changes occurring in matter.

2. CHEMICAL REACTION

- Such process in which the original substances lose their nature and identity and form new chemical substances with different properties are called chemical changes. The process involving a chemical change is called a chemical reaction.
- The substances which take part in a chemical reaction are called reactants while the new substances produced as a result of chemical reaction are called products.
For example, in the reaction between sodium hydroxide and hydrochloric acid to give sodium chloride and water.



➤ A chemical reaction should satisfy the following conditions :

- There must not be either a gain or loss of matter.
- There must be either an evolution or an absorption of heat i.e. an energy change.
- The products obtained as a result of chemical reaction must have properties different from those of the reactants.

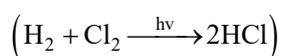
2.1 Conditions for Chemical change

The criterion for a chemical change is the production of one or more new substances. Therefore, certain conditions should be met in order to bring about a chemical change. The necessary conditions are :

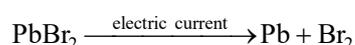
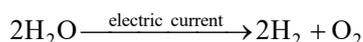
- A minimum amount of energy needed to initiate a reaction, called the activation energy, should be supplied in the form of heat, light or electric current. In a chemical change, the reactants combine to form new products. For this process, it is necessary to break the old bonds of the reactants and form fresh bonds in order to give products. This requires a certain amount of energy.
- For the occurrence of any reaction, the molecules or atoms of the reactants must collide with one another, in order to break old bonds and form new bonds.
- The speed with which the chemical reaction takes place is known as the rate of the chemical reaction. This should be appreciable, to bring about the change.

1.2.2 Factors on which rate of a reaction depends

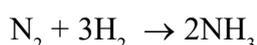
- Temperature :** Certain chemical reactions do not take place at room temperature but occur readily at a higher temperature. Accordingly, heat is required to start the reaction e.g. fuels like coal and wood only start burning when heated to a certain temperature called its ignition temperature.
- Presence of Light :** Some reactions take place only in light and do not take place in dark e.g. **photosynthesis** in green plants or reaction between H_2 and Cl_2 to form HCl .



- Presence of a Catalyst :** A catalyst is a substance that increases the rate of chemical reaction without itself undergoing change.
- Electricity :** Certain reactions take place with the help of an electric current. Example : Decomposition of acidulated water to give hydrogen and oxygen gas.



- Pressure :** Some chemical reactions need very high pressure to proceed. For e.g. in the commercial manufacture of ammonia from nitrogen and hydrogen by Haber's Process of over 2000 atmosphere is required, in presence of a catalyst iron and a temperature 450°C to 500°C .

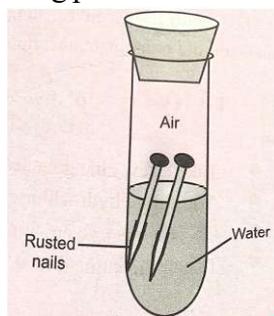


ACTIVITY 2

Aim : To demonstrate the phenomenon of rusting.

Method :

- Place a few iron nails in a test tube. Pour some water in it and place a rubber cork on its mouth.
- Leave the glass tube undisturbed for a few days.
- Observe the changes taking place.

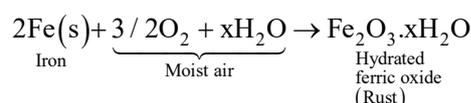


Rusting of iron nails

Observation

A brown deposit will appear on the surface of the iron nails. This is known as **rust**.

Chemical Reaction Involved :



Conclusion

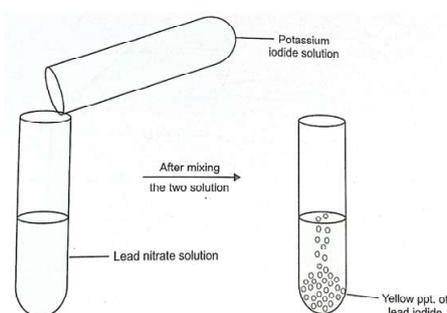
- The phenomenon of rusting occurs as a result of a chemical reaction in which iron combines with moist air (oxygen and moisture) to form hydrated ferric oxide ($\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$) known as rust.
- When lead nitrate and potassium iodide solution which both are colourless are mixed, a yellow precipitate of lead iodide is obtained.

ACTIVITY 3

Aim : To study the reaction between lead nitrate and potassium iodide solution.

Method :

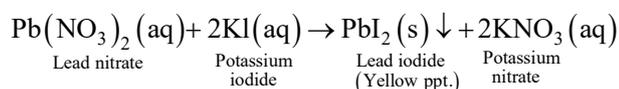
- Take lead nitrate solution in a test tube.
- Add potassium iodide solution to this.
- What do you observe ?



Mixing potassium iodide solution and lead nitrate solution to give a yellow ppt. of lead iodide.

Observation

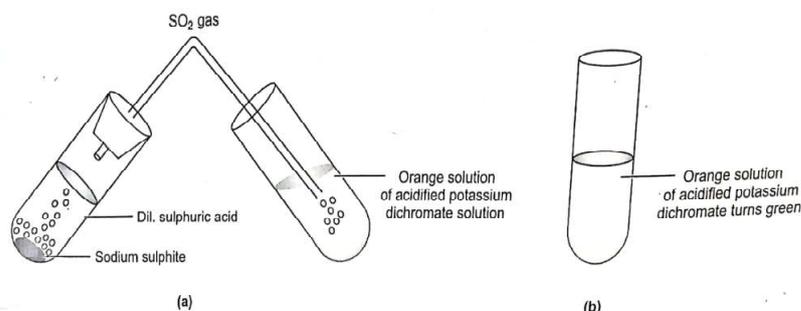
A yellow precipitate is formed.



Conclusion

Lead nitrate solution reacts with potassium iodide solution to form a **yellow precipitate of lead iodide**. The reaction between lead nitrate and potassium iodide is a double decomposition reaction. Since, PbI_2 is formed as an insoluble precipitate, therefore, this reaction is also called precipitation reaction.

When sulphur dioxide gas is passed through acidified potassium dichromate solution, the orange coloured solution turns green.



- (a) Sulphur dioxide gas through acidified potassium dichromate solution
 (b) The orange solution turns green

(iii) **Evolution of a gas** :Some chemical reactions are characterised by the evolution of a gas.
 e.g.(a) When zinc granules react with dilute sulphuric acid, bubbles of hydrogen gas are produced.

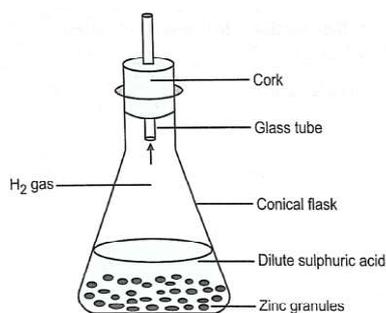
➤ **ACTIVITY 4**

Aim :

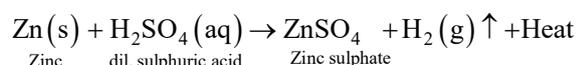
Aim : To study the reaction between zinc and dil. sulphuric acid or dil. hydrochloric acid.

Method :

- Take a few zinc granules in a conical flask.
- Add dilute hydrochloric or sulphuric acid to this (Figure. 1.3)
- Do you observe anything happening around the zinc granules ?
- Touch the conical flask. Is there any change in temperature ?

**Reaction between zinc and dilute sulphuric acid****Observation**

Bubbles of a gas are evolved with brisk effervescence. Upon touching the flask, it is found to be heated up. The gas evolved can be tested by lighted candle. It is found, to burn with a **'poppin'** sound.

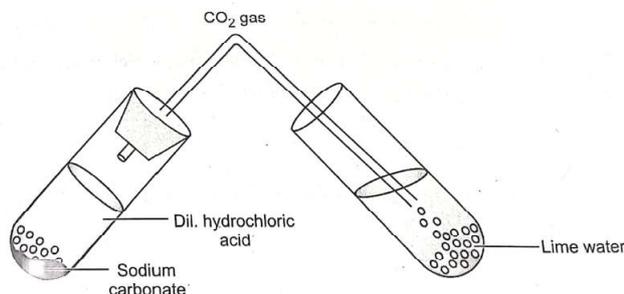
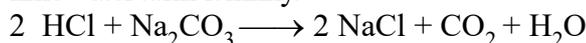
Chemical Reaction involved :**Conclusion**

Zinc reacts with dilute hydrochloric or sulphuric acid to evolve hydrogen gas and heat is evolved during the reaction, i.e., the reaction is exothermic.

CAUTION

Handle acid with care.

- When dilute hydrochloric acid is added to sodium carbonate, brisk effervescence takes place with the evolution of carbon dioxide gas. Carbon dioxide gas when passed through lime water turns it milky.

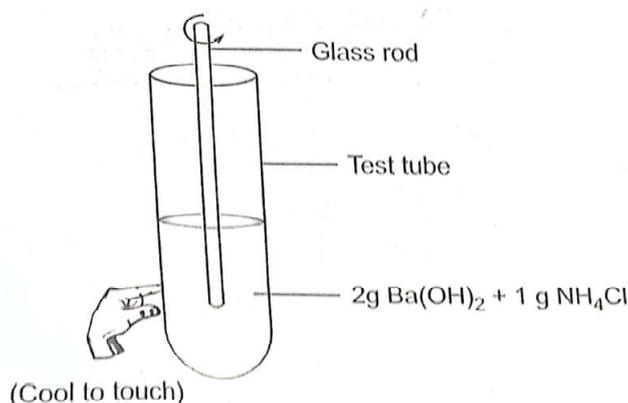
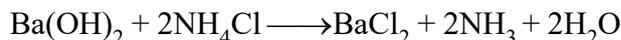


- (iv) **Change in energy** : All chemical reactions proceed either with the absorption or release of energy.

➤ **On the basis of energy changes, there are two types of reactions :**

- Endothermic reaction** : A chemical reaction which is accompanied by the absorption of energy is called an endothermic reaction.

- (i) When barium hydroxide [$\text{Ba}(\text{OH})_2$] is added to ammonium chloride (NH_4Cl) taken in a test tube and mixed, then the test tube is found to be cooler on touching. A lot of heat is absorbed during this reaction due to which the temperature of the reaction mixture falls and the test tube becomes very cold.

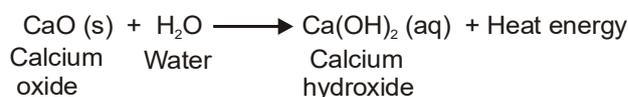


- (ii) Light energy is essential for biochemical reaction, photosynthesis, by which green plants prepare their food from carbon dioxide & water.



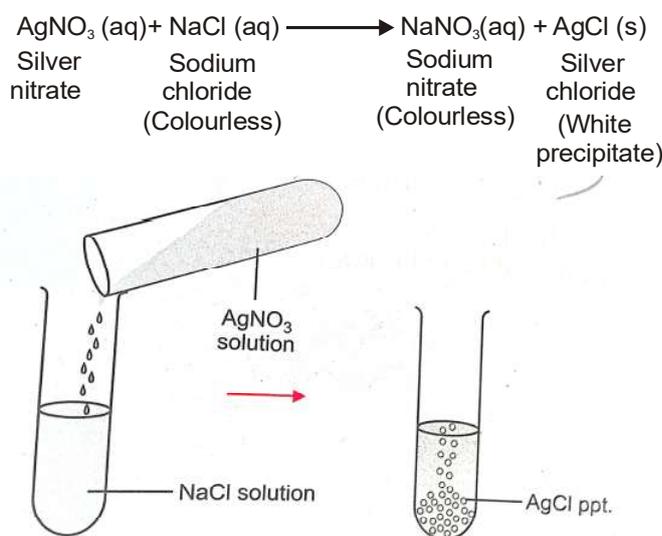
- Exothermic reaction** : A chemical reaction which is accompanied by the release of energy is called exothermic reaction.

- (i) When water is added to quick lime (CaO), then slaked lime [$\text{Ca}(\text{OH})_2$] is formed and a lot of energy is produced and the reaction mixture becomes hot.

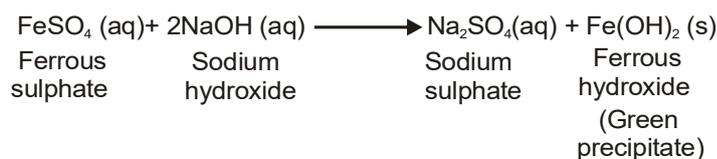


- (ii) When zinc granules react with dilute sulphuric acid in a beaker, it is found to be warm. (See an activity)

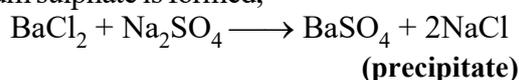
- (v) **Formation of precipitate** : Some chemical reactions are characterised by the formation of precipitate (an insoluble substance), when the solutions of two soluble chemical compounds are mixed together.
- When silver nitrate solution is added to sodium chloride solution, a white precipitate of silver chloride is formed.



- A dirty green precipitate of ferrous hydroxide is formed, when a solution of ferrous sulphate is mixed with sodium hydroxide solution.



- When barium chloride solution is added to sodium sulphate solution, a curdy white precipitate of barium sulphate is formed,



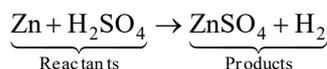
4. CHEMICAL EQUATION :

➤ Chemical Equations

The method of representing a chemical reaction with the help of symbols and formulae of the substances involved in it is known as a chemical equation.

There are two ways of representing a chemical reaction :

- In the terms of words (called word equation)** : Zinc metals react with dilute sulphuric acid to form zinc sulphate and hydrogen gas. This reaction can be in words as
Zinc + Dil. Sulphuric acid → Zinc sulphate + hydrogen
- In terms of symbols and formulae (called symbol equation)** : By putting the symbols and formulae of all the substance in the above word equation, we get the following chemical equation.



This is called a chemical equations.

➤ Writing of a Chemical Equation

- To represent a chemical equation we write :
 - The symbols and formulae of the reactants towards the left hand side (LHS) with plus sign between them.
 - The symbols and formulae of the products towards the right hand side (RHS) with plus sign between them.
 - An arrow (→) sign is put between the reactants and the products, pointing from reactants towards products.



Let's know

The arrow (\longrightarrow) is read as “to yield” or “to form”

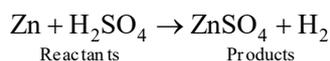
5. UNBALANCED AND BALANCED CHEMICAL EQUATIONS

A balanced chemical equation has equal number of atoms different elements in the reactants and products.

For example,

Zinc + Sulphuric acid \rightarrow Zinc sulphate + Hydrogen

The above word equation may be represented by the following chemical equation



Let us examine the number of atoms of different elements on both sides of the arrow.

Element	Number of atoms in reactants(LHS)	Number of Atoms in products (RHS)
Zn	1	1
H	2	2
S	1	1
O	4	4

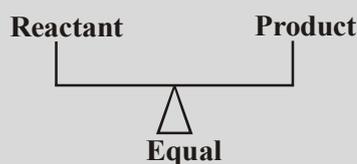
As the number of atoms of each element is the same on both sides of the arrow, the above equation is a balanced chemical equation.

An unbalanced or skeletal equation is one which the number of atoms of different elements (one or more) is not equal on the two sides of the equation.



Let's know

- The balancing of a chemical equation is essential or necessary to fulfil the requirement of the law of Conservation of Mass. The law may be stated as :
The total mass of all the products of reaction in a chemical reaction is equal to the total mass of all the reactants.
- Keep in mind that the key feature of balanced chemical equation is the conservation law.



5.1 Steps Involved in the Balancing of a Chemical Equation :

The balancing of a chemical equation involves in counting up the number of atoms of each element on both sides and trying to equalize them.

The following steps are involved in the balancing of a chemical equations :

Step-I : To write the word equations : Write the chemical equations in the forms of a word equations. Keep the reactants on left hand side (LHS) and the product on the right hand side (RHS). Separated them by and arrow (\rightarrow) head of which points from the reactants towards the products.

Step-II : To write the skeletal chemical equation : Which down the symbols and formulae of the various reactants and products. This gives us the skeletal chemical equation.

Step-III : Enclose the formulae of each reactant and product in a box. Do not change anything inside the boxes while balancing equation.

Step-IV : List the number of atoms or different elements on LHS (Reactants) and RHS (Products) in the unbalanced equation.

Step-V : Select the biggest formula to start balancing : It is often convenient to start balancing with the compound that contains the maximum number of atoms. It may be a reactant or a product.

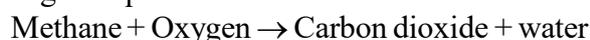
Step-VI : To start balancing different elements : Having selected the compounds with the biggest formula, first balance the element of this compound. Then balance other elements one by one. To balance the atoms of an element put a whole number coefficient before the formula of the compound. If the selection of the biggest formula appears inconvenient, balance the atoms of that element which occurs at minimum number of places on both sides of the equation. Atoms of the element which occur at maximum places are balanced last of all.

Step-VII : To check the correctness of the balance equation : Finally, to check the correctness of the balanced equation, count atoms of each element on both sides of the equation. If the number of atoms of elements on both sides of the equation are equal then the equation is balanced.

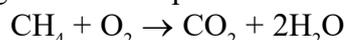
The method of balancing chemical equation is called Hit and Trial Method as we make trial to balance the equation by using the smallest whole number coefficient.

Eg. 1 Combustion of methane in oxygen to form carbon dioxide and water :

Sol. Step-I : Writing the equation in word form :



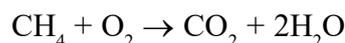
Step-II : Writing the skeletal equation :



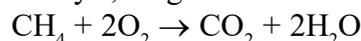
Step-III : Selecting the element which occurs at minimum number of places, i.e. C or H.

No. of C-atoms is same on LHS & RHS.

No. of H-atoms is 4 on LHS and 2 H-atoms on RHS. To balance H-atoms, multiply H_2O on RHS by 2, we get



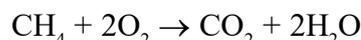
Step-IV : To balance O-atoms : There are 4 O-atoms on RHS and 2 O-atoms on LHS. To balance O-atoms, multiply O_2 on LHS by 2, we get



Step-V : To check the corrections of the balanced equation :

Element	Number of atoms on(LHS)	Number of Atoms on (RHS)
C	1	1
H	4	4
O	4	4
O	4	4

Since, the number of atoms of each element on both sides of the equation is same, the equation is balanced. Hence, the balanced equation is :

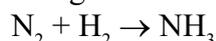


Eg.2 Nitrogen and hydrogen combine to form ammonia

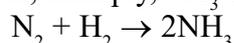
Sol. Step-I : Writing the chemical equation in word form :



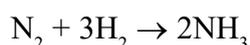
Step-II : Writing the skeletal chemical equation



Step-III : Balancing of atoms on both sides : There are 2 N-atoms on LHS and 1 N-atom on RHS. To balance N-atom, multiply, NH_3 on RHS by 2 we get



Now there are 6 H-atom on RHS and 2 H-atoms on LHS. To balance H-atoms, multiply H_2 on LHS by 3, we get

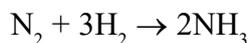


Step-IV : To check the correctness of the balance equations :

Element	Number of atoms on LHS	Number of Atoms on RHS
N	2	2
H	6	6

Since, the number of atoms of each element is equal on both sides of the equation, it is balanced

Hence, the balanced equation is :

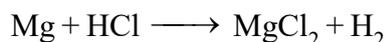


Eg.3 Magnesium metal reacts with hydrochloric acid to form magnesium chloride and hydrogen.

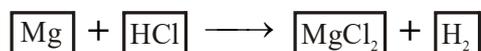
Sol. Step-1 : Word equation.

Magnesium + Hydrochloric acid \rightarrow Magnesium chloride + Hydrogen

Step-II : Chemical equation,



Step-III : Enclose all formulae into boxes.



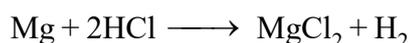
Step-IV : Count the number of atoms for all elements.

Element	Number of atoms in reaction (L.H.S.)	Number of atoms in products (R.H.S)
Mg	1	1
Cl	1	2
H	1	2

We can see that number of Mg is same on both side but Cl and H atoms differs on both sides.

Step - V : As the number of atoms is deficient at reactant side, let's begin from here. At reactant side HCl is the bigger formula, so we will start with it.

Step-VI : Put coefficient 2 before HCl to make chlorine equal to reactant side



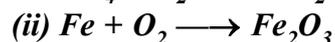
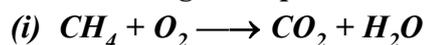
Here, we can see that H automatically gets balanced.

Step-VII : Now check the number of atoms of different elements on both sides of the equation. These are equal.

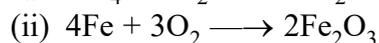
This means that the equation is balanced.

EXAMPLES

Example: 1 : Balance the given equation



Solution : (i) $\text{CH}_4 + 2\text{O}_2 \longrightarrow \text{CO}_2 + 2\text{H}_2\text{O}$



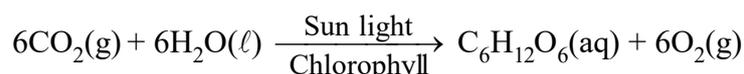
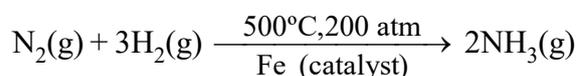
Example: 2 : Why it is necessary to balance a chemical equation ?

Solution : In order to make law of conservation of mass, applicable on the given chemical equation, it is necessary to make number of atoms of all elements equal on L.H.S. & R.H.S. Thus balancing is required.

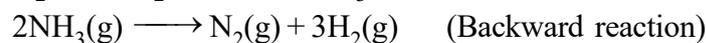
► **Making a chemical equation more informative :**

We have studied that a chemical equation is the true representation of a chemical reaction. It is always better to make the equation is informative as possible to get a better picture of the chemical reaction. The various steps in this direction are :

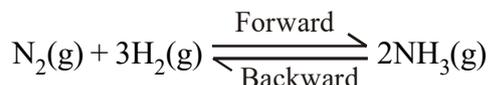
- (a) Write the state symbols for the reactions and products participating in the reaction.
 ⇒ (s) for solid state
 ⇒ (l) for liquid state
 ⇒ (g) for gaseous state
 ⇒ (aq) for aqueous solution i.e. solution prepared in water.
- (b) Indicate the gas evolved in the reaction by an arrow pointing upwards (↑)
- (c) Represent the precipitate if formed in the reaction by an arrow pointing downwards (↓) or by using the abbreviation 'ppt'.
- (d) Mention the actual heat evolved in the exothermic reaction by plus (+) sign and heat absorbed in the endothermic reaction by negative (-) sign on the product side.
 $C(s) + O_2(g) \longrightarrow CO_2(g) + 393.5 \text{ kJ}$ (Exothermic reaction)
 $C(s) + 2H_2(g) \longrightarrow CH_4(g) + 74.8 \text{ kJ}$ (Exothermic reaction)
 $N_2(g) + O_2(g) \longrightarrow 2NO(g) - 180.0 \text{ kJ}$ (Endothermic reaction)
- (e) In some chemical reactions conditions of temperature, pressure, catalyst etc. are mentioned either above or below the arrow head that separates the reactants from products. For example,



- (f) Certain chemical reactions can proceed in both the directions. The reactants change into products in forward reaction. The products are converted into reactants in the backward reaction. For example :



Such reaction are also called reversible reactions and are indicated by the symbol (\rightleftharpoons).



TRY YOURSELF

Q.1 Write a balanced chemical equation for the following reactions :

- Sodium metal reacts with water to give sodium hydroxide and hydrogen gas.
- Magnesium burns in air to form magnesium oxide.
- Hydrogen sulphide gas burns in air to give water and sulphur dioxide.
- Barium chloride solution reacts with sodium sulphate to give a white ppt. of barium sulphate and sodium chloride solution.
- An aqueous calcium hydroxide solution (lime water) reacts with carbon dioxide to produce a solid calcium carbonate precipitate and water.

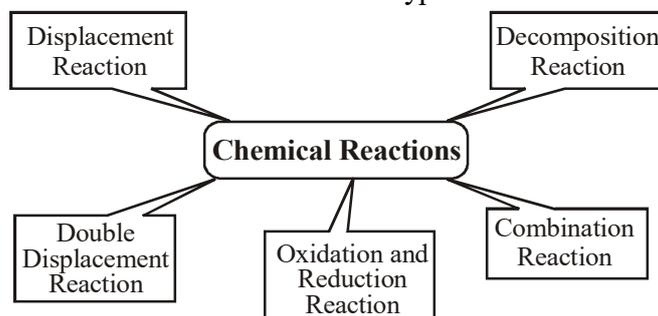
Q.2 Balance the following equation :

- $Mg(OH)_2 + HCl \longrightarrow MgCl_2 + H_2O$
- $Al(OH)_3 \xrightarrow{\text{Heat}} Al_2O_3 + H_2O$
- $NH_3 + CuO \xrightarrow{\text{Heat}} Cu + N_2 + H_2O$
- $Al_2(SO_4)_3 + NaOH \longrightarrow Al(OH)_3 + Na_2SO_4$
- $BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 + HCl$

6. DIFFERENT TYPES OF CHEMICAL REACTIONS

During a chemical reaction atoms of one element do not change into those of another element. No of atoms disappear from the mixture or appear elsewhere. Actually, chemical reactions involve the breaking and making of bonds between atoms to produce new substances.

Accordingly the reactions are classified in different types.



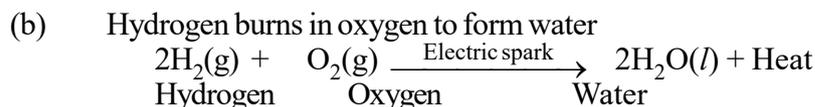
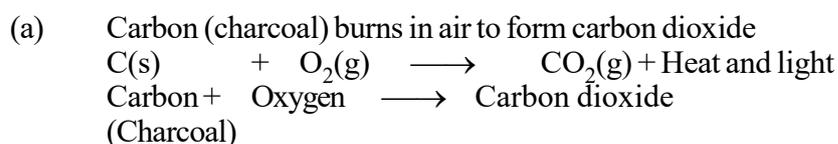
6.1 Combination Reaction or Synthesis reaction :

- The chemical reaction involving combination of two or more reactants (elements or compounds) to form a single new product is called combination reaction.
- A reaction made to obtain a product by using two or more elements is usually referred as synthesis of that compound. Thus combination reaction is also known as synthesis reaction.
- Combination reaction like other reactions also involves the exchange of energy i.e., heat light electricity pressure or catalyst e.g.

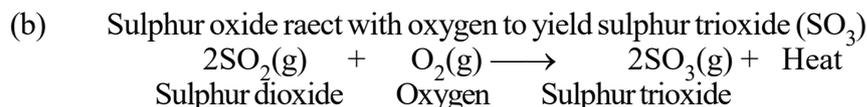
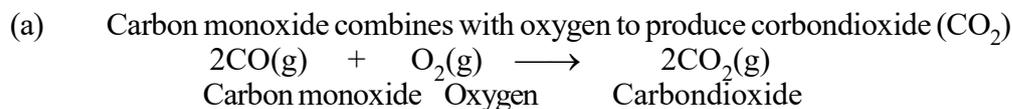


Where, A and B are reactants while AB is the product.

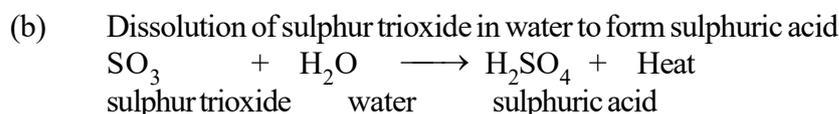
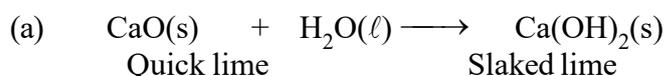
- (i) **Combination reactions involving two elements** : Some examples of combination reactions involving two elements are :



- (ii) **Combination reactions involving an element and a compound** : Some examples of combination reactions involving an element and a compound are :



- (iii) **Combination reactions involving two compounds** : Some examples of such reactions are :



ACTIVITY 5

Aim : To study combination reaction between calcium oxide, i.e., quick lime and water.

Method :

- (i) Take a small amount of calcium oxide or quick lime in a beaker.
- (ii) Slowly add water to his
- (iii) Touch the beaker.

Now answer

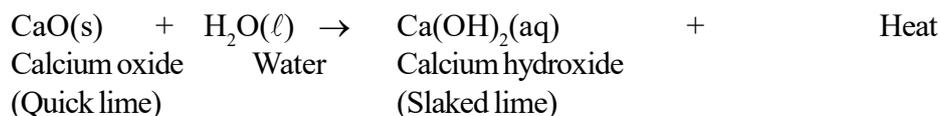
Do you feel any change in temperature ?

Discussion

A vigorous reaction is found to occur and the beaker is found to become very hot.

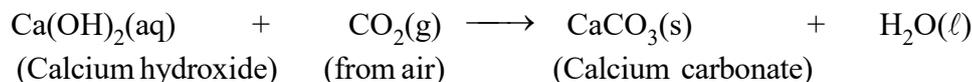
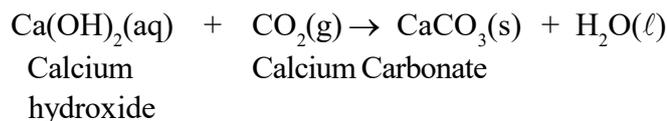
Conclusion

Calcium oxide combines with water to form calcium hydroxide (slaked lime) and this reaction is highly exothermic.



Slaked lime for white wash

A solution of slaked lime produced by the reaction above is used for while washing walls. Calcium hydroxide reacts slowly with the carbon dioxide in the air to form a thin layer of calcium carbonate on the walls. Calcium carbonate is fomed after two to three days of white washing and gives a shiny finish to the walls.



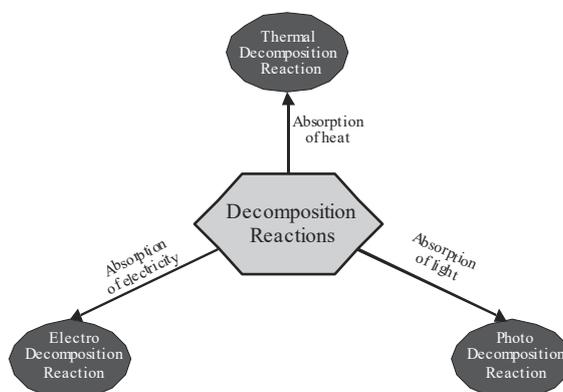
6.2 Decomposition Reactions :

- The chemical reaction in which a compound is broken up into two or more simpler substances (elements or compounds) is called a decomposition reaction.



A single reactant AB decomposes to give simpler product like C, D etc.

- Decomposition reaction involves absorption of energy e.g. heat, light or electricity. Heat, light and electricity are form of energy and causes breaking of bonds in the molecules of reactants to yield simpler products.



- (a) **Thermal Decomposition Reactions:** Chemical reactions in which the decomposition is achieved by supplying heat energy are called thermal decomposition reactions.

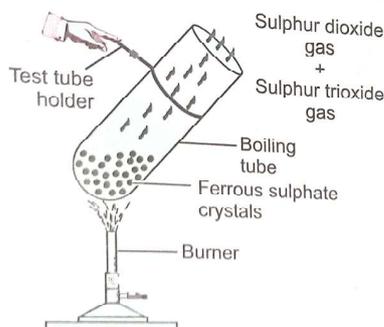
- (i) Decomposition of ferrous sulphate.

ACTIVITY 6

Aim : To study the decomposition of ferrous sulphate on heating.

Method :

- Take about 2 g ferrous sulphate crystals in a dry boiling tube.
- Note the colour of the ferrous sulphate crystals.
- Heat the boiling tube over the flame of a burner or spirit lamp as shown in Fig. 1.13.
- Observe the colour of the crystals after heating.

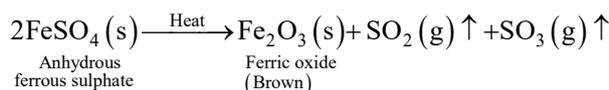
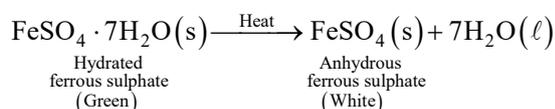


While performing the experiment keep the mouth of the test tube away from yourself.

Conclusion

Hydrated ferrous sulphate crystals ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) which is **green** in colour lose their water of crystallisation when heated and form anhydrous ferrous sulphate (FeSO_4) which is white in colour. On strong heating anhydrous ferrous sulphate decomposes to give ferric oxide (Fe_2O_3), sulphur dioxide (SO_2) and sulphur trioxide (SO_3). Ferric oxide (Fe_2O_3) is a **brown solid** while the gases SO_2 and SO_3 have the smell of burning sulphur.

Chemical Reactions Involved :



Observation

The reddish brown residue is, of ferric oxide along with the evolution of sulphur dioxide and sulphur trioxide gases, This is an example of a decomposition reaction.

6.3 Types of Decomposition Reactions

(i) Thermal Decomposition Reaction

When decomposition is carried out by heating it is called **thermal decomposition**.

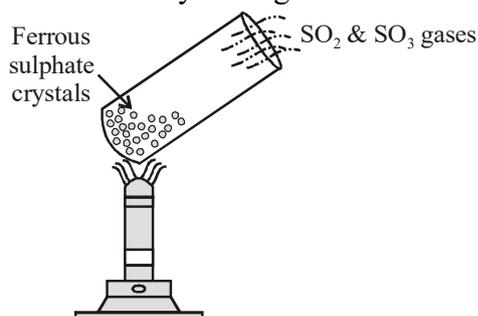


Figure : Decomposition of Ferrous sulphate crystals

(ii) Decomposition of lead nitrate

▶ ACTIVITY 7

Aim : To study the thermal decomposition of lead nitrate.

Method :

- Take 2 g of lead nitrate powder in a boiling tube.
- Heat the boiling tube over a burner as shown in fig. 1.14.

Conclusion

- (i) The lead nitrate powder which is white in colour gives a yellow residue of lead monoxide or litharge (PbO).
- (ii) Brown fumes of nitrogen dioxide (NO₂) are evolved and also a colourless gas is evolved which rekindles a glowing splint. This gas is oxygen (O₂).

Observation

In the above reaction lead nitrate is breaking down into three compounds lead monoxide, nitrogen dioxide and oxygen, so it a decomposition reaction. Since, the decomposition of lead nitrate is brought by heat, therefore, it is an exmple of thermal decomposition.

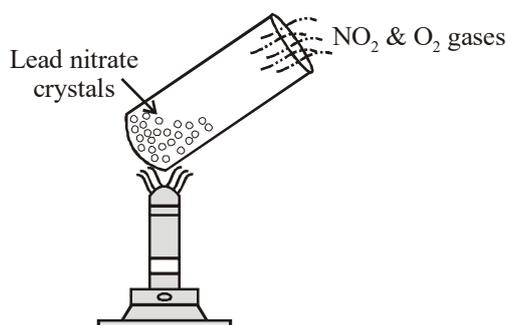
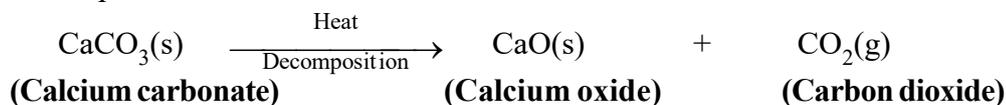


Figure : Decomposition of Lead nitrate crystals

(iii) Decomposition of calcium carbonate



When calcium carbonate is heated it breaks up into calcium oxide (quick lime) and carbon dioxide, so it is an example of thermal decomposition reaction. The calcium oxide (quick lime) obtained by the decomposition of calcium carbonate has many uses in industry. It is used in the manufacture of cement.

(B) Electrolytic Decomposition Reactions : Decomposition reactions which take place when electric current is passed through the compound in molten state or in aqueous solution are called electrolytic decomposition reactions or simply electrolysis.

- In electrolysis, electro refer to electricity and lysis refers to break down.

e.g. (i) Electrolytic decomposition of water →

▶ ACTIVITY 8

Aim : To study electrolytic decomposition, i.e., electrolysis of water.

Method :

Water

- (i) Take a plastic mug. Drill two holes at its base and fit rubber stoppers in these holes. Insert carbon electrodes in these rubber stoppers.
- (ii) Connect these electrodes to a 6 volt battery.
- (iii) Fill the mug with water such that the electrodes are immersed. Add a few drops of dilute sulphuric acid to the water.
- (iv) Take two test tubes filled with water and invert them over the two carbon electrodes.
- (v) Switch on the current and leave the apparatus undisturbed for some time.
- (vi) It will be observed that formation of bubbles take place at both the electrodes. These bubbles displace water in the test tubes.

- (vii) Once the test tubes are partially filled with the respective gases, remove them carefully.
 (viii) Test these gases one by one by bringing burning candle close to the mouth of the test tubes.

Now answer

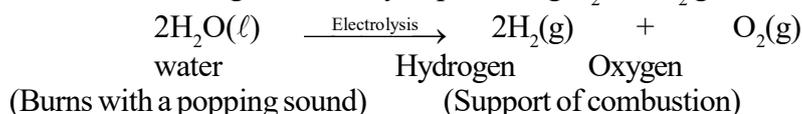
- (i) Is the volume of the gas collected the same in both the test tubes ?
 (ii) What happens in each test tube on bringing the burning candle ?
 (iii) Which gas is present in each test tube ?

Discussion

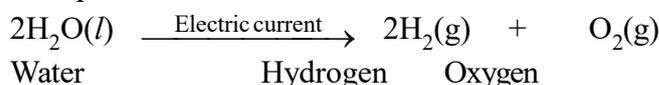
It is observed that the volume of gas collected over the cathode is double than that collected over the anode. The gas with double volume burns with a popping sound whereas the other gas supports burning (combustion). Thus, the gas with double the volume is hydrogen whereas the gas in the other tube is oxygen.

Conclusion

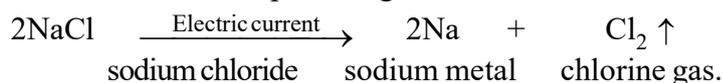
Acidified water undergoes electrolysis producing H_2 and O_2 gases in the ratio of 2 : 1 by volume



Some more examples of combination reactions



e.g. (ii) Electrolytic decomposition of molten sodium chloride : On passing electric current through molten sodium chloride, it decomposes to give sodium metal and chlorine gas.



(c) Photo - decomposition reactions or photolysis : Decomposition reactions which takes place on absorption of light. These reactions are called Photo - decomposition reactions or photolysis.

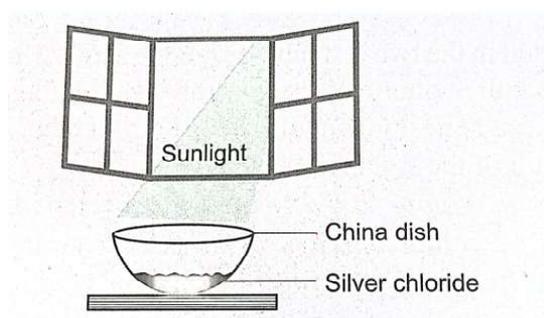
e.g. (i) Photo - decomposition of silver chloride.

➤ **ACTIVITY 9**

Aim : To study photo-decomposition of silver chloride.

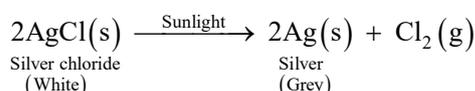
Method :

- Take about 2 g of silver chloride in a china dish.
- Note its colour.
- Place this china dish in sunlight for sometime (see Fig. 1.18).
- Observe the colour of the silver chloride after sometime.

**Observation**

It is observed that white crystals of silver chloride turn grey in the sunlight.

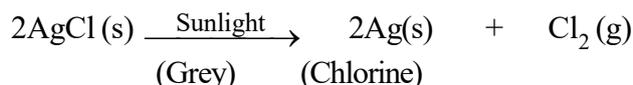
Chemical Reaction Involved :



Conclusion

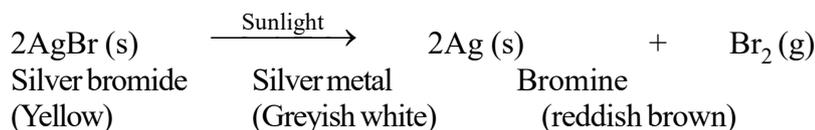
Silver chloride is photosensitive and decomposes into grey and chlorine in the presence of light.

This is an example of a photochemical reaction.



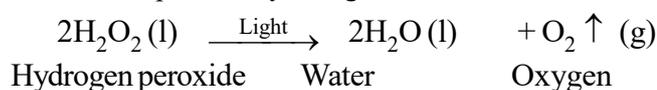
e.g.

- (ii) **Decomposition of silver bromide in the presence of light :** Silver bromide behaves in the same way as silver chloride with light energy. Thus when silver bromide is exposed to light, it decomposes to form silver metal and bromine vapours.



e.g.

- (iii) **Photolytic decomposition of hydrogen peroxide :** hydrogen peroxide decomposes in the presence of sunlight into water and oxygen. Therefore, it is stored in dark coloured bottles to avoid decomposition by sunlight.



- Hence, we have seen that the decomposition reactions require energy either in the form of heat, light or electricity for breaking down the reactants. So, Decomposition reactions are endothermic reactions.

**Let's know**

- Silver halides are generally kept in dark coloured bottles.
- Silver halides are photosensitive and are decomposed by sunlight. This reaction of decomposition of silver bromide is used in black and white photography.
- During photosynthesis, liberation of O₂ takes place because of photolysis of water.

➤ **Uses of Decomposition Reactions :**

- (i) **Extraction of metals :** Metals like sodium, potassium, aluminium, calcium, magnesium, etc. can be extracted by the electrolytic decomposition of their molten salts. When fused (molten) metal chloride or oxide is decomposed by passing electricity, the metal is produced at the cathode (negative electrode).
- (ii) **Isolation of some non-metals :** Some non-metals like hydrogen, oxygen and chlorine etc. can be obtained on large scale by the electrolytic decomposition of their respective compounds. For example, hydrogen and oxygen can be obtained by the electrolysis of acidulated water.
- (iii) **Digestion of food in our body :** The digestion of food in our body is accompanied by a number of decomposition reactions. The carbohydrates, fats, proteins, etc., are the main constituents of our food. In the presence of enzymes carbohydrates, fats and proteins break down into simpler substances. For e.g., starch decomposes into glucose, proteins into amino acid and fats into fatty acids and glycerol.

6.5 Simple displacements reactions :

These reactions in which one element takes the position or place of another element in a compound. These reactions are generally found to occur in the solution. The elements involved may be metals or non-metals. i.e., a more active metal displaces a less active metal or more active non-metal may displace a less active non-metal from its compound.



Where, an element C displaces another element B from the compound AB.

➤ **Chemical Reaction Involved :**

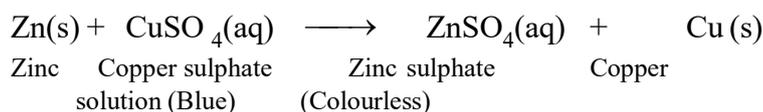
Observation

Since, iron is more reactive than copper, therefore, it displaces copper from copper sulphate solution. The blue colour of copper sulphate solution fades due to the formation of pale green solution of iron sulphate. The copper displaced from copper sulphate by iron gets coated as a reddish brown coating on the iron nail.

The displacement reaction occurs because iron is more reactive than copper.

e.g.

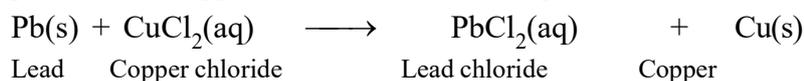
(ii) **Displacement of copper by zinc :** If we dip a strip of zinc metal in copper sulphate solution, zinc displaces copper from copper sulphate forming zinc sulphate and copper metal



As zinc sulphate solution is colourless, therefore, the blue colour of copper sulphate solution goes on fading with the passage of time. At the same time, a reddish brown deposit of copper metal is formed on the zinc strip.

e.g.

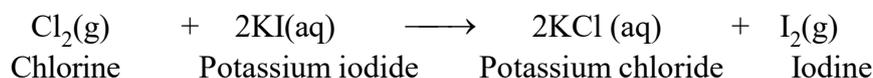
(iii) Displacement of copper from its salt solution is given below :



(b) **Displacement reactions in which a more active non-metal displaces a less active non-metal from its compound :**

e.g.

(i) When chlorine gas is passed through potassium iodide solution, chlorine being more reactive than iodine, displaces iodine from KI solution. The iodine liberated during the reaction dissolves in the solution giving it violet colour.



6.6 Double Displacement Reactions :

➤ **Double Displacement Reactions are also known as METATHESIS REACTIONS.**

The chemical reactions involving two compounds reacting together and forming two new compounds by exchanging one of their ions is called a **double displacement reaction**.



➤ **The double decomposition reactions can be further classified in two types :**

(A) **Precipitation reactions** (B) **Neutralisation reactions**

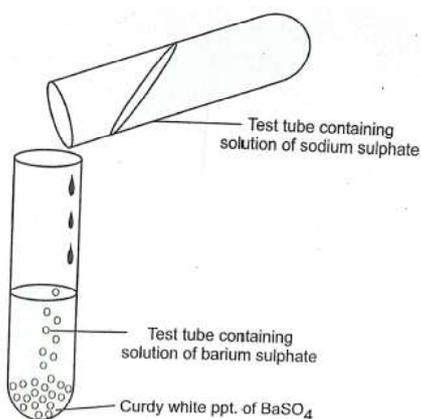
(A) **Precipitation reaction :** Those reactions in which two clear and transparent solutions on mixing result in the formation of an insoluble product are known as precipitation reactions and the insoluble product is known as precipitate.

➤ **ACTIVITY 11**

Aim : To study double decomposition reaction between barium chloride solution and sodium sulphate solution.

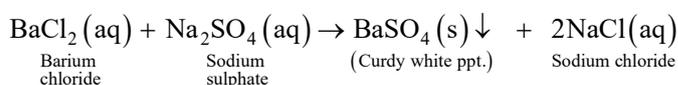
Method :

- Take about 3 mL of sodium sulphate solution (colourless) in a test tube.
- Take about 3 mL of barium chloride solution (colourless) in another test tube.
- Now add barium chloride to sodium sulphate solution.

**Observation**

A curdy white precipitate is formed

Chemical Reaction Involved : Barium chloride reacts with sodium sulphate solution to form a curdy white precipitate of barium sulphate.

**Conclusion**

The reaction between barium chloride and sodium sulphate is a double decomposition reaction.

Since, barium sulphate is insoluble it separates out as a precipitate, therefore, this reaction is also called precipitation reaction.

➤ **ACTIVITY 12**

Aim : To study double decomposition reaction between lead nitrate solution and potassium iodide solution

Method :

- Take 3 mL of lead nitrate solution in a beaker.
- Take 3 mL of potassium iodide in another beaker.

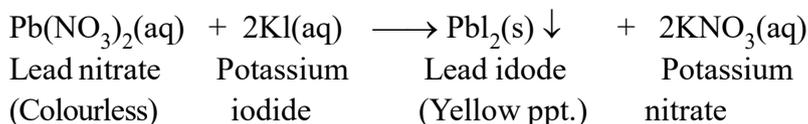
Add potassium iodide solution to lead nitrate solution.

Observe the changes taking place.

Observation

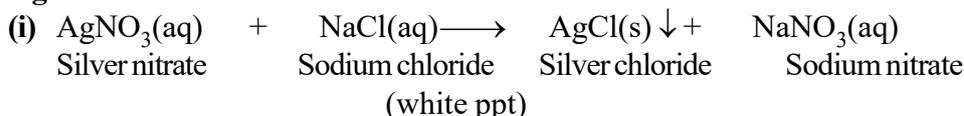
A yellow precipitate is formed.

Chemical reaction Involved : Potassium iodide reacts with lead nitrate to form a yellow precipitate of lead iodide.

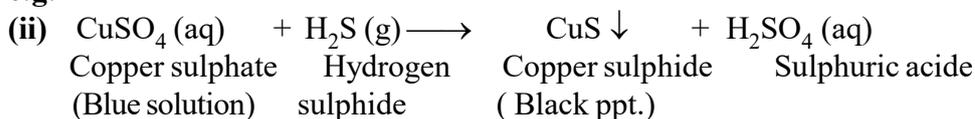


Some more examples of double displacement reaction -

e.g.



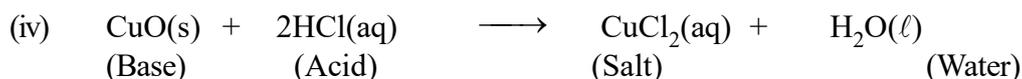
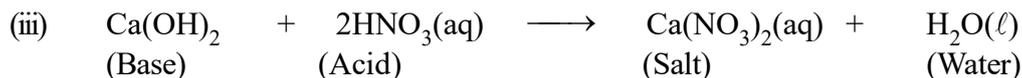
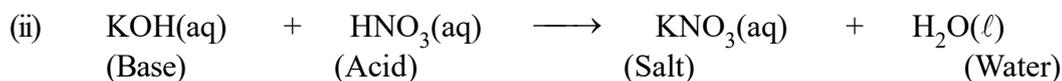
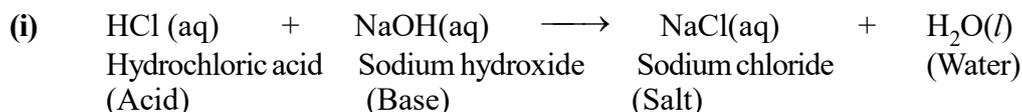
e.g.



(B) Neutralisation Reactions :

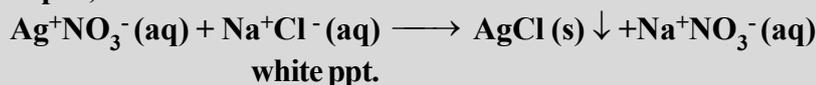
When acids and bases mix, they exchange their radicals and form compounds called salt and water. Since, the products formed as a result of the reaction between acids and bases are neutral to litmus, the reaction is called neutralisation.

e.g.

**Let's know**

- **Double decomposition reactions are generally ionic reactions taking place in aqueous solution. There is an exchange of ion in solution and this results in the formation of products. These ionic reactions are fast and do not require any specific conditions.**

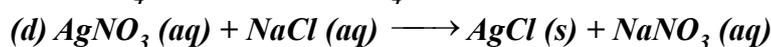
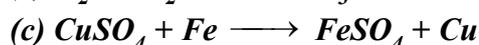
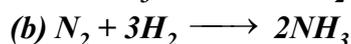
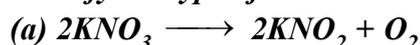
For example,



- **The most important use of neutralization reaction is in the form of antacids. The substances which remove excess acid in our stomach are called antacids. Antacids are simple bases that neutralize digestive acids. Their ability to neutralize acids is due to the hydroxide, carbonate or bicarbonate they contain.**

EXAMPLES

Example 3 : Identify the type of chemical reaction



Solution : (a) Decomposition (b) Combination
(c) Displacement (d) Double displacement reaction

6.7 Oxidation and reduction reactions :

- The classical concept of oxidation and reduction is based on the addition or removal of oxygen or hydrogen.
- Oxidation may be defined as a chemical reaction which involves the addition of oxygen to a substance or the removal of hydrogen from a substance.
- Reduction may be defined as a chemical reaction which involves the addition of hydrogen to a substance or the removal of oxygen from a substance.
- The process of **reduction** is just the opposite of oxidation. Moreover, oxidation and reduction occur together.
- An overall reaction which involves both oxidation and reduction simultaneously is called an oxidation-reduction or redox reaction (In the name 'redox', the term 'red' stands for reduction and 'ox' stands for oxidation.)

➤ **Oxidising and Reducing agents in terms of loss/gain of oxygen/hydrogen :**

- **Oxidising agent :** The substance which gives oxygen or (ii) gains hydrogen is called an oxidising agent.
- **Reducing agent :** The substance which gives hydrogen or (ii) gains oxygen is called a reducing agent.

➤ **ACTIVITY 13**

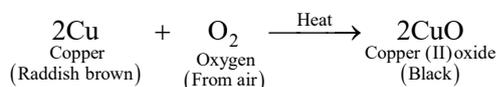
Aim : To study oxidation of copper to copper oxide and reduction of copper oxide to copper.

Method :

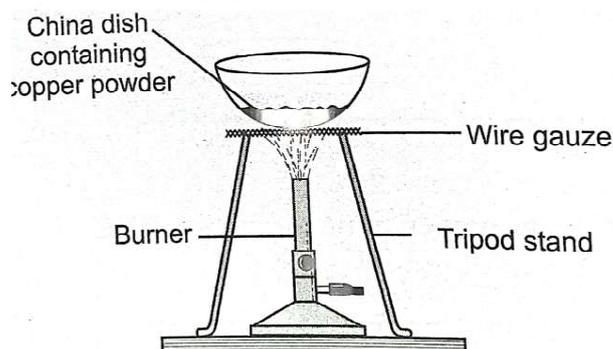
- Heat about 1 g of copper powder in a china dish. The surface of copper powder becomes covered with black copper (II) oxide.
- If hydrogen gas is passed over this heated material (CuO), the black coating on the surface turns brown.

In the first reaction :

- (i) Copper has been oxidised to copper(II) oxide. Since oxygen is being added, it is an oxidation reaction. This is because oxygen is added to copper oxide is obtained :

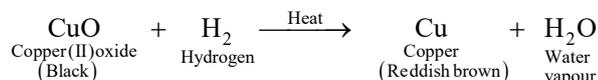


- (ii) Oxygen is the oxidising agent in this reaction.



In the second reaction :

- (i) Copper (II) oxide has lost oxygen to form copper whereas hydrogen has gained oxygen to form water. Thus, we can say that copper oxide is being reduced to copper and hydrogen is being oxidised to water.



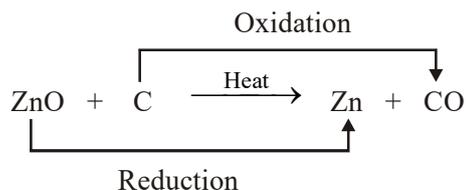
- (ii) Hydrogen is the reducing agent in this reaction.

Conclusion

- (i) We see that hydrogen is being oxidised to water and at the same time copper oxide is being reduced to copper. This means that oxidation and reduction always go side by side i.e., they occur simultaneously. Thus, For the above reaction, we have
- (ii) In the above reaction copper (II) oxide is giving the oxygen required for the oxidation of hydrogen, therefore, copper (II) oxide is the oxidising agent. Hydrogen is responsible for removing oxygen from Thus, in the above reaction.

- (i) Substance oxidised : H₂
- (ii) Substance reduced : CuO
- (iii) Oxidising agent : CuO
- (iv) Reducing agent : H₂

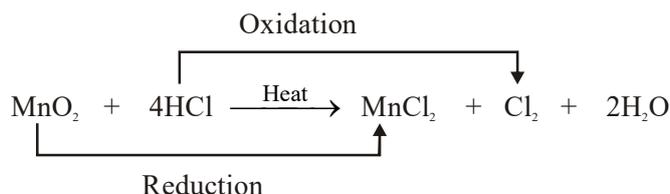
Example : 1 When zinc oxide is heated with carbon, then zinc metal and carbon monoxide is formed:



In this reaction,

- (i) zinc oxide (ZnO) is losing oxygen, so it is being reduced to zinc (Zn).
- (ii) On the other hand, carbon (C) is gaining oxygen, so it is being oxidised to carbon monoxide (CO).
- (iii) Substance oxidised : C
 Substance reduced : ZnO
 Oxidising agent : ZnO
 Reducing agent : C

Example : 2 When manganese dioxide is heated with concentrated hydrochloric acid, then manganese chloride, chlorine and water are formed :



- (i) In this reaction, MnO_2 is losing oxygen to form MnCl_2 so manganese dioxide (MnO_2) is being reduced to manganese chloride (MnCl_2).
- (ii) On the other hand, HCl is losing hydrogen to form Cl_2 , so hydrochloric acid (HCl) is being oxidised to chlorine (Cl_2).
- (iii) Substance oxidised : HCl
 Substance reduced : MnO_2
 Oxidising agent : MnO_2
 Reducing agent : HCl

Example 3 : When a magnesium ribbon is burnt in air (oxygen) it burns with a dazzling flame and forms white substance, magnesium oxide :



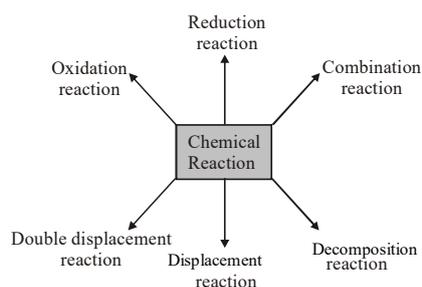
- (i) In this reaction, magnesium (Mg) is oxidised to magnesium oxide (MgO)
- (ii) Oxygen (O_2) is reduced to magnesium oxide (MgO)
- (iii) Oxidising agent : O_2
 Reducing agent : Mg



Let's know

- Oxidation and reduction together are written as 'OILRIG' which means
OIL-Oxidation Is Loss
RIG - Reduction Is Gain (of electrons)

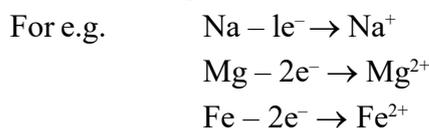
Memory map



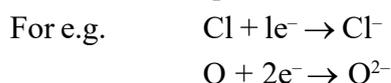
7. MODERN CONCEPT OF OXIDATION AND REDUCTION

According to the modern concept, oxidation and reduction are explained in terms of loss and gain of electrons. This is also called the electronics of oxidation and reduction. According to this concept:

Oxidation is a process in which an atoms or ion loses one or more electrons.



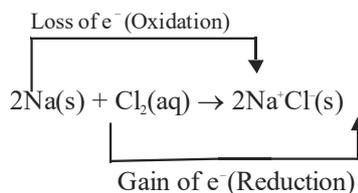
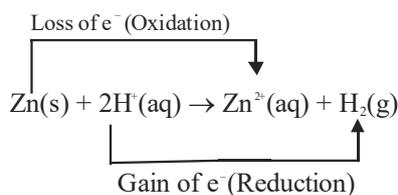
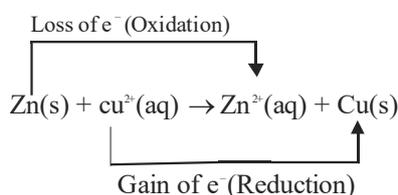
Reduction is the process in which an atom or ion grains one or more electrons.



Electron losing species is called reducing agent.

Electron accepting species is called oxidising agent.

For example,



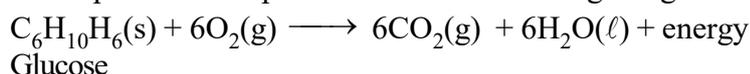
8. EFFECTS OF OXIDATION REACTIONS IN EVERYDAY LIFE

Redox changes are important reactions which influence our day- to - day life in several ways. Some of its examples such as burning of fuels, digestion of food etc. are boon to mankind and are very helpful in sustaining life. On the other hand, Some of its effect are quite damaging also e.g. burning of causing air pollution, rancidification of food, corroion of metals etc.

➤ **Useful effects of oxidation :**

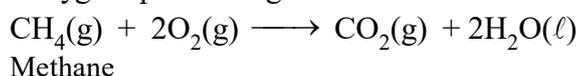
8.1 Respiration :

Respiration is the most important biochemical reaction which releases energy in the cells. When we breathe in air, oxygen enters our lungs and passes into thousands of small air sacs (alveoli). These air sacs occupy a large area of membranes and oxygen diffuses from the membranes into blood. It binds itself to haemoglobin present in red blood cells and is carried to millions of cells in the body. Respiration occurs in these cells and is accompanied by the combustion of glucose producing carbon dioxide and water. Since the reaction is of exothermic nature, the energy released during respiration carries many cell reactions and keeps our heart and muscles working. It also provides the desired warmth to the body. Both carbon dioxide and water pass back into the blood and we ultimately breathe them out. Please note that respiration takes place in the cells of all living beings.

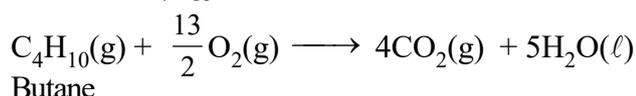


8.2 Combustion Reactions :

A chemical reaction in which a substance burns or gets oxidised in the presence of air or oxygen is called combustion reaction. For example, kerosene, coal, charcoal, wood etc. burn in air and thus, undergo combustion. Methane (CH_4), a major constituent of natural gas, undergoes combustion in excess of oxygen upon heating.

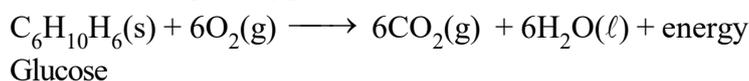


Similarly, butane (C_4H_{10}), the main constituent of L.P.G. also undergoes combustion.



Remember that all the combustion reactions are oxidation reactions in nature.

The human body may be regarded as a furnace or machine in which various food stuff that we eat undergo combustion or oxidation or oxidation. The heat energy evolved keeps our body working. Carbohydrates such as glucose, fructose, starch etc. are the major source of energy to the human body. They undergo combustion with the help of oxygen that we inhale to form carbon dioxide and water. For example,



8.3 Harmful Effects of oxidation:

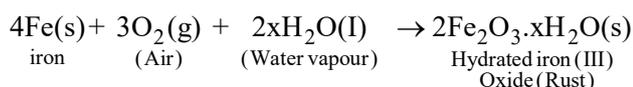
There are two common effects of oxidation reactions which we observe in daily life. These are :

- (i). Corrosion (ii). Rancidity

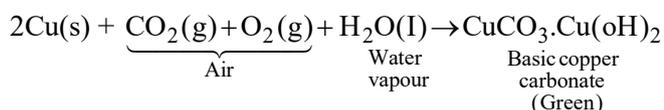
- (i). **Corrosion :** Corrosion is the process in which metals are eaten up gradually by the action of air, moisture or a chemical (such as an acid) on their surface.

- Corrosion is caused mainly by the oxidation of metals by the oxygen of air.

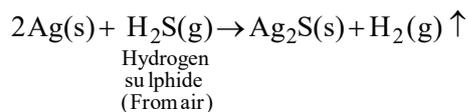
The most common example of corrosion is the rusting of iron. when an iron object remain exposed to moist air for a long time, its surface gets covered with a brown flaky substance called 'rust'. Rust is mainly hydrated ferric oxide $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$. It is formed due to the attack of oxygen gas and water vapour present in the air on the surface of iron.



Similarly, copper objects lose their lusture after time. In the presence of moist air, a thin film of green basic copper carbonatate is formed on its surface and therefore, it corrodes.



Likewise, silver metal gets tarnished in an atmosphere containing traces of H_2S due to the formation of black silver sulphide.



Rust is a soft and flaky (non-sticky) substance which gradually falls off from the surface of an iron object, and then the iron below starts rusting. Thus, rusting of iron (or corrosion of iron) is a continuous process which, if not prevented in time, eats up the whole iron object.

(ii). Harmful effects of corrosion :

Corrosion weakens the iron and steel objects and structures such as railings, car bodies, bridges and ships, etc., and cuts short their life. A lot of money has to be spent every year to prevent the corrosion of iron and steel objects, and to replace the damaged iron and steel structures.

(iii). Methods used to prevent rusting :

Rusting can be prevented or retarded by the following methods:

- Rusting can be prevented if iron objects are not allowed to come in contact with damp air by using a barrier. This method is called barrier protection. The barrier protection can be achieved by any of the following methods:
 - (i) The surface is coated with paint or some chemicals, e.g. biphenol
 - (ii) The surface is protected by applying a thin film of oil or grease.
 - (iii) The metal is electroplated with metals like tin, nickel, zinc, chromium, aluminium, etc.
 - (iv) Sacrificial protection : In this, iron is protected from rusting by covering it with a layer of more active metal (e.g., Mg, Zn) than iron. The active metal like Mg, Zn, etc., corrodes itself but saves the object. This is called sacrificial protection. Zinc is commonly used for covering the iron surface. The process of coating iron with zinc is called galvanisation.
 - (iii) Using anti-rust solutions : To retard the corrosion of iron, certain anti-rust solutions are used. For e.g., Solution of alkaline phosphates and alkaline chromates are generally used as anti-rust solutions.

8.4 Rancidity : The food prepared using unsaturated fats or oils if kept a long time undergo oxidation, they start giving unpleasant smell and taste, they are said to have become rancid.

Thus, the oxidation of unsaturated fats or oils resulting in unpleasant smell and taste is called rancidity.

Rancidity spoils the food materials prepared from fats and oils which have been kept for a considerable time and makes them unfit for eating.

➤ **Methods used to prevent rancidity :**

- (i) **By adding anti-oxidants to foods containing fats and oils.** Anti-oxidant is a substance (or chemical) which prevents oxidation. These compounds retard the action of oxygen on the food due to which unsaturated fats and oil in food products do not undergo deterioration due to free radical production. Antioxidants are usually reducing agents. They destroy the free radical formed and prevent the oxidation of food. The two common anti-oxidants used in foods to prevent the development of rancidity are BHA (Butylated Hydroxy Anisole) and BHT (Butylated Hydroxy Toluene).



Let's know

Vitamin-E and vitamin-C (ascorbic acid) are the two antioxidants occurring in natural fats.

- (ii) **By packaging fat and oil containing foods in nitrogen gas.** When the packed food is surrounded by an unreactive gas nitrogen, there is no oxygen (of air) to cause its oxidation and make it rancid. The manufacturers of potato chips (and other similar food products) fill the plastic bags containing chips with nitrogen gas to prevent the chips from being oxidised and turn rancid.
- (iii) **By keeping food in a refrigerator.** The refrigeration of food stuffs, slows down the oxidation of food stuffs due to low temperatures. So the development of rancidity due to oxidation is slowly down or retarded.
- (iv) **By storing food in air-tight containers.** When food is stored in air-tight containers, then there is little exposure to oxygen of air. Due to reduced exposure to oxygen, the oxidation of fats and oils present in food is slowed down and hence the development of rancidity is retarded.
- (v) **By storing foods away from light.** In the absence of light, the oxidation of fats and oils present in food is slowed down and hence the development of rancidity is retarded.
- (vi) **By vacuum packing :** In vacuum packing, after packing the food, the container is evacuated before sealing, so that no air (oxygen) is available to bring about the oxidation of food.



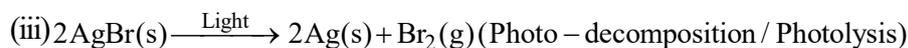
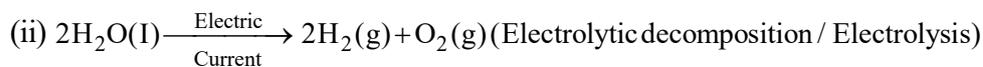
Let's know

There are some cases where corrosion plays a useful role. We all know that aluminium is placed high in the activity series and is expected to be quite reactive. It combines with oxygen present in air to form its oxide called aluminium oxide (Al_2O_3) and this is a case of corrosion. The metal oxide formed slowly gets deposited on the surface of aluminium. It forms a protective coating on the surface. This coating makes the metal passive to the attack by water, air, acids and alkalies etc. As a result, aluminium articles and containers are not corroded. Aluminium foils are commonly used for packing food preparations, cigarettes etc.

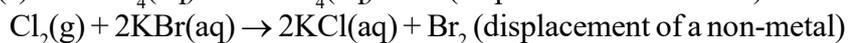
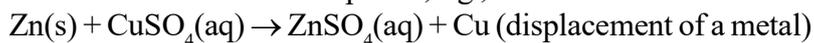
SUMMARY

1. Chemical reaction : A process in which the substance taken (called reactants) lose their nature and identify to form new chemical substances with different properties, i.e., a process which involves a chemical change is called a chemical reaction.
2. Chemical reaction : The representation of a chemical reaction by using the symbols and formulae of the different reactants and products is called a chemical equation.
3. Balanced and unbalanced (skeletal) chemical equations : An equation in which the number of atoms of each elements are equal on both sides of the equation is called a balanced chemical equation. On the other hand, if these are not equal, it is called unbalanced or skeletal equation.
4. Balancing of a chemical equation : It means making the number of atoms of each element equal on both sides of the equation. A chemical equation is balanced so that the number of atoms of each type involved in a chemical reaction are the reactant and products sides of the equation. Equations must always be balanced.
5. Combination reactions : These are those reactions in which two or more elements or compounds combine together to form a single compound, e.g.,
 - (i) $\text{Fe(s)} + \text{S(s)} \rightarrow \text{FeS(s)}$ (Two elements combine)
 - (ii) $\text{NH}_3(\text{g}) + \text{HCl(g)} \rightarrow \text{NH}_4\text{Cl(s)}$ (Two compounds combine)
 - (iii) $2\text{NO(g)} + \text{O}_2(\text{g}) \rightarrow 2\text{NO}$ (A compound and an element combine)

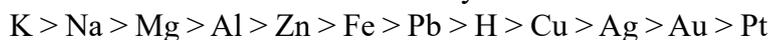
6. Decomposition reactions: These are those reaction in which a single compound splits to give two or more simple substance, e.g.,



7. Simple displacement reaction : These are those reaction in which a more active elements displaces a less active element from its compound, e.g.,



8. Activity series of metals : The arrangement of metals in order of decreasing reactivity is called activity series of metals. The order of reactivity is



Metals more reactive than hydrogen displace hydrogen from acids whereas metals less reactive than hydrogen cannot.

9. Double displacement reaction : These are those reaction in which two ionic compound in solution exchange their ions to form new compounds. One of the products is a precipitate or a gas, e.g.,

EXERCISE-I

NCERT Solutions



Q.1 Why should a magnesium ribbon be cleaned before burning in air?

Sol. Magnesium is very reactive metal. When stored it reacts with oxygen to form a layer of magnesium oxide on its surface. This layer of magnesium oxide is quite stable and prevents further reaction of magnesium with oxygen. The magnesium ribbon is cleaned by sand paper to remove this layer so that the underlying metal can be exposed to air.

Q.2 Write the balanced equation for the following chemical reactions.

- (i) Hydrogen + Chlorine \longrightarrow Hydrogen chloride
 (ii) Barium chloride + Aluminium sulphate \longrightarrow Barium sulphate + Aluminium chloride
 (iii) Sodium + Water \longrightarrow Sodium hydroxide + Hydrogen

Sol. (i) $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \longrightarrow 2\text{HCl}(\text{g})$
 (ii) $3\text{BaCl}_2(\text{aq}) + \text{Al}_2(\text{SO}_4)_3(\text{aq}) \longrightarrow 3\text{BaSO}_4(\text{s}) + 2\text{AlCl}_3(\text{aq})$
 (iii) $2\text{Na}(\text{s}) + 2\text{H}_2\text{O}(\ell) \longrightarrow 2\text{NaOH}(\text{aq}) + \text{H}_2(\text{g})$

Q.3 Write a balanced chemical equation with state symbols for the following reactions.

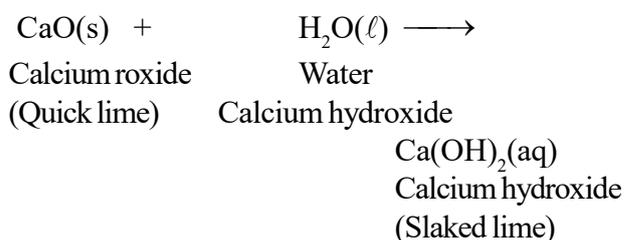
- (i) Solutions of barium chloride and sodium sulphate in water react to give insoluble barium sulphate and the solution of sodium chloride.
 (ii) Sodium hydroxide solution (in water) reacts with hydrochloric acid solution (in water) to produce sodium chloride solution and water.

Sol. (i) $\text{BaCl}_2(\text{aq}) + \text{Na}_2\text{SO}_4(\text{aq}) \longrightarrow \text{BaSO}_4(\text{s}) + 2\text{NaCl}(\text{aq})$
 (ii) $\text{NaOH}(\text{aq}) + \text{HCl}(\text{aq}) \longrightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\ell)$

Q.4 A solution of a substance 'X' is used for white washing.

- (i) Name the substance 'X' and write its formula.
 (ii) Write the reaction of the substance 'X' named in (i) above with water.

Sol. (i) The substance 'X' is calcium oxide. Its chemical formula is CaO.
 (ii) Calcium oxide reacts vigorously with water to form calcium hydroxide (slaked lime).

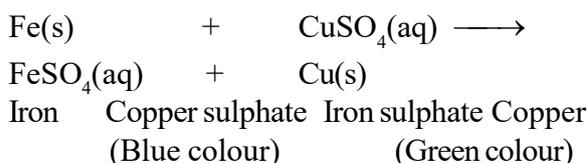


Q.5 Why is the amount of gas collected in one of the test tubes on electrolysis of H_2O , double of the amount collected in the other? Name this gas.

Sol. Water (H_2O) contains two parts of hydrogen and one part of oxygen. Therefore, the amount of hydrogen and oxygen produced during electrolysis of water is in a 2 : 1 ratio. During electrolysis, since hydrogen goes to one test tube and oxygen goes to another, the amount of gas collected in one of the test tubes is double of the amount collected in the other.

Q.6 Why does the colour of copper sulphate solution change when an iron nail is dipped in it?

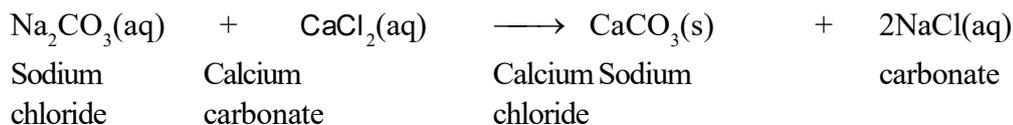
Sol. When an iron nail is placed in a copper sulphate solution, iron displaces copper from copper sulphate solution forming iron sulphate, which is green in colour.



Therefore, the blue colour of copper sulphate solution fades and green colour appears.

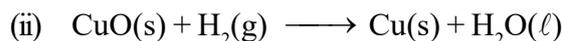
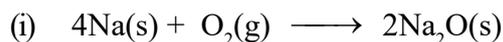
Q.7 Give an example of a double displacement reaction.

Sol. Sodium carbonate reacts with calcium chloride to form calcium carbonate and sodium chloride.



In this reaction, sodium carbonate and calcium chloride exchange ions to form two new compounds. Hence, it is a double displacement reaction.

Q.8 Identify the substances that are oxidised and the substances that are reduced in the following reactions.



Sol. (i) Sodium (Na) is oxidised as it gains oxygen and oxygen gets reduced.

(ii) Copper oxide (CuO) is reduced to copper (Cu) while hydrogen (H₂) gets oxidised to water (H₂O).

NCERT Exercise Questions :

Q.1 Which of the statements about the reaction below are incorrect?



- (a) Lead is getting reduced.
 (b) Carbon dioxide is getting oxidised.
 (c) Carbon is getting oxidised.
 (d) Lead oxide is getting reduced.
 (A) (a) and (b) (B) (a) and (c)
 (C) (a), (b) and (c) (D) all

Sol. (A) (a) and (b)



The above reaction is an example of a

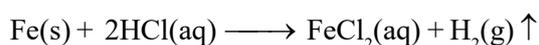
- (A) combination reaction.
 (B) double displacement reaction.
 (C) decomposition reaction.
 (D) displacement reaction.

Sol. (D) The given reaction is an example of a displacement reaction.

Q.3 What happens when dilute hydrochloric acid is added to iron filings? Tick the correct answer.

- (A) Hydrogen gas and iron chloride are produced.
 (B) Chlorine gas and iron hydroxide are produced.
 (C) No reaction takes place.
 (D) Iron salt and water are produced.

Sol. (A) Hydrogen gas and iron chloride are produced. The reaction is as follows:

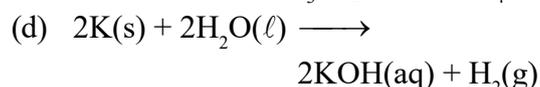
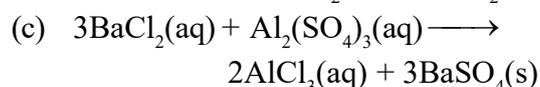
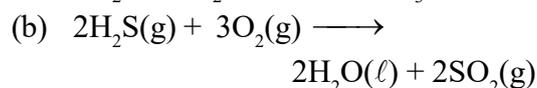
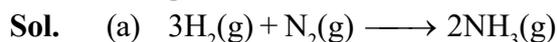


Q.4 What is a balanced chemical equation? Why should chemical equations be balanced?

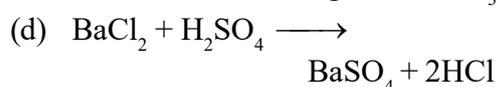
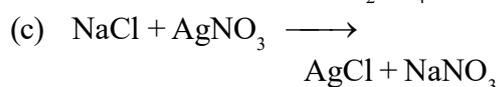
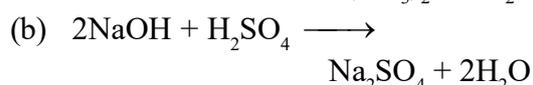
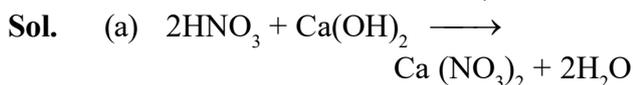
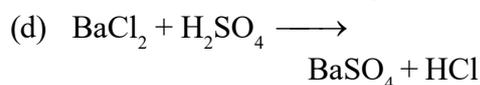
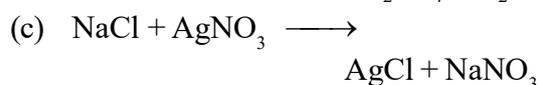
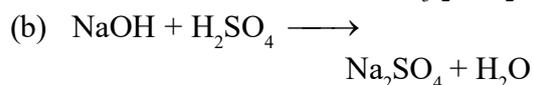
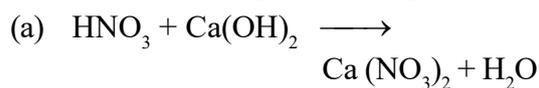
Sol. A reaction which has an equal number of atoms of all the elements on both sides of the chemical equation is called a balanced chemical equation. The law of conservation of mass states that mass can neither be created nor destroyed. Hence, in a chemical reaction, the total mass of reactants should be equal to the total mass of the products. It means that the total number of atoms of each element should be equal on both sides of a chemical equation. Hence, it is for this reason the chemical equations should be balanced.

Q.5 Translate the following statements into chemical equations and then balance them.

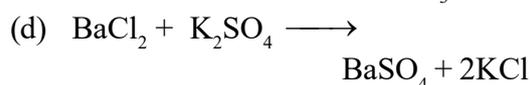
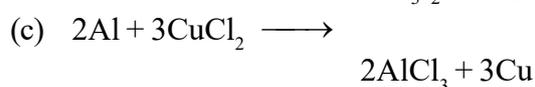
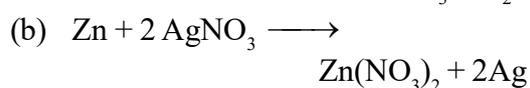
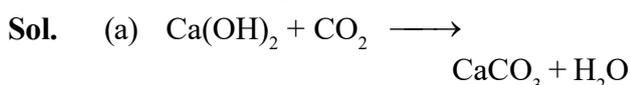
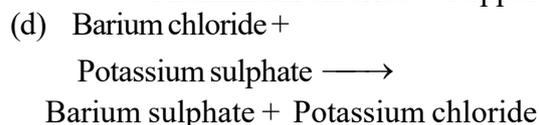
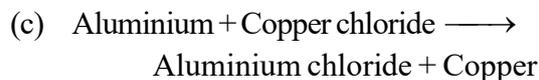
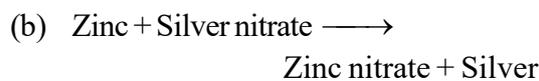
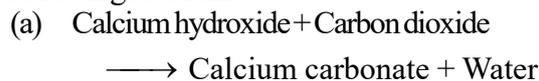
- (a) Hydrogen gas combines with nitrogen to form ammonia.
 (b) Hydrogen sulphide gas burns in air to give water and sulphur dioxide.
 (c) Barium chloride reacts with aluminium sulphate to give aluminium chloride and a precipitate of barium sulphate.
 (d) Potassium metal reacts with water to give potassium hydroxide and hydrogen gas.



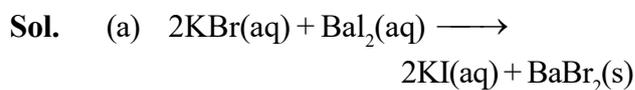
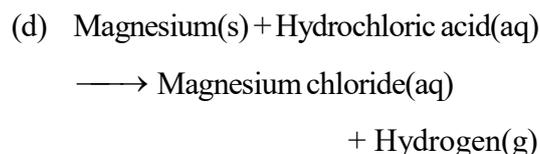
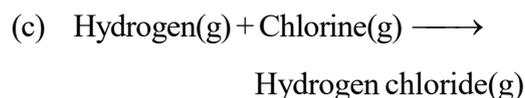
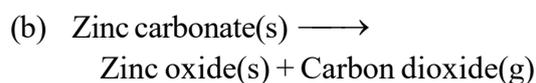
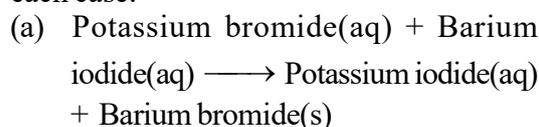
Q.6 Balance the following chemical equations.



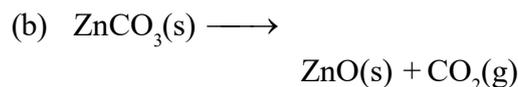
Q.7 Write the balanced chemical equations for the following reactions.



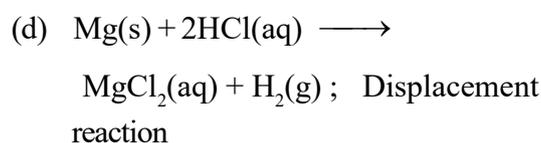
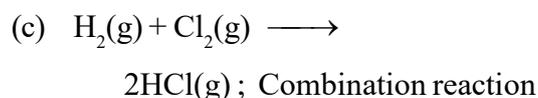
Q.8 Write the balanced chemical equation for the following and identify the type of reaction in each case.



; Double displacement reaction



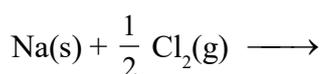
; Decomposition reaction



Q.9 What does one mean by exothermic and endothermic reactions? Give examples.

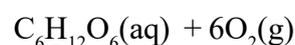
Sol. Chemical reactions that release energy in the form of heat, light, or sound are called exothermic reactions.

Example: Mixture of sodium and chlorine to yield table salt



In other words, combination reactions are exothermic.

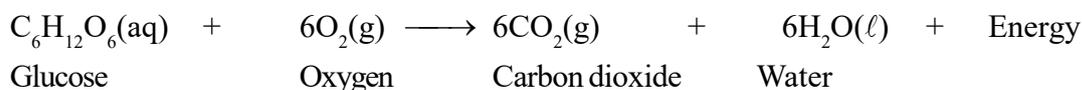
Reactions that absorb energy or require energy in order to proceed are called endothermic reactions. For example: In the process of photosynthesis, plants use the energy from the sun to convert carbon dioxide and water to glucose and oxygen.



Glucose

Q.10 Why is respiration considered as an exothermic reaction? Explain.

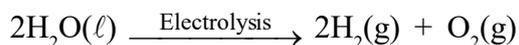
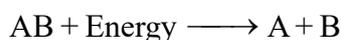
Sol. Energy is required to support life. Energy in our body is obtained from the food we eat. During digestion, large molecules of food are broken down into simpler substances such as glucose. Glucose combines with oxygen in the cells and provides energy. The special name of this combustion reaction is respiration. Since energy is released in the whole process, it is an exothermic process.



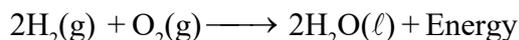
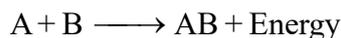
Q.11 Why are decomposition reactions called the opposite of combination reactions? Write equations for these reactions.

Sol. Decomposition reactions are those in which a compound breaks down to form two or more substances. These reactions require a source of energy to proceed. Thus, they are the exact opposite of combination reactions in which two or more substances combine to give a new substance with the release of energy.

Decomposition reaction :

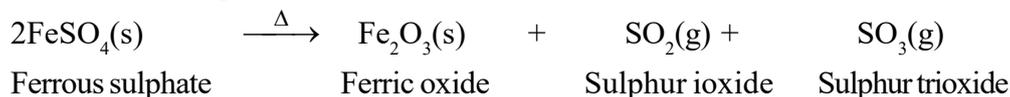


Combination reaction :

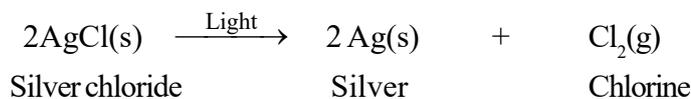


Q.12 Write one equation each for decomposition reactions where energy is supplied in the form of heat, light or electricity.

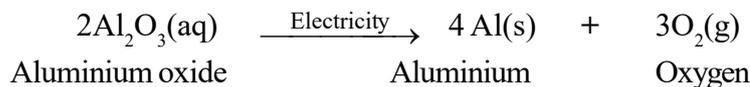
Sol. (a) **Thermal decomposition :**



(b) **Decomposition by light :**



(c) **Decomposition by electricity :**



Q.13 What is the difference between displacement and double displacement reactions? Write equations for these reactions.

Sol. In a displacement reaction, a more reactive element displaces a less reactive element from a compound.



In a double displacement reaction, two atoms or a group of atoms switch places to form new compounds.

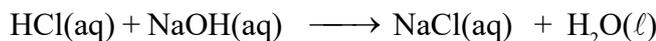


For example:

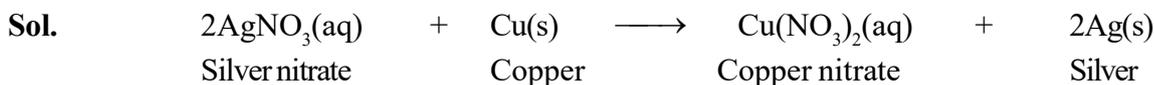
Displacement reaction :



Double displacement reaction:

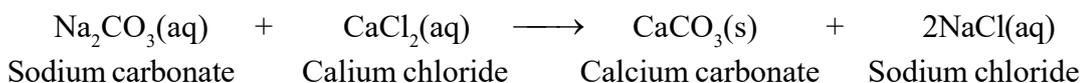


Q.14 In the refining of silver, the recovery of silver from silver nitrate solution involved displacement by copper metal. Write down the reaction involved.



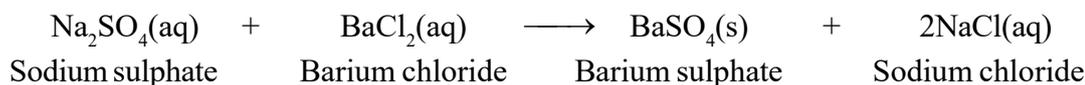
Q.15 What do you mean by a precipitation reaction? Explain by giving examples.

Sol. A reaction in which an insoluble solid (called precipitate) is formed is called a precipitation reaction. For example:



In this reaction, calcium carbonate is obtained as a precipitate. Hence, it is a precipitation reaction.

Another example of precipitation reaction is :



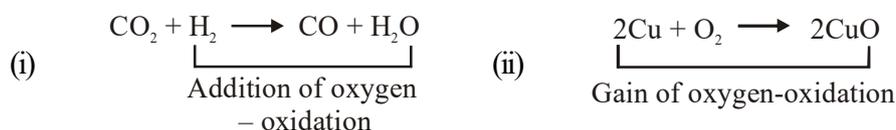
In this reaction, barium sulphate is obtained as a precipitate.

Q.16 Explain the following in terms of gain or loss of oxygen with two examples each.

(a) Oxidation (b) Reduction

Sol. (a) Oxidation is the gain of oxygen.

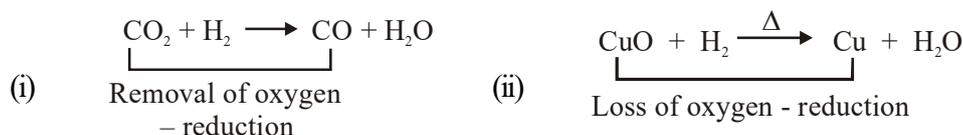
For example :



In equation (i), H_2 is oxidized to H_2O and in equation (ii), Cu is oxidised to CuO .

(b) Reduction is the loss of oxygen.

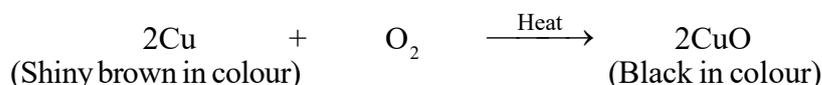
For example :



In equation (i), CO_2 is reduced to CO and in equation (ii), CuO is reduced to Cu .

Q.17 A shiny brown-coloured element 'X' on heating in air becomes black in colour. Name the element 'X' and the black coloured compound formed.

Sol. 'X' is copper (Cu) and the black-coloured compound formed is copper oxide (CuO). The equation of the reaction involved on heating copper is given below.



Q.18 Why do we apply paint on iron articles?

Sol. Iron articles are painted because it prevents them from rusting. When painted, the contact of iron articles from moisture and air is cut off. Hence, rusting is prevented.

Q.19 Oil and fat containing food items are flushed with nitrogen. Why?

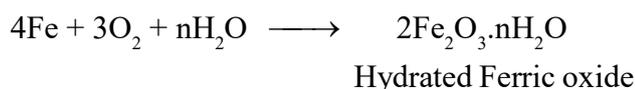
Sol. Nitrogen is an inert gas and does not easily react with these substances. On the other hand, oxygen reacts with food substances and makes them rancid. Thus, bags used in packing food items are flushed with nitrogen gas to remove oxygen inside the pack. When oxygen is not present inside the pack, rancidity of oil and fat containing food items is avoided.

Q.20 Explain the following terms with one example each.

- (a) Corrosion (b) Rancidity

Sol. (a) Corrosion : Corrosion is defined as a process where materials usually metals deteriorate as a result of a chemical reaction with air, moisture, chemicals, etc.

For example, iron in the presence of moisture reacts with oxygen to form hydrated Ferric oxide.



This hydrated iron oxide is rust.

(b) Rancidity : The process of oxidation of fats and oils that can be easily noticed by the change in taste and smell is known as rancidity.

For example, the taste and smell of butter changes when kept for long. Rancidity can be avoided by :

1. Storing food in air tight containers
2. Storing food in refrigerators
3. Adding antioxidants
4. Storing food in an environment of nitrogen

EXERCISE - II

Knowledge Vault



MCQ BASED QUESTIONS:

- Q.1** When quick lime is reacted with water, calcium hydroxide is formed, it is a
(A) combination reaction
(B) displacement reaction
(C) double displacement reaction
(D) decomposition reaction
- Q.2** When water is added in a vessel containing lumps of quick lime, it is observed that
(A) the vessel becomes hot
(B) a hissing sound is produced
(C) lump of quick lime breaks and dissolves partially in water
(D) All the above.
- Q.3** In a beaker 5 g of calcium oxide (quick lime) is mixed with some water, it is observed that
(A) it dissolves completely
(B) it does not dissolve at all
(C) it is sparingly soluble
(D) it forms a transparent mixture
- Q.4** Quick lime is a
(A) red coloured solid
(B) green coloured solid
(C) blue coloured solid
(D) colourless or white coloured solid
- Q.5** Calcium oxide (CaO) is also known as
(A) quick lime (B) slaked lime
(C) milk of lime (D) lime water
- Q.6** The products of reaction between water and quick lime are
(A) calcium, hydrogen and oxygen
(B) calcium and hydrogen
(C) calcium hydroxide
(D) calcium hydroxide and oxygen
- Q.7** When Quick lime reacts with water
(A) heat is absorbed
(B) heat is released.
(C) no change of temperature takes place
(D) none of these
- Q.8** When we heat ferrous sulphate crystals we observe that
(A) no gas is evolved
(B) a brown coloured gas is evolved
(C) a gas having smell of burning sulphur is evolved
(D) no residue is left after heating.
- Q.9** When crystals of ferrous sulphate are heated strongly red coloured residue is obtained. It is an example of:
(A) combination reaction
(B) decomposition reaction
(C) displacement reaction
(D) double displacement reaction
- Q.10** The colour of ferrous sulphate crystals is
(A) Blue (B) Yellow
(C) Green (D) Brown
- Q.11** When we heat crystals of ferrous sulphate in a test tube which one of the following is NOT obtained ?
(A) Brown solid is formed
(B) A gas having smell of burning sulphur is evolved
(C) A brown gas is evolved
(D) Oxides of sulphur are produced
- Q.12** A student while heating some ferrous sulphate crystals in a dry boiling tube will observe:
(A) water droplets near the mouth of boiling tube
(B) colour change of the crystals
(C) smell of burning sulphur
(D) All of the above
- Q.13** When we heat ferrous sulphate crystals a gas evolves which has a smell of:
(A) rotten eggs (B) pleasant smell
(C) irritating smell (D) burning smell
- Q.14** The colour changes observed when the ferrous sulphate crystals are heated in a dry boiling tube is
(A) green → orange → brown
(B) green → white → brown
(C) blue → green → white
(D) green → brown → black
- Q.15** A student heated small amount of ferrous sulphate in a test tube. She made the following observations:
(i) Ferrous sulphate colour changes to brown
(ii) A gas having a smell of burning sulphur is evolved
(iii) Water droplets collect on the upper side of the test tube
(iv) Brown coloured gas is evolved.
The correct set of observation is
(A) (i), (ii), (iv) (B) (i), (ii), (iii)
(C) (i), (iii), (iv) (D) (ii), (iii), (iv)

- Q.16** To a solution of copper sulphate in a beaker, some iron filings are dropped. After a few minutes it is observed that
 (A) a white precipitate is formed
 (B) the colour of the solution becomes darker
 (C) a reddish brown coating starts appearing on the iron filings
 (D) the solution becomes colourless.
- Q.17** When an iron nail rubbed with sand paper is dipped in copper sulphate solution, we observe that copper gets deposited.
 (A) first on the lower part of the nail and proceeds to the upper part
 (B) first on the upper part of the nail and proceeds to the lower part
 (C) on the entire surface of the nail
 (D) on the nail in small patches
- Q.18** Reaction of iron nails with copper sulphate solution is an example of
 (A) combination reaction
 (B) decomposition reaction
 (C) displacement reaction
 (D) double displacement reaction
- Q.19** Iron filings were added to an aqueous solution of copper sulphate solution. After sometime on observation it was found that the colour of the solution has changed from :
 (A) blue to pale green
 (B) blue to dark green
 (C) blue to colourless
 (D) blue to reddish brown
- Q.20** Four groups of the students were assigned separately the experiment of interaction of iron nail with a solution of copper sulphate. Each group recorded the observations as given below in the table. Which group of students recorded all the observations correctly?
- | Group of Students | Initial colour of solution | Final colour of solution | Change in the iron nail |
|-------------------|----------------------------|--------------------------|-------------------------|
| (A) | Blue | Colourless | Grey coat |
| (B) | Green | Green | Brown coat |
| (C) | Blue | Blue | Brown coat |
| (D) | Blue | Light green | Brown coat |
- Q.21** To show that iron is more reactive than copper, the correct procedure is to :
 (A) prepare ferrous sulphate solution and dip copper strip in it
 (B) prepare copper sulphate solution and dip iron strip in it
 (C) add dil. nitric acid on both strips
 (D) heat iron and copper strips both
- Q.22** Four students were asked to study the reaction between aqueous solutions of barium chloride and sodium sulphate. They reported that their experiment as follows. On mixing the solutions of the two salts in a test tube
 (i) the colour of the mixture becomes brown
 (ii) the solutions form separate layer
 (iii) a colourless mixture is obtained
 (iv) a white substance settles at the bottom. The correct report is
 (A) (i) (B) (ii) (C) (iii) (D) (iv)
- Q.23** White ppt obtained when aqueous solutions of BaCl_2 and Na_2SO_4 are mixed, is that of
 (A) NaCl (B) BaSO_4
 (C) Both (A) and (B) (D) None of these
- Q.24** Reaction between a solution of sodium sulphate in water and barium chloride in water is an example of
 (A) combination reaction
 (B) decomposition reaction
 (C) displacement reaction
 (D) double displacement reaction
- Q.25** Barium sulphate is
 (A) colourless and soluble in water
 (B) colourless and insoluble in water
 (C) green colour and soluble in water
 (D) None of these
- Q.26** The insoluble product (precipitate) formed when barium chloride is mixed with sodium sulphate solution is
 (A) barium (B) barium sulphate
 (C) sodium chloride (D) barium sulphide
- Q.27** To study the reaction between barium chloride and sodium sulphate, the two compounds are mixed in the form of:
 (A) dry powders (B) molten liquids
 (C) aqueous solutions (D) None of these
- Q.28** A solution of barium chloride in water is
 (A) colourless
 (B) sky blue in colour
 (C) pale green in colour
 (D) reddish brown in colour
- Q.29** A solution of sodium sulphate in water is-
 (A) sky blue in colour
 (B) pale green in colour
 (C) yellow in colour
 (D) colourless
- Q.30** When a solution of barium chloride in water is added to an aqueous solution of sodium sulphate, the following happens:
 (A) a white precipitate is formed
 (B) a red precipitate is formed
 (C) the colour of the solution turns blue
 (D) a pungent smelling gas is evolved

- Q.31** Dilute sulphuric acid is poured on zinc granules. Which of the following statements is false regarding this reaction ?
 (A) Hydrogen gas is released
 (B) It is an endothermic reaction
 (C) It is a chemical reaction
 (D) There will be rise in temperature
- Q.32** Which of the following is false about chemical reaction ?
 (A) A new substance with entirely different properties is formed.
 (B) Old chemical bonds are broken while some new ones are formed.
 (C) Atoms are rearranged to form new substance.
 (D) Atoms of reactants are destroyed and products are formed with double the number of atoms of reactants.
- Q.33** Which of the following pairs of reactions is not opposite to each other.
 (A) Combination - decomposition
 (B) Displacement - Double displacement
 (C) Reduction - Oxidation
 (D) Endothermic - Exothermic
- Q.34** The metal which can displace copper from copper sulphate solution.
 (A) Hg (B) Au
 (C) Fe (D) Ag
- Q.35** Which of the following is an example of endothermic reaction ?
 (A) burning of paper
 (B) respiration
 (C) decomposition of limestone
 (D) slaking of lime
- Q.36** Which of the following is not correct about the balanced chemical equation ?
 (A) Short hand representation of a chemical reaction
 (B) How much amount of reactants required to produce the given amount of products.
 (C) How much amount of product will be obtained from given reactants.
 (D) Rate of reactions can be known by chemical equation
- Q.37** The CO_2 gas is produced during
 (A) Complete combustion of fuel
 (B) Incomplete respiration
 (C) Complete combustion and respiration
 (D) incomplete combustion and respiration
- Q.38** The substance reduced in the $\text{MnO}_2 + 4\text{HCl} \longrightarrow \text{MnCl}_2 + 2\text{H}_2\text{O} + \text{Cl}_2$ reaction is :
 (A) MnO_2 (B) HCl
 (C) MnCl_2 (D) H
- Q.39** Which of the following on dissolution in water, will rise the temperature ?
 (A) sodium chloride
 (B) ammonium chloride
 (C) glucose
 (D) sodium hydroxide.
- Q.40** During double displacement reaction :
 (A) exchange of ions take place
 (B) precipitate is formed
 (C) colour change may take place
 (D) all of these
- Q.41** The rate of corrosion depends upon
 (A) temperature
 (B) presence of electrolyte
 (C) electropositive nature of the metal
 (D) all of these
- Q.42** In which of the following, heat energy is not released ?
 (A) $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$
 (B) $\text{CaO} + \text{H}_2\text{O} \longrightarrow \text{Ca(OH)}_2$
 (C) $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$
 (D) $\text{NH}_4\text{OH} \longrightarrow \text{NH}_3 + \text{H}_2\text{O}$
- Q.43** Digestion is the example of
 (A) displacement reaction
 (B) Combination reaction
 (C) neutralisation reaction
 (D) Decomposition reactions
- Q.44** $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$ this reaction is the example of
 (A) Combination reaction
 (B) exothermic reaction
 (C) redox reaction
 (D) all of these
- Q.45** $2\text{H}_2\text{S} + \text{SO}_2 \rightarrow 3\text{S} + 2\text{H}_2\text{O}$, In this reaction the substance which gets reduced is :
 (A) H_2O (B) S
 (C) SO_2 (D) H_2S
- Q.46** When a black and white photographic film is exposed to light, the gray colour on the film appears due to the presence of
 (A) Silver oxide (B) Bromine
 (C) Silver (D) All of these

- Q.47** A metal 'M' produces white ash of 'N' and dazzling white light on burning in the presence of oxygen gas. The metal 'M' and ash 'N' would be
 (A) magnesium oxide, manganese respectively
 (B) manganese dioxide, magnesium respectively
 (C) magnesium, magnesium oxide respectively
 (D) magnesium carbonate, magnesium respectively
- Q.48** A student heated lead nitrate with an aqueous solution of potassium iodide. He would be getting
 (A) white precipitate of lead
 (B) yellow precipitate of lead iodide.
 (C) white precipitate of potassium
 (D) yellow coloured gas of lead.
- Q.49** Green coating on copper utensils in rainy season is due to the presence of
 (A) CuCO_3 (B) $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$
 (C) Cu(OH)_2 (D) CuS
- Q.50** An acid which can decolourise purple colour of potassium permanganate solution is
 (A) H_2SO_4 (B) KI
 (C) MnO_3 (D) $\text{K}_2\text{Cr}_2\text{O}_7$.
- Q.51** In order to prevent the spoilage of potato chips, they are packed in pouches filled with
 (A) nitrogen gas (B) oxygen gas
 (C) sulphur gas (D) none of these
- Q.52** When we add common salt in AgNO_3 (silver nitrate) solution the precipitate formed will be
 (A) black coloured (B) blue coloured
 (C) yellow coloured (D) white coloured
- Q.53** Which of the following can be decomposed by the action of light?
 (A) AgCl (B) KCl
 (C) CuCl_2 (D) NaCl
- Q.54** Give the number of molecules of carbon-dioxide formed upon complete oxidation of glucose.
 (A) 1 (B) 3
 (C) 6 (D) 4
- Q.55** Chemical equation for the formation of hydrogen sulphide gas is $\text{ZnS} + x\text{HCl} \longrightarrow \text{ZnCl}_2 + \text{H}_2\text{S} \uparrow$. What is the value of "x and y" in the equation, respectively?
 (A) 2 and 1 (B) 1 and 2
 (C) 2 and 2 (D) 3 and 1
- Q.56** Chemical equation for the combustion of methanol is as follows:
 $x\text{CH}_3\text{OH}(\text{g}) + y\text{O}_2(\text{g}) \rightarrow z\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{g})$. What is the value of 'x, y and z' in the equation, respectively?
 (A) 1, 2 and 3 (B) 1, 2 and 4
 (C) 2, 3 and 4 (D) 2, 3 and 2.
- Q.57** The reaction between aqueous solutions of sodium chloride and silver nitrate is
 (A) displacement reaction
 (B) synthesis reaction
 (C) double displacement reaction
 (D) analysis reaction
- Passage (Q.58 to Q.60)**
 In a double displacement reaction between aqueous potassium iodide and aqueous lead nitrate, a yellow precipitate of lead iodide is formed.
- Q.58** While performing the activity if lead nitrate is not available, which of the following can be used in place of lead nitrate?
 (A) Lead sulphate (insoluble)
 (B) Lead acetate
 (C) Ammonium nitrate
 (D) potassium sulphate
- Q.59** Which of the following statements is true regarding precipitates?
 (A) Product formation after saturation point
 (B) Product formation before saturation point
 (C) Precipitation does not relate to saturation point of a solution
 (D) Product with higher concentration in a reaction is precipitate.
- Q.60** Which of the following is a double displacement reaction?
 (A) $2\text{KI} + \text{Cl}_2 \longrightarrow 2\text{KCl} + \text{I}_2$
 (B) $\text{Al} + \text{Fe}_2\text{O}_3 \longrightarrow \text{Al}_2\text{O}_3 + 2\text{Fe}$
 (C) $\text{BaCl}_2 + \text{H}_2\text{SO}_4 \longrightarrow \text{BaSO}_4 + 2\text{HCl}$
 (D) $\text{Mg} + \text{CuSO}_4 \longrightarrow \text{MgSO}_4 + \text{Cu}$
- Q.61** The reaction that releases energy is
 (A) $2\text{FeSO}_4(\text{s}) \xrightarrow{\Delta} \text{Fe}_2\text{O}_3(\text{s}) + \text{SO}_2(\text{g}) + \text{SO}_3(\text{g})$
 (B) $3\text{Pb}(\text{NO}_3)_2(\text{s}) \xrightarrow{\Delta} 2\text{PbO}(\text{s}) + 4\text{NO}_2(\text{g}) + \text{O}_2(\text{g})$
 (C) $2\text{AgBr}(\text{s}) \xrightarrow{\text{Sunlight}} 2\text{Ag}(\text{s}) + \text{Br}_2(\text{g})$
 (D) $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$

Q.62 $\text{CH}_4 + \text{Cl}_2 \longrightarrow \text{CH}_3\text{Cl} + \text{HCl}$ reaction is an example of

- (A) synthetic (B) analytical
(C) displacement (D) neutralisation

Q.63 A brown and bright element “x” when heated in presence of air turns into black substance “y”. If hydrogen gas is passed over this heating material again “x” is obtained. “x” and “y” are

- (A) Cu and CuO (B) S & SO_2
(C) C & CO_2 (D) Na and NaH

Q.64 Displacement reaction is :

- (A) $\text{CaO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Ca(OH)}_2\text{(aq)}$
(B) $\text{Pb(s)} + \text{CuCl}_2\text{(aq)} \rightarrow \text{PbCl}_2\text{(aq)} + \text{Cu(s)}$
(C) $\text{MnO}_2\text{(s)} + 4\text{HCl(l)} \rightarrow$
 $\text{MnCl}_2\text{(s)} + 2\text{H}_2\text{O} + \text{Cl}_2\text{(g)}$
(D) $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$

Q.65 The Chemical reaction $\text{HNO}_3 + \text{KOH} \rightarrow \text{KNO}_3 + \text{H}_2\text{O}$ is an example of :

- (A) neutralization
(B) double displacement
(C) neutralization and double displacement
(D) Combination

Q.66 Magnesium ribbon is rubbed with sand paper before making it to burn. The reason of rubbing the ribbon is to

- (A) remove moisture condensed over the surface of ribbon.
(B) generate heat due to exothermic reaction.
(C) remove magnesium oxide formed over the surface of magnesium.
(D) Mix silicon from sand paper (silicon dioxide) with magnesium for lowering ignition temperature of the ribbon.

Q.67 The reaction that differs from the rest of the reactions given is :

- (A) Formation of calcium oxide from limestone
(B) Formation of aluminium from aluminium oxide.
(C) Formation of sodium carbonate from sodium hydrogen carbonate
(D) Formation of mercury from mercuric oxide.

FILL IN THE BLANKS :

Q.68 When pH of a solution is 2 the $[\text{H}^+]$ in mol/L is

Q.69 Electrolytic refining of copper is based on _____ reaction

Q.70 Combustion of coal is an example of _____ reaction

Q.71 After white washing with a solution of slaked lime a thin layer of _____ is formed

Q.72 Reaction in which heat is absorbed is called _____ reactions.

TRUE / FALSE QUESTION :

Q.73 The speed of light is more in glass than in water,

Q.74 A ray of light when passes from glass to air, bends towards the normal

Q.75 Image is formed by a mirror due to refraction of light.

Q.76 The focal length of a convex mirror is equal to its radius of curvature

Q.77 A convex mirror is used as a shaving mirror.

MATCH THE COLUMN:

Q.78 Match the following :

Column-I

- (a) Neutralisation
(b) Precipitation
(c) Gas-formation
(d) Oxidation

Column-II

- (p) $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$
(q) $\text{H}_2\text{SO}_4 + \text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$
(r) $\text{ZnS} + 2\text{HCl} \longrightarrow \text{ZnCl}_2 + \text{H}_2\text{S}\uparrow$
(s) $\text{PbNO}_3 + \text{Na}_2\text{SO}_4 \rightarrow \text{PbSO}_4 + 2\text{NaNO}_3$
(A) (a)-(p), (b)-(q), (c)-(r), (d)-(s)
(B) (a)-(p), (b)-(r), (c)-(q), (d)-(s)
(C) (a)-(r), (b)-(s), (c)-(q), (d)-(p)
(D) (a)-(q), (b)-(s), (c)-(r), (d)-(p)

Q.79 Match the following :

Column-I

- (a) $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$
 (b) $2\text{KI} + \text{Br}_2 \rightarrow 2\text{KBr} + \text{I}_2$
 (c) $\text{Zn} + 2\text{NaCl} \rightarrow 2\text{Na} + \text{ZnCl}_2$

Column-II

- (p) Double displacement
 (q) No reaction
 (r) Single displacement.
 (A) (a)-(p), (b)-(q), (c)-(r)
 (B) (a)-(p), (b)-(r), (c)-(q)
 (C) (a)-(r), (b)-(p), (c)-(q)
 (D) (a)-(q), (b)-(p), (c)-(r)

Q.80 Column II gives type of reaction mention in column I, match them correctly.

Column-I

- (a) $\text{C} + \text{O}_2 \longrightarrow \text{CO}_2$
 (b) $\text{AgBr} \xrightarrow{\text{light}} \text{Ag} + \text{Br}$
 (c) $\text{Zn} + \text{CuSO}_4 \longrightarrow \text{ZnSO}_4 + \text{Cu}$
 (d) $\text{CH}_3\text{CH}_2\text{OH} \xrightarrow{\text{Cu}} \text{CH}_3\text{CHO} + \text{H}_2$

Column-II

- (p) Displacement
 (q) Combination
 (r) Decomposition
 (s) Oxidation
 (A) (a)-(q), (b)-(r), (c)-(p), (d)-(s)
 (B) (a)-(p), (b)-(r), (c)-(q), (d)-(s)
 (C) (a)-(r), (b)-(s), (c)-(q), (d)-(p)
 (D) (a)-(q), (b)-(s), (c)-(r), (d)-(p)

Q.81 **Column I**

- (a) Double displacement
 (b) Decomposition
 (c) Precipitation
 (d) Redox

Column II

- (p) $\text{CuO} + \text{H}_2 \xrightarrow{\text{heat}} \text{Cu} + \text{H}_2\text{O}$
 (q) $\text{Na}_2\text{SO}_4(\text{aq}) + \text{BaCl}_2(\text{aq}) \rightarrow \text{BaSO}_4(\text{aq}) + 2\text{NaCl}(\text{aq})$
 (r) $\text{CaCO}_3 \xrightarrow{\text{heat}} \text{CaO} + \text{CO}_2$
 (s) $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$
 (A) (a)-(q), (b)-(r), (c)-(p), (d)-(s)
 (B) (a)-(p), (b)-(r), (c)-(q), (d)-(s)
 (C) (a)-(s), (b)-(r), (c)-(q), (d)-(p)
 (D) (a)-(q), (b)-(s), (c)-(r), (d)-(p)

Q.82 **Column I**

- (a) Oxidation
 (b) reduction
 (c) Reducing agent
 (d) Oxidising agent

Column II

- (p) Gain of electron
 (q) Electron accepting species
 (r) Electron losing species
 (s) Loss of electron
 (A) (a)-(s), (b)-(r), (c)-(p), (d)-(q)
 (B) (a)-(r), (b)-(s), (c)-(q), (d)-(p)
 (C) (a)-(p), (b)-(s), (c)-(q), (d)-(r)
 (D) (a)-(s), (b)-(p), (c)-(r), (d)-(q)

ASSERTION & REASON TYPE QUESTIONS:

Q.83 **Assertion :** Calcium carbonate when heated decomposes to give calcium oxide and water.

Reason : Calcium carbonate when heated decomposes to give calcium oxide and carbon dioxide.

- (A) Both assertion and reason are true and reason is the correct explanation of assertion
 (B) Both assertion and Reason are true but reason is not the correct explanation of assertion.
 (C) Assertion is true but Reason is false.
 (D) Assertion is false but reason is true.

Q.84 **Assertion :** Brown fumes are produced when lead nitrate is heated because a displacement reaction takes place and lead is formed.

Reason : Nitrogen dioxide gas is produced as a by product.

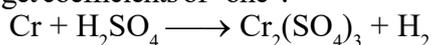
- (A) Both assertion and reason are true and reason is the correct explanation of assertion
 (B) Both assertion and Reason are true but reason is not the correct explanation of assertion.
 (C) Assertion is true but Reason is false.
 (D) Assertion is false but reason is true.

Q.85 **Assertion :** Iodine can't displace bromine from a solution because the reactivity of bromine is higher as compared to iodine.

Reason : Iodine is smaller than bromine and the outermost electrons are not influenced by the force of attraction exerted by the nucleus.

- (A) Both assertion and reason are true and reason is the correct explanation of assertion
- (B) Both assertion and Reason are true but reason is not the correct explanation of assertion.
- (C) Assertion is true but Reason is false.
- (D) Assertion is false but reason is true.

Q.86 Assertion : Balance the following equation with the smallest whole number coefficients. Choose the answer that is the sum of the coefficients, in the balanced equation. Do not forget coefficients of "one".



The sum of the coefficients, representing the smallest whole number coefficient is 9.

Reason : The equation can be balanced in many ways.

- (A) Both assertion and reason are true and reason is the correct explanation of assertion
- (B) Both assertion and Reason are true but reason is not the correct explanation of assertion.
- (C) Assertion is true but Reason is false.
- (D) Assertion is false but reason is true.

Q.87 Assertion : Decomposition of vegetable matter into compost is an example of exothermic reactions.

Reason : Exothermic reaction are those reactions in which heat is evolved.

- (A) Both assertion and reason are true and reason is the correct explanation of assertion
- (B) Both assertion and Reason are true but reason is not the correct explanation of assertion.
- (C) Assertion is true but Reason is false.
- (D) Assertion is false but reason is true.

EXERCISE - III

Subjective Stuff



VERY SHORT TYPE QUESTIONS:

- Q.1** What is the colour of fresh crystals of ferrous sulphate?
- Q.2** Name the type of reaction when ferrous sulphate is heated.
- Q.3** What is the formula of crystalline ferrous sulphate?
- Q.4** Name the gases evolved when ferrous sulphate crystals are heated strongly.
- Q.5** What is the colour of the residue obtained when crystals of ferrous sulphate are heated strongly in air? What is its chemical composition?
- Q.6** What are thermal decomposition reactions?
- Q.7** Give an example of thermal decomposition reaction.
- Q.8** Can the heating of ferrous sulphate be classified as redox reaction?
- Q.9** What is the smell of the gases evolved when crystals of ferrous sulphate are heated strongly?
- Q.10** What happens when crystals of ferrous sulphate are kept exposed to atmosphere for a long time?
- Q.11** State an example of each an endothermic and exothermic reaction.
- Q.12** To prevent rancidity of foods containing fats and oils, some substances are added to them. What are these substances called.
- Q.13** Why burning of a candle wax is considered a chemical change?
- Q.14** Give reason that moist air and acidic gases are not good for some metals.
- Q.15** Why does white coloured silver chloride turn grey when kept in sunlight?
- Q.16** Give one industrial application of reduction.

SHORT TYPE QUESTIONS:

- Q.17** Identify the type of chemical reaction and also write the chemical equation for the reaction that takes place when a solution of potassium chloride is mixed with silver nitrate solution. Write the chemical name of one of the products obtained.
- Q.18** Identify the type of each of the following reactions. Also write balanced chemical equation for each.
(a) The reaction mixture becomes warm.
(b) An insoluble substance is formed.
- Q.19** Write the balanced chemical equation for the following reaction and identify the type of reaction and define it.
'Iron(III) oxide reacts with aluminium and gives molten iron and aluminium oxide.'
- Q.20** Write two observations that you will make when an iron nail is kept in an aqueous solution of copper sulphate. Write the chemical equation for this reaction.
- Q.21** Identify the type of each of the following reactions :
(a) A reaction in which a single product is formed from two or more reactants.
(b) The reaction mixture becomes warm.
(c) An insoluble substance is formed.
(d) External surface of the container in which reaction takes place becomes freezing/cold.
- Q.22** Explain giving chemical equation any two uses of chemical decomposition reaction in industry.
- Q.23** Classify the following as exothermic and endothermic reactions:
(a) Photosynthesis
(b) Respiration
(c) Burning of natural gas
(d) Electrolysis of water.

- Q.24** Write two examples of everyday life, where redox reactions are taking place.
- Q.25** (i) When a metal 'X' is added to salt solution of a metal 'Y', following chemical reaction takes place :

$$\text{Metal X} + \text{Salt solution of 'Y'} \longrightarrow \text{Salt solution of 'X'} + \text{Metal 'Y'}$$
(ii) Mention the inference you draw regarding the reactivity of metal 'X' and 'Y' and also about the type of reaction. State the reason of your conclusions.
- Q.26** On heating blue coloured powder of copper (II) nitrate in a boiling tube, copper oxide (black), oxygen gas and a brown gas X is formed.
(a) Write a balanced chemical equation of the reaction.
(b) Identify the brown gas X evolved.
(c) Identify the type of reaction.
(d) What could be the pH range of aqueous solution of the gas X ?
- Q.27** $\text{MnO}_2 + 4\text{HCl} \longrightarrow \text{MnCl}_2 + 2\text{H}_2\text{O} + \text{Cl}_2$
Identify the substance in the above reaction which is :
(i) Oxidised (ii) reduced
(iii) oxidising agent (iv) reducing agent

LONG TYPE QUESTIONS:

- Q.28** What is meant by balanced chemical equation ? Why chemical equations are balanced? Balance the chemical equation given below :

$$\text{Al}_2\text{O}_3 + \text{NaOH} \longrightarrow \text{NaAlO}_2 + \text{H}_2\text{O}$$
- Q.29** What is meant by a skeletal chemical equation?
What does it represent? Using the equation for electrolytic decomposition of water, differentiate between a skeletal chemical equation and a balanced chemical equation.
• Skeletal chemical equation is an unbalanced chemical equation.
• It represents a chemical reaction.

$$\text{H}_2\text{O} \xrightarrow{\text{Electricity}} \text{H}_2 + \text{O}_2 \rightarrow \text{Skeletal}$$

$$2\text{H}_2\text{O} \xrightarrow{\text{Electricity}} 2\text{H}_2 + \text{O}_2 \rightarrow \text{Balanced}$$
- Q.30** Write two observations each for the following chemical reactions :
(a) Dilute sulphuric acid is poured over zinc granules.
(b) Potassium iodide solution is added to lead nitrate solution
(c) Lead nitrate is strongly heated in a hard glass test tube.

- Q.31** Consider the following reaction :

$$\text{Pb}(\text{NO}_3)_2(\text{s}) \xrightarrow{\text{Heat}} \text{PbO}(\text{s}) + \text{NO}_2(\text{g}) + \text{O}_2(\text{g})$$
(a) Name the gases produced in the above reaction.
(b) Balance the above chemical equation.
(c) Name the type of chemical reaction.
- Q.32** Give three examples to indicate the role of decomposition reactions in metal industries.
- Q.33** In the electrolysis of water :
(i) Name the gas collected at the cathode and anode respectively.
(ii) Why is the volume of one gas collected at one electrode double that at the other ? Name this gas
(iii) How will you test the evolved gases ?
- Q.34** A magnesium ribbon is burnt in oxygen to give a white compound X accompanied by emission of light. If the burning ribbon is now placed in an atmosphere of nitrogen, it continues to burn and forms a compound Y.
(a) Write the chemical formulae of X and Y.
(b) Write a balanced chemical equation when X is dissolved in water.
- Q.35** Point out the oxidising and reducing agents in the following reactions:

$$\text{SO}_2 + 2\text{HNO}_3 \longrightarrow \text{H}_2\text{SO}_4 + 2\text{NO}_2$$
- Q.36** "Oxidation and reduction processes occur simultaneously." Justify this statement with the help of an example. [CBSE]
- Q.37** Write the balanced chemical equations for the following reactions and identify the type of reaction in each case.
(a) Nitrogen gas is treated with hydrogen gas in the presence of a catalyst 773 K to form ammonia gas.
(b) Sodium hydroxide solution is treated with acetic acid to form sodium acetate and water.
(c) Ethanol is warmed with ethanoic acid to form ethyl acetate in the presence of concentrated H_2SO_4 .
(d) Ethene is burnt in the presence of oxygen to form carbon dioxide, water and release heat and light.
(e) Thermit reaction, iron (III) oxide reacts with aluminium and gives molten iron and aluminium oxide.

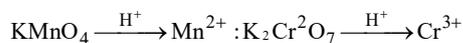
- Q.38** List three effects of oxidation in our daily life. Are these effects useful or harmful? Justify.
- Q.39** What happens when zinc granules are treated with dilute solution of H_2SO_4 , HCl , HNO_3 , NaCl and NaOH , also write the chemical equations if reaction occurs.
- Q.40** (i) Solid calcium oxide was taken in a container and water was added slowly to it :
(a) Write the observation.
(b) Write the chemical formula of the product formed.
(ii) What happens when carbon dioxide gas is bubbled through lime water:
(a) in small amount?
(b) in excess?
(iii) Why do you apply paint on iron articles?
- Q.41** Balance the following chemical equations and identify the type of chemical reaction:
(a) $\text{Mg(s)} + \text{Cl}_2(\text{g}) \rightarrow \text{MgCl}_2(\text{s})$
(b) $\text{HgO(s)} \xrightarrow{\text{Heat}} \text{Hg(l)} + \text{O}_2(\text{g})$
(c) $\text{Na(s)} + \text{S(s)} \xrightarrow{\text{Fuse}} \text{Na}_2\text{S(s)}$
(d) $\text{TiCl}_4(\text{l}) + \text{Mg(s)} \longrightarrow \text{Ti(s)} + \text{MgCl}_2(\text{s})$
(e) $\text{H}_2\text{O}_2(\text{l}) \xrightarrow{\text{UV}} \text{H}_2\text{O(l)} + \text{O}_2(\text{g})$

EXERCISE-IV

Competitive Edge



- Q.1** What is the ratio of number of electrons gained by acidified KMnO_4 and acidified in the reaction given below



- (A) 5:6 (B) 6:5
(C) 3:5 (D) 5:3

- Q.2** Sati was studying neutralisation reaction. She accidentally dropped 'x' grams of sodium carbonate monohydrate into a 100 ml solution of HCl whose concentration was taken and titrated against 0.05M NaOH solution to yields a titre value of 20mL. What is the value of 'x'.

- (A) 186mg (B) 93mg
(C) 1860mg (D) 930mg

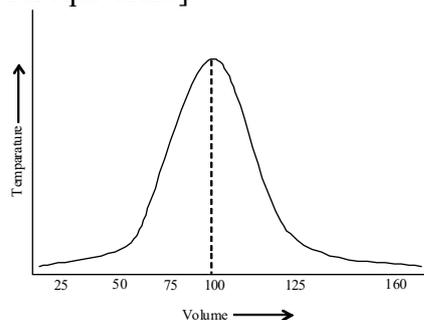
- Q.3** Oxygen exhibits (-1) oxidation state in

- (A) OF_2 (B) H_2O
(C) H_2O_2 (D) HClO

- Q.4** Oxidation number and co-ordination number of Pt in cisplatin $\text{PtCl}_2(\text{NH}_3)_2$ are respectively

- (A) +4 and 2 (B) +2 and 4
(C) 0 and 4 (D) +2 and 6

- Q.5** Mayuri was performing thermometric titration and she took 100ml of 1 M sulphuric acid and started adding 1 M calcium hydroxide and she plotted a graph of temperature vs volume of the titrant added. In that experiment she found that temperature was initially increasing and then it started decreasing. The maximum of the graph is obtained at 100 ml. Calcium hydroxide. What will be the enthalpy change of this reaction. [Given $H = 13.7$ kcal for equivalent.]



- (A) -13.7 kcal (B) -27.4 kcal
(C) -1.37 kcal (D) -2.74 kcal

- Q.6** The mass percent of MnO_2 in a sample of a mineral is determined by reacting it with a measured excess of As_2O_3 in acid solution, and then titrating the remaining As_2O_3 with standard KMnO_4 . A 0.225 g sample of the mineral is ground and boiled with 75.0 mL of 0.0125 M As_2O_3 solution containing 10 mL of concentrated sulfuric acid. After the reaction is complete, the solution is cooled, diluted with water, and titrated with 2.25×10^{-3} M KMnO_4 , requiring 16.00 mL to reach the endpoint.

Note : 5 mol of As_2O_3 react with 4 mol of MnO_4^-

- Write a balanced equation for the reaction of As_2O_3 with MnO_2 in acid solution. The products are Mn^{2+} and AsO_4^{3-} .
- Calculate the number of moles of
 - As_2O_3 added initially.
 - MnO_4^- used to titrate the excess As_2O_3
 - MnO_2 in the sample.
 - Determine the mass percent of MnO_2 in the sample.
 - Describe how the endpoint is selected in the KMnO_4 titration

EXERCISE-V

Board Navigator



- Q.1** Sodium reacts with water to form sodium hydroxide and hydrogen gas. The balanced equation which represents the above reaction is (2021-2022)
- (a) $\text{Na}_{(s)} + 2\text{H}_2\text{O}_{(l)} \rightarrow 2\text{NaOH}_{(aq)} + 2\text{H}_{2(g)}$
 (b) $2\text{Na}_{(s)} + 2\text{H}_2\text{O}_{(l)} \rightarrow 2\text{NaOH}_{(aq)} + \text{H}_{2(g)}$
 (c) $2\text{Na}_{(s)} + 2\text{H}_2\text{O}_{(l)} \rightarrow \text{NaOH}_{(aq)} + 2\text{H}_{2(g)}$
 (d) $2\text{Na}_{(s)} + \text{H}_2\text{O}_{(l)} \rightarrow 2\text{NaOH}_{(aq)} + 2\text{H}_{2(g)}$
- Q.2** It is important to balance the chemical equations to satisfy the law of conservation of mass. Which of the following statements of the law is incorrect? (2021-2022)
- (a) The total mass of the elements presents in the reactants is equal to the total mass of the elements presents in the products.
 (b) The number of atoms of each element remains the same, before and after a chemical reaction.
 (c) The chemical composition of the reaction is the same before and after the reaction.
 (d) Mass can neither be created nor can it be destroyed in a chemical reaction
- Q.3** In which of the following the identity of initial substance remains unchanged? (2020)
- (a) Curdling of milk
 (b) Formation of crystals by process of crystallisation
 (c) Fermentation of grapes
 (d) Digestion of food
- Q.4** Identify 'X', 'Y' and 'Z' in the following reaction: (2020)
- $$2\text{KClO}_{3(x)} \xrightarrow{Y} 2\text{KCl}_{(y)} + \text{O}_{2(l)}$$
- (a) x = gas; y = reaction condition, z = gas
 (b) x = solid; y = liquid, z = gas
 (c) x = number of moles KClO_3 ;
 y = reaction condition,
 z = number of molecules of oxygen
 (d) x = physical state of KClO_3 and KCl ;
 y = reaction condition,
 z = physical state of O_2
- Q.5** Assertion (A) : following is a balanced chemical equation for the action of steam on iron: (2020)
- $$3\text{Fe} + 4\text{H}_2\text{O} \rightarrow \text{Fe}_3\text{O}_4 + 4\text{H}_2$$
- Reason (R) : The law of conservation of mass holds good for a chemical equation.
- (a) Both (A) and (R) are true and reason (R) is correct explanation of the assertion (A).
 (b) Both (A) and (R) are true, but reason (R) is not the correct explanation of the assertion
 (c) (A) is true, but (R) is false
 (d) (A) is false, but (R) is true
- Q.6** What is a balanced chemical equation? (2021)
- Q.7** Translate the following statement into a sulphate to give aluminium chloride and barium sulphate" (2019)
- Q.8** Give the chemical name of the reactants as well as the products of the following chemical equation: (2021)
- $$\text{HNO}_3 + \text{Ca}(\text{OH})_2 \rightarrow \text{Ca}(\text{NO}_3)_2 + \text{H}_2\text{O}$$
- Q.9** Explain the significance of photosynthesis. Write the balanced chemical equation involved in the process. (2017)
- Q.10** Write balanced chemical equations for the following chemical reactions: (2017)
- (a) Hydrogen + Chlorine \rightarrow Hydrogen chloride
 (b) Lead + Copper chloride \rightarrow Lead chloride + Copper
 (c) Zinc oxide + Carbon \rightarrow Zinc + Carbon monoxide
- Q.11** When aqueous solutions of potassium iodide and lead nitrate are mixed an insoluble substance separates out. The chemical equation for the reaction involved is (2017)
- (a) $\text{KI} + \text{PbNO}_3 \rightarrow \text{PbI} + \text{KNO}_3$
 (b) $2\text{KI} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{PbI}_2 + 2\text{KNO}_3$
 (c) $\text{KI} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{PbI} + \text{KNO}_3$
 (d) $\text{KI} + \text{PbNO}_3 \rightarrow \text{PbI}_2 + \text{KNO}_3$

- Q.12** A metal ribbon 'X' burns in oxygen with a dazzling white flame forming a white ash 'Y'. The correct description of X, Y and the type of reaction is **(2023)**
- (a) $X = Ca$; $Y = CaO$;
Type of reaction = Decomposition
- (b) $X = Mg$; $Y = MgO$;
Type of reaction = Combination
- (c) $X = Al$; $Y = Al_2O_3$;
Type of reaction = Thermal decomposition
- (d) $X = Zn$; $Y = ZnO$;
Type of reaction Endothermic
- Q.13** The balanced chemical equation showing reaction between quick lime and water is **(2023)**
- (a) $2CaO + H_2O \rightarrow 2CaOH + H_2 + \text{Heat}$
- (b) $CaO + H_2O \rightarrow Ca(OH)_2 + H_2 + \text{Heat}$
- (c) $CaO + H_2O \rightarrow Ca(OH)_2 + \text{Heat}$
- (d) $2CaO + 3H_2O \rightarrow 2Ca(OH)_3 + O_2 + \text{Heat}$
- Q.14** Study the following chemical reaction :
 $2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)} \uparrow$
 The reducing agent in this reaction is **(2023)**
- (A) Na (B) H_2O
 (C) NaOH (D) H_2
- Q.15** **Assertion (A)** : In the following reaction
 $ZnO + C \rightarrow Zn + CO$
 ZnO undergoes reduction.
Reason (R) : Carbon is reducing agent that reduces ZnO to Zn. **(2023)**
- (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)
- (B) Both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of the Assertion (A)
- (C) Assertion (A) is true, but Reason (R) is false.
- (D) Assertion (A) is false, but Reason (R) is true.
- Q.16** **Assertion (A)** : Reaction of quick lime with water is an exothermic reaction.
Reason (R) : Quicklime reacts vigorously with water releasing a large amount of heat. **(2023)**
- (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)
- (B) Both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of the Assertion (A)
- (C) Assertion (A) is true, but Reason (R) is false.
- (D) Assertion (A) is false, but Reason (R) is true.
- Q.17** A student took sodium sulphate solution in a test tube and added barium chloride solution to it. He observed that an insoluble substance has formed. The colour and molecular formula of the insoluble substance is **(2021-2022)**
- (A) grey, Ba_2SO_4
- (B) yellow, $Ba(SO_4)_2$
- (C) white, $BaSO_4$
- (D) pink, $BaSO_4$
- Q.18** $C_6H_{12}O_{6(aq)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)}$
 The above reaction is a/an **(2021-2022)**
- (A) displacement reaction
- (B) endothermic reaction
- (C) exothermic reaction
- (D) neutralisation reaction
- Q.19** Which of the following statement about the reaction given below are correct?
 $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$
- (i) HCl is oxidized to Cl_2 . **(2022-2023)**
- (ii) MnO_2 is reduced to $MnCl_2$.
- (iii) $MnCl_2$ acts as an oxidizing agent.
- (iv) HCl acts as an oxidizing agent.
- (A) (ii), (iii) and (iv)
- (B) (i), (ii) and (iii)
- (C) (i) and (ii) only
- (D) (iii) and (iv) only
- Q.20** Which one of the following reactions is categorised as thermal decomposition reaction? **(2023)**
- (A) $2H_2O_{(l)} \rightarrow 2H_{2(g)} + O_{2(g)}$
- (B) $2AgBr_{(s)} \rightarrow 2Ag_{(s)} + Br_{2(g)}$
- (C) $2AgCl_{(s)} \rightarrow 2Ag_{(s)} + Cl_{2(g)}$
- (D) $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$

ANSWER KEY

EXERCISE-II

Q.1	A	Q.2	D	Q.3	C	Q.4	D	Q.5	A	Q.6	C	Q.7	B
Q.8	C	Q.9	B	Q.10	C	Q.11	C	Q.12	D	Q.13	C	Q.14	B
Q.15	B	Q.16	C	Q.17	C	Q.18	C	Q.19	A	Q.20	D	Q.21	B
Q.22	D	Q.23	B	Q.24	D	Q.25	B	Q.26	B	Q.27	C	Q.28	A
Q.29	D	Q.30	A	Q.31	B	Q.32	D	Q.33	B	Q.34	C	Q.35	C
Q.36	D	Q.37	C	Q.38	A	Q.39	D	Q.40	D	Q.41	D	Q.42	D
Q.43	D	Q.44	D	Q.45	C	Q.46	C	Q.47	C	Q.48	B	Q.49	B
Q.50	B	Q.51	A	Q.52	D	Q.53	A	Q.54	C	Q.55	A	Q.56	D
Q.57	C	Q.58	B	Q.59	A	Q.60	C	Q.61	D	Q.62	C	Q.63	A
Q.64	B	Q.65	C	Q.66	C	Q.67	B						

FILL IN THE BLANKS :Q.68 1×10^{-2}

Q.69 Electrolytic decomposition

Q.70 irrecersible

Q.71 CaCO_3

Q.72 Endothermic

TRUE / FALSE QUESTION:

Q.73 False

Q.74 False

Q.75 False

Q.76 False

Q.77 False

MATCH THE FOLLOWING:

Q.78 D

Q.79 B

Q.80 A

Q.81 C

Q.82 D

ASSERTION & REASON TYPE QUESTIONS:

Q.83 D

Q.84 D

Q.85 C

Q.86 B

Q.87 A

EXERCISE-IV

Q.1 B

Q.2 D

Q.3 D

Q.4 D

Q.5 B

Q.6 A

1. INTRODUCTION

- **Life processes** : All the living organisms including humans perform a number of activities such as nutrition, respiration, excretion, growth & reproduction. These activities are characteristics of living organism & help in maintenance of life. These maintenance functions of living organisms are known as **life processes**.

➤ Some Characteristic of living organisms

- Cellular organization** : All organisms are made up of cells.
- Sensitivity** : Giving response to stimuli (Stimulus = change in environment) (Response = visible effect because of stimulus) Consciousness is one of the most important definite life feature. *eg.* Plants grows towards light, pupil dilate in dark etc.
- Respiration & Energy utilization**: Respiration is the process in which nutrients are converted into useful energy in a cell. Energy produced during respiration is used to perform many kinds of works with in the body.
- Internal growth**:It is characteristic feature of livings.
- Homeostasis**: All organism maintain relatively constant internal conditions in different environments, known as homeostasis.
- Regulation**: All organism have neural or chemical regulatory mechanism that co-ordinate internal processes.
- Reproduction**: It is a process of producing young ones of their own kinds. Heredity character are passed from parent to the offsprings during reproduction.
- Excretion** : A number of waste products are formed as by-products of metabolism. They are usually toxic and removed from the body.
- Irritability** : Every living organism is aware of its surroundings. It responds to changes in the environment.
- Metabolism**: The sum total of all the chemical & physical changes that are constantly taking place in living organisms & are necessary for life.

➤ Types of metabolic pathways

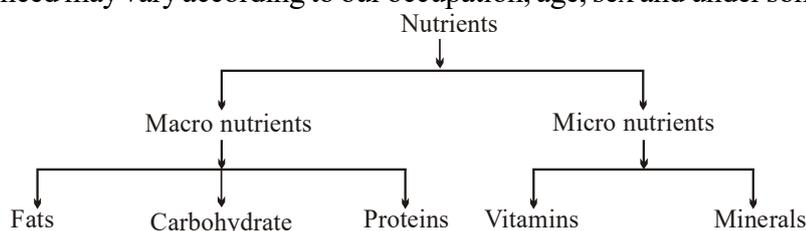
- Anabolic pathways** : Biosynthetic pathways, in which complex substances are synthesized from simpler ones. Ex : Photosynthesis (Endothermic reaction – energy is used)
- Catabolic pathways** : Break down of complex organic substances into simpler ones. Ex : Respiration. (Exothermic – energy released)

NUTRITION

"Nutrition" is a process of intake as well as utilization of nutrients by an organism. It is the process of breakdown of nutrients into smaller molecules and their absorption. Food provides us nutrition and energy. It contains different types of nutrients in varying amounts according to the need of our body.

➤ Nutrients :

These are the substances required by our body for its growth, repair, work and maintenance of the body. Different types of nutrients are carbohydrates, fats, proteins, vitamins, mineral etc. Our daily energy need may vary according to our occupation, age, sex and under some specific conditions.



2. MODES OF NUTRITION :

- There are several modes of nutrition on the basis of which organisms are classified as follows :

I. Autotrophic : (Auto = self, trophic = food)

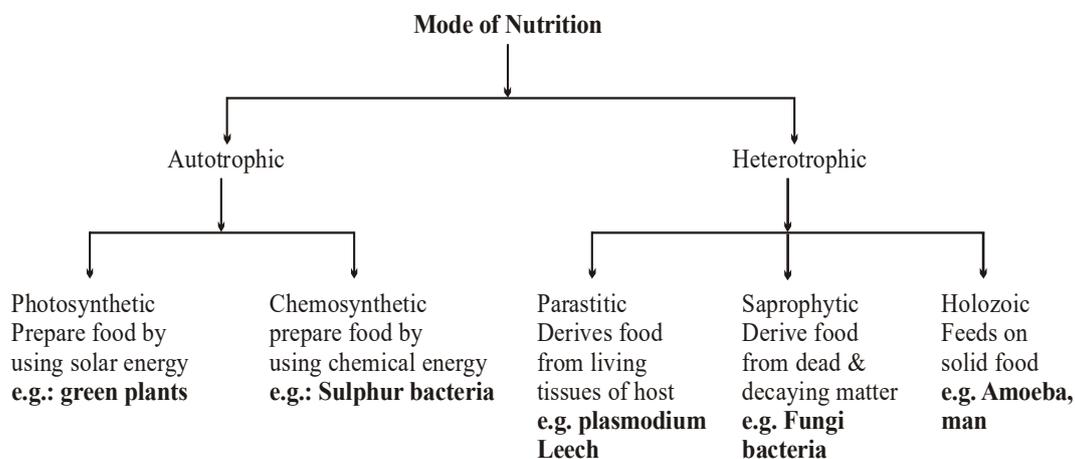
- It is a mode of nutrition in which organisms prepare their own food.
- Inorganic molecules like CO_2 and H_2O are converted into organic molecules like carbohydrates in the presence of sunlight and chlorophyll. e.g. Green plants. Autotrophs are further categorized. as:
 - (i) **Photoautotroph** : Those which utilize sunlight for preparing their food Ex. Green plants, Blue Green Algae
 - (ii) **Chemoautotroph** : Those which utilize chemical energy for preparing their food. Eg. Methane Bacteria, Sulphur Bacteria

II. HETEROTROPHIC : (Hetero = different ; trophic = food)

- It is a mode of nutrition in which organisms derive their food from some other animals or plants.
- They cannot prepare their own food e.g. human being. Heterotrophs are further categorized depending on the nature of food they consume :
 - (i) **Herbivores** : Animals which eat only plants, e.g. Cow, goat etc.
 - (ii) **Carnivores** : They feed on flesh of other animals, e.g. Lion, vulture etc.
 - (iii) **Omnivores** : They feed on plants and animals both e.g. Dog, human etc.
 - (iv) **Detritivores** : Feed on detritus or dead organic remains, e.g. Earthworm etc.
 - (v) **Sanguivorous** : Feed on blood e.g. Leech, female mosquito etc.
 - (vi) **Frugivorous** : Feed on fruits, e.g. Parrot etc.
 - (vii) **Insectivores** : Feed on insects, e.g. Bats etc.

➤ On the Basis of Mode of Feeding Organisms are Categorised As :

- (A) **Holozoic** : 'Holos' means entire and 'zoon' means animals.
Holozoic nutrition means 'feeding on solid food'. This solid food may be a plant product or an animal product.
In this mode of nutrition, an organism takes the complex organic food materials into its body by the process of ingestion, the ingested food is digested and then absorbed into the body cells.
E.g. : Man, frog, lizard, bird, and amoeba.
- (B) **Saprotrophic** : They absorb organic matter from dead and decaying organisms with the help of their enzymes. e.g., Bacteria, fungi etc.
- (C) **Parasitic** : They derive their nutrition from other living plants or animals e.g. Plasmodium, round worms, etc.



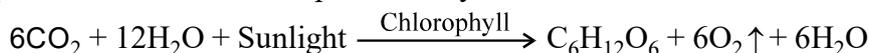
➤ Nutrition can be divided into two categories on the basis of occurrence.

1. Nutrition in plants

2. Nutrition in animals.

3. NUTRITION IN PLANTS

- Plant perform photosynthesis [Photo (light) and synthesis (Build up)]. **Photosynthesis is a process that converts carbon dioxide into organic compounds, especially sugars, using sunlight in presence of chlorophyll. Photosynthesis occurs in plants, algae, and many species of bacteria.** It is represented by:



- It takes place in every green part of plant mainly in the green leaves. Plants stores food in the form of **Starch**.



Let's know

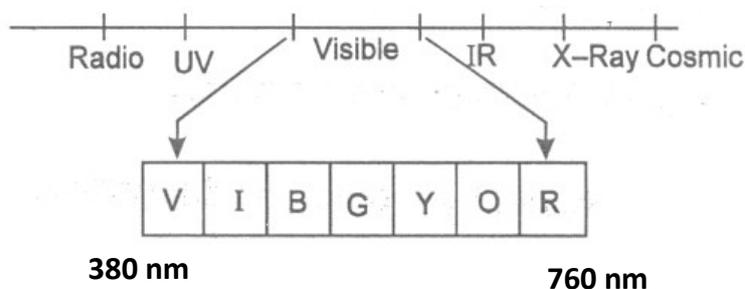
Stored food of plants - Starch

Stored foods of animals - Glycogen

➤ Factors involved in Photosynthesis

1. Sunlight :

- For plants, sun is the basic source of radiant energy.
- Plants utilize the light in the visible region of solar spectra (electromagnetic spectrum) which comes under the range of 380 nm - 780 nm.
- Visible region consists of white light which is a mixture of 7 lights of different wavelengths.



Note : Plants utilize carbon dioxide during photosynthesis. The intensity of light at which amount of CO_2 used during photosynthesis becomes equal to the amount of CO_2 released during respiration by plants in called as **Compensation point**.

Compensation point occurs at low light intensity that is during morning and during evening hours.

Sunlight \longrightarrow **V I B G Y O R**

Red/Orange \rightarrow Maximum Photosynthesis

Blue/violet \rightarrow Highest rate of absorption

Green \rightarrow Minimum photosynthesis because green parts of plants reflect whole of the green light.



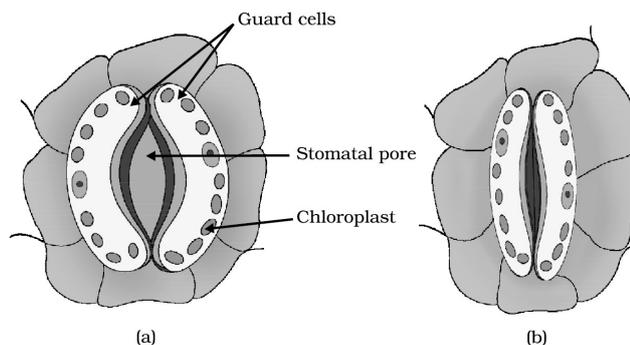
Let's know

Starch test : Requirement for photosynthesis can be tested by reaction between starch and iodine refer as starch test.

$\text{Starch} + \text{I}_2 \rightarrow \text{Blue Black Colour}$

2. Carbon-di-oxide :

- Terrestrial plants obtain carbon dioxide from the atmosphere through the small openings present on leaves called as **stomata**.
- They help in exchange of gases and water.
- Stomata opening is guarded by the presence of guard cells (kidney shaped).
- Aquatic plants obtain CO_2 dissolved in water through their general body surface so they perform more photosynthesis than terrestrial plants.



3. Chlorophyll :

These are the green pigments present in chloroplast. They are found in green leaves in a maximum amount as well as in other green aerial parts of plant. There are six different types of chlorophyll, they are chlorophyll a, b, c, d, e and bacteriochlorophyll, amongst them chlorophyll a and chlorophyll b are the most commonly occurring chlorophylls.

Besides chlorophyll certain other pigments are also present in plants like.

(i) **Carotenes** : Orange in colour e.g. Carrot.

(ii) **Xanthophylls** : Orange yellow in colour e.g. Maize.

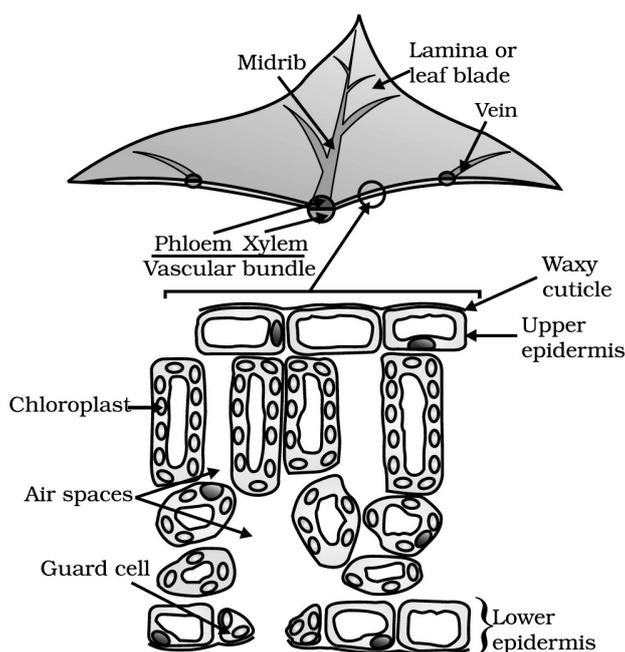
(iii) **Phycobilins** : Different colour like red, violet e.g. Blue-green algae, brown algae etc.

4. Water

Plants absorb water by root hairs from the soil by the process of osmosis which get transported upward through xylem to the leaves. It act as an important raw material.

➤ SITE OF PHOTOSYNTHESIS :

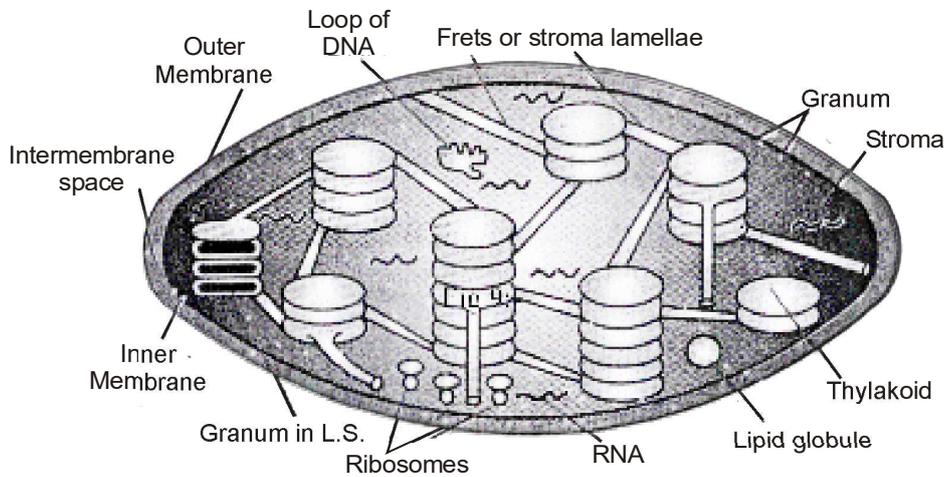
- The actual site of photosynthesis is chloroplast (cell organelle)
- **Leaf → Mesophyll tissue → Palisade / Spongy parenchyma → Chloroplast → Chlorophyll**
- Site of photosynthesis is different in prokaryotes and eukaryotes.
In prokaryotes – Photosynthesis occurs in lamellar chromatophores.
In eukaryotes – Photosynthesis occurs in chloroplast.
- **In higher plants** – Chloroplast is the main site of photosynthesis.



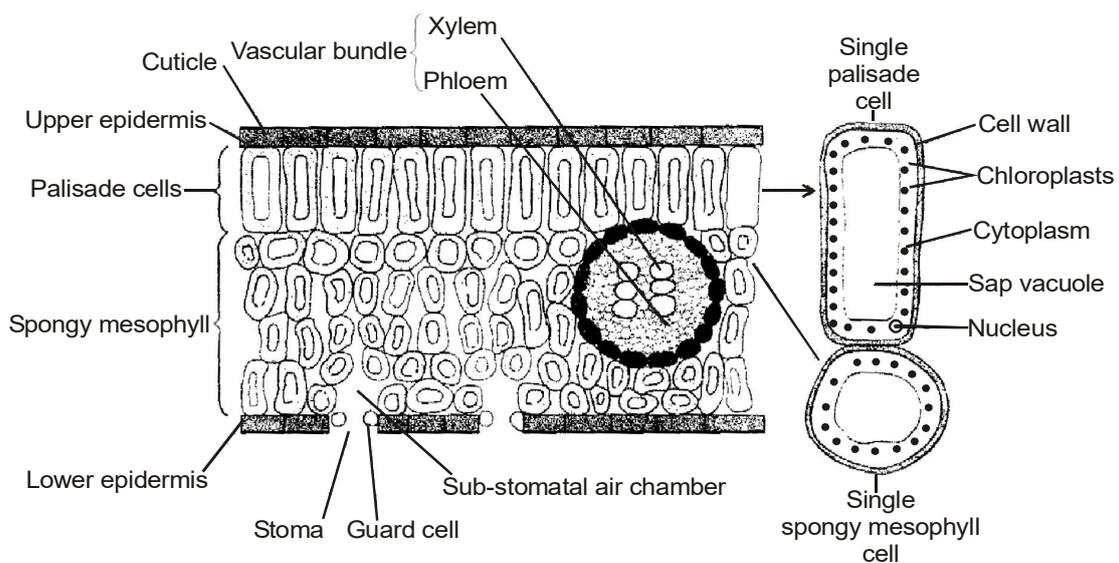


Let's know

- Chloroplast is also called as green plastid.
- Plastid was first observed by **Haeckel**.
- Plastids are of 3 different types on the basis of pigments present in them.
- (i) **Leucoplast** : White in colour, found in underground parts, lacks coloured pigment. Helps in storage of protein (Aleuroplst), oil (Elaioplast), starch (Amyloplast)
- (ii) **Chromoplast** : Colour other than green found in aerial parts on the plants.
- (iii) **Chloroplast** :
 - Contain green pigment, called as **chlorophyll**.
 - Chloroplast was discovered by **Schimper**.
 - Number of chloroplasts is variable in different species of plants.
 - In lower plants like algae they are 1 or 2 number.
 - In higher plants their number varies from 40 - 100 per palisade cell or more.
 - Chloroplast also have variable shapes, for example cup shaped, ribbon shaped etc. in algae while it is discoidal in higher plants.



Internal structure of chloroplast



The structure of a leaf showing chloroplast

- A typical structure of chloroplast is a double membranous structure having two parts.

(a) Grana :

- It is a lamellar system consisting of stacks of granum lamella each bounded by a membranous box called as **thylakoid**.
- They are 40 - 60 per cell. Number of thylakoids per grana is 50 or more Chlorophyll molecules are found inside the thylakoid membrane where they trap solar energy in the form of small energy packets called '**photon**' or '**quanta**'.
- Grana are interconnected to each other by a channel called as **stroma lamellae** or **Fret's channel**.

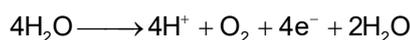
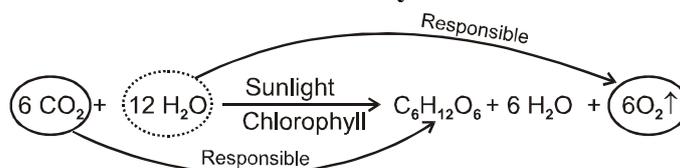
(b) Stroma :

- It is a non pigmented proteinaceous matrix in which grana remain embedded. It contain enzymes for dark reaction.

➤ **MECHANISM OF PHOTOSYNTHESIS :**

Mechanism of photosynthesis : It consists of following steps

- (i) Photo excitation of chlorophyll molecule :** During this process chlorophyll molecule receives sunlight in the form of small energy bundles called as **photons** and become excited to higher energy level.
- (ii) Photolysis of water :** It is also called as photo-oxidation of water. This takes place in presence of Mn^{+2} and Cl^{-} ions.

**(iii) Reduction of carbon dioxide to carbohydrates**

- Water is responsible for evolution of oxygen.

**Let's know**

Photosynthesis occurs in two steps -

- (1) Light reaction - (i) In the presence of light (ii) In grana of chloroplast
- (2) Dark reaction - (i) In presence or absence of light (ii) In stroma of chloroplast.

➤ **FACTORS AFFECTING PHOTOSYNTHESIS :****(a) Light :**

- Normally plants utilize sunlight but marine algae can perform photosynthesis even in the moon light.
- Plants can also perform photosynthesis in the artificial lights.
- Highest rate of photosynthesis : Red light
- Minimum photosynthesis : Green light
- Very high light intensity can cause reduction in the rate of photosynthesis by causing
 - (i) Decrease in transpiration rate
 - (ii) Denaturation of chlorophyll molecule

(b) Temperature :

- Optimum range = $25^{\circ}C$ to $30^{\circ}C$
- It ranges from $10^{\circ}C$ - $40^{\circ}C$
- In some forms like algae of hot spring $60^{\circ}C$ - $70^{\circ}C$ is normal

(c) Carbon dioxide :

- It is the raw material for the formation of glucose. Land plants obtain CO_2 from the atmosphere through the stomata. The aquatic plants get their CO_2 as bicarbonates through their general surface.
- CO_2 used by the green plants during photosynthesis is released due to respiration in green plants and other organisms.
- Hence, we say that photosynthesis and respiration are antagonistic to each other.
- It has been proved experimentally that an increase in CO_2 concentration up to 0.5 percent may cause increase in photosynthesis but only for a limited time period provided other conditions remain constant.

(d) Oxygen :

- O_2 acts as competitive inhibitor of CO_2 . Over concentration of O_2 stops photosynthesis.

(e) Chlorophyll :

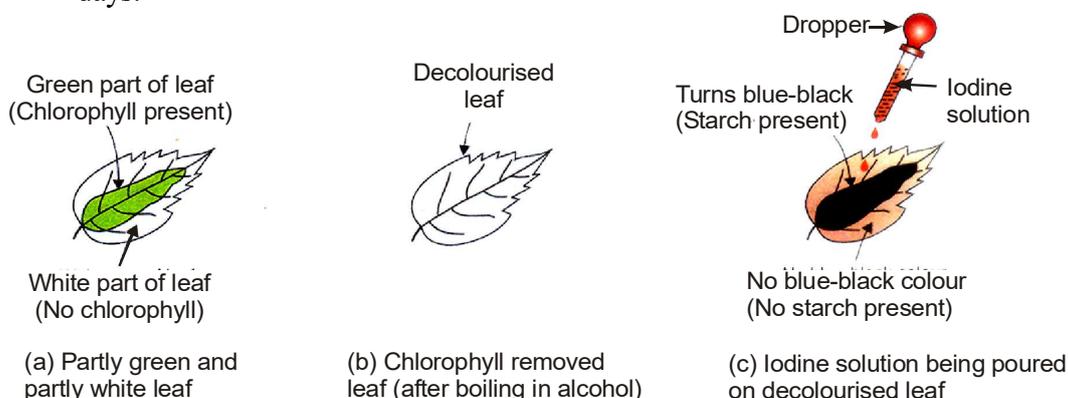
- Chlorophyll content is directly proportional to rate of photosynthesis. No photosynthesis occurs in etiolated cells, In variegated leaves it occurs only at places where chlorophyll is present.

➤ SIGNIFICANCE OF PHOTOSYNTHESIS :

- Photosynthesis is a boon to the nature and to the human beings. It has following significance :
 - (i) Production of food material
 - (ii) Atmospheric control and purification of air.

➤ Activities related to photosynthesis**(i) Experiment to show that chlorophyll is necessary for the process of photosynthesis**

- Take a potted plant like croton plant or variegated leaves whose leaves are partly green and partly white. The green part of the leaf has chlorophyll but the white part of the leaf does not have chlorophyll.
- Place this plant in a completely dark place for about three days to destarch its leaves.
- Take out the potted plant from the dark place and keep it in bright sunshine for three to four days.

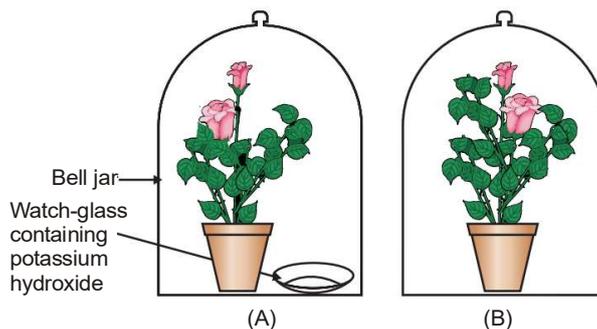
**Experiment to show that chlorophyll is necessary for photosynthesis**

- Boil these leaves in water for a few minutes and then remove its green colour 'chlorophyll' by boiling it in alcohol. The green parts of the leaf get decolourised.
- Wash the decolourised leaf with hot water to soften it and remove any chlorophyll.
- Pour iodine solution over the colourless leaf and observe the change in colour of the leaf.
- The outer part of leaf that was originally white (without chlorophyll) does not turn blue-black on adding iodine solution showing that no starch is present in this outer part of the leaf.
- From this observation, **we conclude that the photosynthesis to make starch does not take place without chlorophyll.**
- The inner part of leaf which was originally green (contained chlorophyll) turns blue-black on adding iodine solution showing that starch is present in this inner part of the leaf. From this observation **we conclude that the process of photosynthesis to make starch takes place in the presence of chlorophyll.**

(ii) Experiment to show that carbon dioxide is necessary for the photosynthesis

- Take two healthy potted plants which are nearly the same size.
- Keep them in a dark room for three days.
- Now place each plant on separate glass plates.
- Place a watch-glass containing potassium hydroxide by the side of one of the plants. The potassium hydroxide is used to absorb carbon dioxide.
- Cover both plants with separate bell-jars as shown in figure.
- Use vaseline to seal the bottom of the jars to the glass plates so that the set-up is air-tight.
- Keep the plants in sunlight for about two hours.
- Pluck a leaf from each plant and check for the presence of starch with iodine solution.

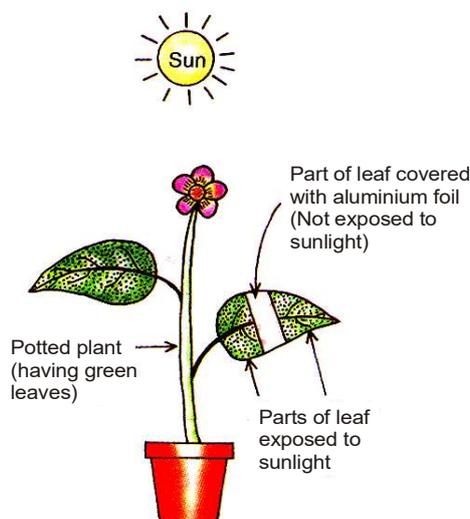
➤ **We conclude that only leaf from the plant which was kept without KOH will show blue color as CO_2 has not been absorbed so available for photosynthesis.**



Experimental set-up
(a) with potassium hydroxide
(b) without potassium hydroxide

(iii) Experiment to show that sunlight is necessary for the process of photosynthesis.

- Take a potted plant and destarch its leaves by keeping it in dark for 2-3 days.
- Take a thin strip of aluminium foil (or black paper) and wrap it in the centre of one leaf on both the sides (while the leaf is still attached to the plant). The aluminium foil should be fixed tightly to the leaf that sunlight may not enter it from the sides. The aluminium foil should cover only a small part of the leaf so that the remaining part of the leaf remains uncovered and exposed to sunlight
- Place the plant in sunlight for three to four days and then again test for starch.
- Positive starch test will be obtained only in the portion of leaf exposed to light and negative test in parts with aluminium foil. **We conclude that sunlight is necessary for photosynthesis to make food like starch.**



Potted plant with one leaf partly covered with aluminium foil and kept in sunlight.

Experiment to show that light is essential for photosynthesis

➤ NUTRITION IN ANIMALS :

- Animal are heterotrophs (consumers). They depend upon plants or animals for food and can not synthesize their own food.

➤ Process of Nutrition in Animals : -

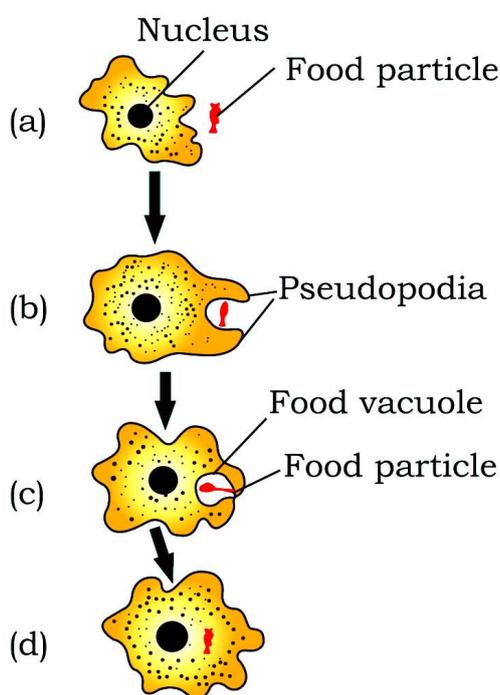
- **Ingestion** : The process of intake of food.
 - **Digestion** : It is the breakdown of large and complex molecules into simpler, smaller and soluble forms.
 - **Absorption** : Taking up of the digested food through intestinal wall to blood or body fluid.
 - **Assimilation** : In this process absorbed food is taken by body cells.
 - **Egestion** : The process by which undigested matter is expelled out.
- Ingestion → Digestion → Absorption → Assimilation → Egestion

1. Nutrition in Amoeba :

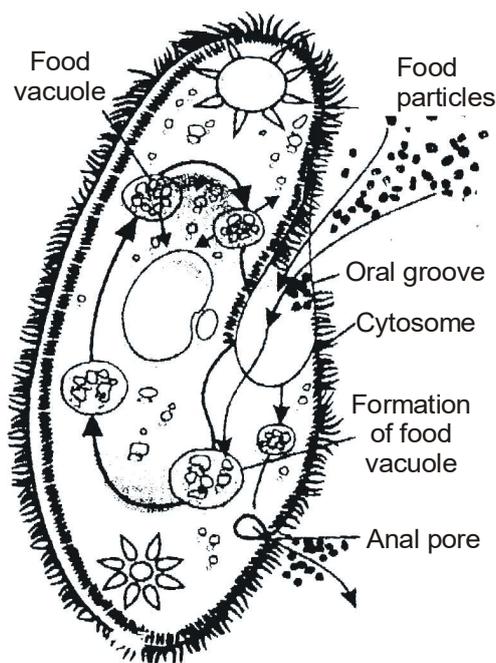
- Amoeba is holozoic (takes solid food). It is omnivorous i.e. it ingests all kinds of aquatic micro-organisms like bacteria, diatoms, algae, other protozoans, etc.

➤ Steps of Nutrition in amoeba

- Ingestion:** Food is taken in with help of pseudopodia
- Digestion:** Intracellular with help of enzymes present in lysosomes.
- Absorption and Assimilation
- Egestion:** Undigested food thrown out

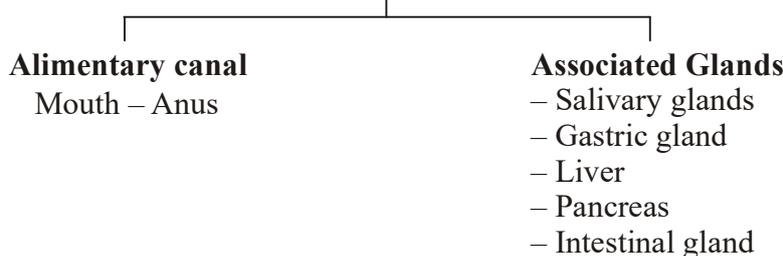


- 2. Nutrition in Paramecium :** Paramecium, is also a unicellular organism that lives in water. The cell has a definite shape and food is taken in at a specific spot. Food is moved to this spot by the movement of cilia which cover the entire surface of the cell. Fine food particles enter through the cell mouth and are rapped of in the food vacuole. This is the first step of the nutrition, called ingestion. Ingestion is followed by other steps such as digestion, asorption, assimilation and egestion .

Nutrition in *Paramecium*

3. Nutrition in Human Being

Human Digestive System



Mouth → Pharynx → Oesophagus → Stomach → Duodenum → Jejunum → Ileum → Caecum → Colon → Rectum → Anus

➤ DIGESTIVE SYSTEM OF MAN

- All the organs that are responsible for the intake of food, its digestion, assimilation and removal of the undigested waste in an organism constitute the digestive system. It is made up of :
 1. Alimentary canal
 2. Associated digestive glands

1. ALIMENTARY CANAL

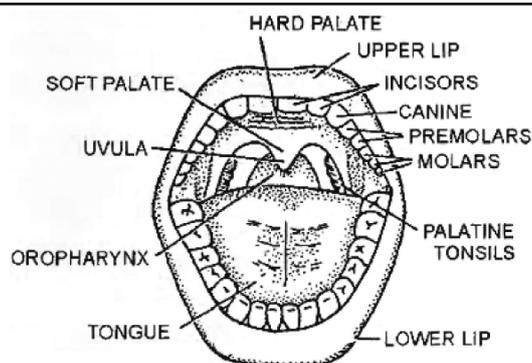
Buccal Cavity -

- It is an organ of ingestion, mastication and swallowing of food.
- It consists of teeth, tongue, palate and its muscles. It opens outside through the mouth aperture.
- It lies below the nasal cavity and is separated from it by the palate.
- The hard palate forms the roof of the mouth and continues posteriorly into soft palate.
- The extension of soft palate in the form of uvula can be seen in an open mouth.
- Internally the buccal cavity is lined with mucous membrane containing mucus glands.
- There are 3 pairs of salivary glands which pour their secretions in the form of saliva in the mouth i.e.

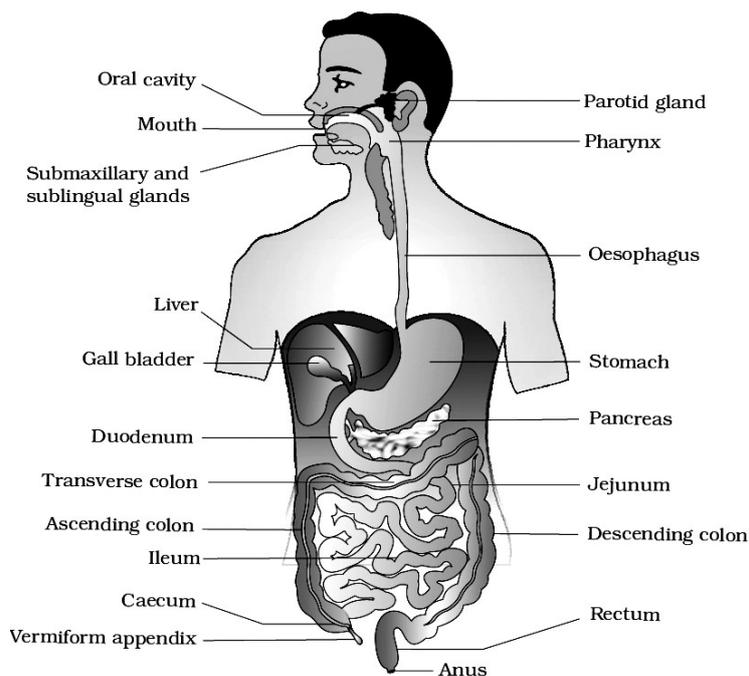
1. Parotid gland

2. Submandibular

3. Sub lingual



Buccal Cavity of Man



Human Digestive System

- **Teeth -**
Jaws present in buccal cavity are provided with four different types of teeth (**Heterodont**):
- | | | |
|-----------|---|--------------|
| Incisors | : | For cutting |
| Canines | : | For tearing |
| Premolars | : | For grinding |
| Molars | : | For grinding |
- **Dental formula of humans :** In human beings two set of teeth appear during their life time (**Diphyodont**)-
- (A) **Milk teeth :** These are temporary , arise at 6 – 11 month age, 20 in number
- $$\frac{\text{Half upper jaw}}{\text{Half lower jaw}} = i \frac{2}{2}, c \frac{1}{1}, pm \frac{0}{0}, m \frac{2}{2}$$
- (B) **Permanent teeth :** In adults
- $$\frac{\text{Half upper jaw}}{\text{Half lower jaw}} = i \frac{2}{2}, c \frac{1}{1}, pm \frac{2}{2}, m \frac{3}{3}$$
- **Tongue-**
- At the floor of the oral cavity is present a musculo-sensory organ, the tongue.
 - It has voluntary muscles and is richly supplied with blood vessels and sensory neurons.
 - Upper surface of the tongue bears numerous papillae that contains **taste buds**.
 - Tongue is not only an organ of taste but also helps in swallowing the food and is essential for speech.



Let's know

Dental Caries : The hard, outer covering of a tooth is called enamel. Tooth enamel is the hardest material in our body. It is harder than even bones.

The part of tooth below enamel is called dentine. Dentine is similar to bone. Inside the dentine is pulp cavity. The pulp cavity contains nerves and blood vessel. The formation of small cavities (or holes) in the teeth due to the action of acid-forming bacteria and improper dental care is called **Dental caries**. If the teeth are not cleaned regularly, they become covered with a sticky, yellowish layer of food particles and bacteria cells '**dental plaque**'. Since plaque covers the teeth forming a layer over them, the alkaline saliva cannot reach the tooth surface to neutralise the acid formed by bacteria and hence tooth decay sets in.



Pharynx-

- It is a wide opening at the back of mouth.
- Posteriorly it leads into two tubes - gullet (food pipe) and glottis (wind pipe).



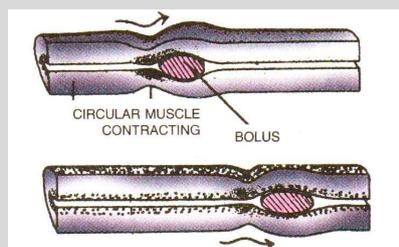
Oesophagus-

- It is a long narrow muscular tube which connects mouth to stomach.
- Food passes through oesophagus by peristaltic movements of the muscular wall.



Let's know

- **Peristalsis** - The process of waves of contractions in the wall of alimentary canal pushing the food forward is called **peristalsis** and the wave of contraction is called **peristaltic movement**.



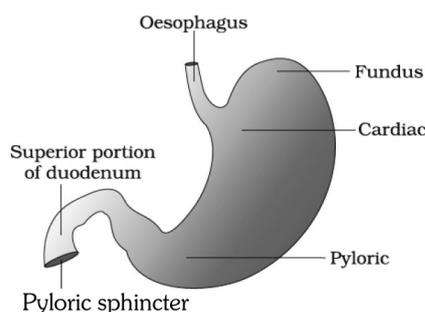
Peristaltic movement

- Food bolus keeps on rolling from its anterior to posterior side due to the peristaltic movements as shown in figure.
- Peristaltic movements occur because of the contraction of circular muscles present all along the length of alimentary canal.
- Mucus lining the internal lining of gut facilitates in the passage of food because of lubrication.



Stomach-

- It is a large muscular elastic bag situated below the diaphragm.
- Its walls are supplied with glandular epithelium secreting gastric juices and mucus.
- It is J shaped and is present on the left hand side of the abdomen. It has three parts- **cardiac**, **fundus**, and **pylorus**. Cardiac end is towards the oesophagus and food passes into the duodenum through the pylorus.



Structure of Stomach (mammals)

➤ **Pyloric sphincter-**

- It is a ring of smooth muscles and connective tissue surrounding an opening between the pyloric region of the stomach and duodenum.
- It opens and closes several times. With each opening, a small amount of food (chyme) moves into the duodenum.

➤ **Small Intestine-**

- It consists of three parts.

(a) **Duodenum** (b) **Jejunum** (c) **Ileum.**

(a) **Duodenum-** It forms the upper part of small intestine which is C shaped and about 9 inches long and is only one inch in diameter. It gets pancreatic juice from pancreas and bile juice from liver through a common bile duct.

(b) **Jejunum-** Duodenum leads into a coiled tube called jejunum that is about 7 feet long.

(c) **Ileum-** Jejunum leads to ileum. The internal wall is thrown into number of folds called villi which increase the surface area for absorption.

➤ **Large Intestine-**

It is much shorter than small intestine and is basically for absorption of water and discharging the undigested wastes. It has three parts, caecum, colon and rectum.

➤ (a) **Caecum-**

- Caecum is a blind sac and is present where ileum joins the large intestine (just below the opening of ileum).
- In case of humans, it is very small and from it extends a small finger like **vermiform appendix** which gets infected during appendicitis (Fig.).
- Caecum is large and spacious and a food storage organ in herbivores where cellulose fermentation takes place.

➤ (b) **Colon-**

- It may be 5-6 feet long and 3 inches in diameter and is present in the form of an inverted U in the abdominal cavity (Fig.).

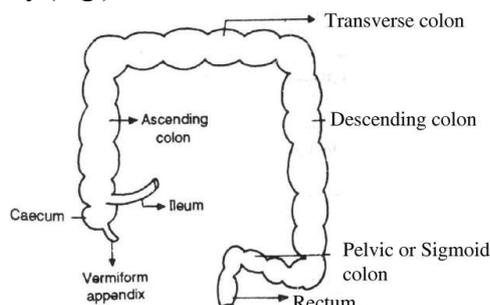


Fig.- Parts of large intestine

- **Ascending colon** is the first part present on the right side that moves upwards from the caecum.
- **Transverse colon** is the horizontal part placed transversely.
- **Descending colon** is the next region that moves down on the left side.
- **Pelvic colon-** It is S shaped and continues into rectum. Food can remain in the colon for a long time may be as long as 36 hours before being passed out to rectum.

➤ (c) **Rectum -**

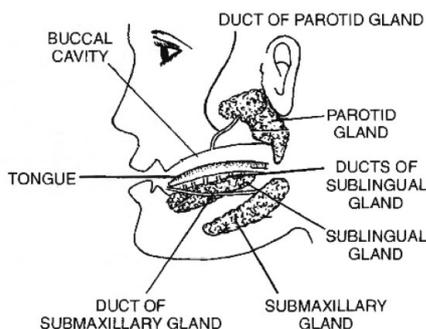
It is a small muscular region at the end of the large intestine. It can store the undigested food for a very short time before passing it out through anus.

2. DIGESTIVE GLANDS -

- Apart from large number of gastric and intestinal glands present in the lining of the stomach, there are three main associated digestive glands which pour their secretions into the alimentary canal.
- They are salivary glands, gastric gland, liver, pancreas and intestine gland.

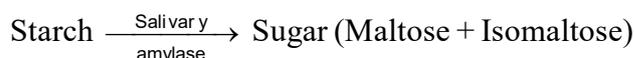
I. Salivary glands

- There are 3 pairs of salivary glands.
- (A) **Parotid glands** : largest glands present just below the external ear. (Stenson's duct)
- (B) **Submaxillary glands / Submandibular glands** : These lie beneath the jaw-angles. (Wharton's duct)
- (C) **Sublingual glands** : Smallest glands which lie beneath the tongue. (Duct)



Human Salivary Glands

It produces saliva. They help in chemical digestion. They secrete an enzyme called **salivary amylase** or **ptyalin**. It helps in digestion of starch.

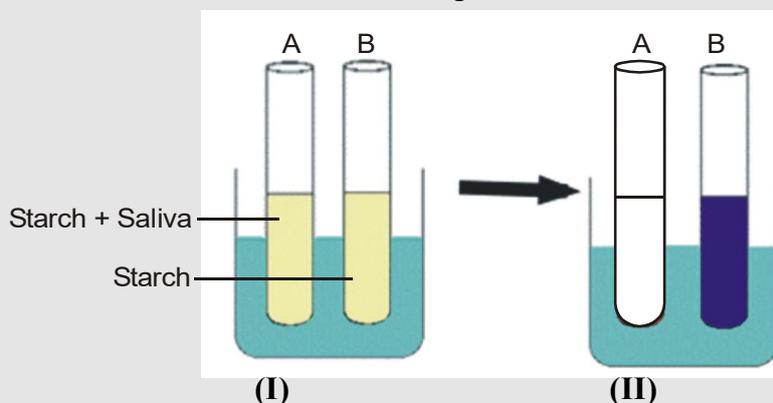


➤ **Activity : To demonstrate the action of saliva on starch.**

Requirements : Two test tubes, 1% starch solution, dilute iodine solution

Procedure : Take two test tubes A and B. Add 1% starch solution in each test tube. Now add 1 ml saliva to the test tube A. leave the test tubes undisturbed for about 20 -30 minutes. Now add a few drops of dilute iodine solution in both the test tubes and observe (In the given figure).

Observation and result : The blue black color appears in test tube B showing the presence of starch. The test tube A doesn't show any color. This indicates that salivary amylase present in saliva has broken down starch into soluble sugar.



(i) A : No color change, (ii) B : shows change in color (blue to black)

II. Gastric glands :

- Present in stomach. They secrete hydrochloric acid, protein digesting enzymes and mucus.
- These are of 3 types :
- (A) **Cardiac glands** : secrete an alkaline mucus.
- (B) **Pyloric glands** : secrete an alkaline mucus.

- (C) **Fundic glands** : each gland has 5 type of cells.
- Peptic / Zymogen cells** : secrete pepsinogen, prorennin.
 - Oxyntic cells** : Secrete HCl
 - Goblet cells** : secrete mucus
 - Argentaffin cells** : produces serotonin somatostatin and histamine
 - G-cells** : secrete and store the hormone gastrin.
- Various steps of digestion in the stomach can be summarised as follows :

$$\text{Prorennin} \xrightarrow{\text{HCl}} \text{Rennin}$$

$$\text{Pepsinogen} \xrightarrow{\text{HCl}} \text{Pepsin}$$

$$\text{Casein} \xrightarrow{\text{Rennin}} \text{Paracasein}$$
 (Soluble milk protein) (Insoluble protein)

$$\text{Proteins} \xrightarrow{\text{Pepsin}} \text{Peptones} + \text{Proteoses}$$
 - Because of churning, mixing of gastric juice and partial digestion, the food in the stomach is converted into a thick paste (pulp-like material) called **chyme**.
 - The chyme enters into the small intestine in small amounts at a time.

III. Liver-

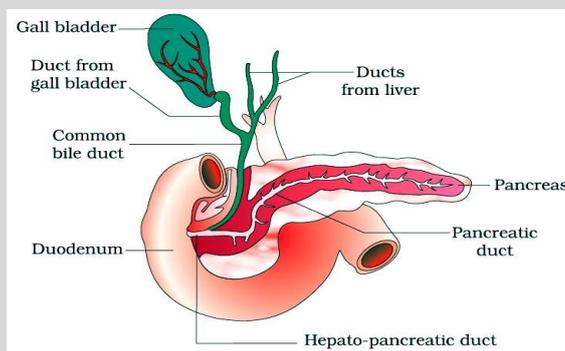
- It is the **largest gland** of the body that lies in the **upper right region** of the abdomen just below the diaphragm.
- It secretes **bile** -a brownish-green fluid that passes from liver through hepatic ducts and is poured into the common bile duct that opens in the duodenum.
- Bile contains bile pigments and organic salts called bile salts. It helps in digestion of fats (Emulsification of fats).



Let's know

Function of liver :

- Formation of glucose from excess organic acids.
- Storage of vitamins : A, D, E, B₁₂ Synthesis of vitamin A from carotene.
- Secretions of blood anticoagulant named **heparin**.
- Synthesis of blood or plasma proteins, fibrinogen and prothrombin.
- Secretion of bile, detoxification of harmful chemicals.
- Elimination of pathogens and foreign particles through phagocytic cells called **Kupffer's cells**.



The duct systems of liver, gall bladder and pancreas

IV. Pancreas-

- It is a compound gland having dual function - exocrine as well as endocrine.
- The exocrine part secretes pancreatic juice.
- It is located in the bend of the duodenal loop.
- The pancreatic juice passes into the duodenum through pancreatic duct which joins the common bile duct.

- Pancreatic juice contains three enzymes -**(i) trypsin (ii) amylase and (iii) lipase.**

Starch $\xrightarrow{\text{Amylase}}$ Maltose

Peptone and proteoses $\xrightarrow{\text{Trypsin}}$ Peptides + Amino acids

Fats $\xrightarrow{\text{Lipase}}$ Fatty acids + Glycerol

V. Intestinal glands

- Throughout the internal lining of small intestine are present numerous unicellular glands, called **intestinal glands**, that secrete **intestinal juice or succus entericus.**
- It contains many enzymes that help in the digestion of food.

➤ These enzymes are :

- Maltase** which digests maltose and produces glucose.
- Lactase** converts milk sugar lactose into glucose and galactose.
- Invertase (Sucrase)** that splits sucrose into glucose and fructose and
- Lipase** which digests fats into fatty acids and glycerol.

Maltose $\xrightarrow{\text{Maltase}}$ Glucose

Lactose $\xrightarrow{\text{Lactase}}$ Glucose + Galactose

Sucrose $\xrightarrow{\text{Sucrase}}$ Glucose + Fructose

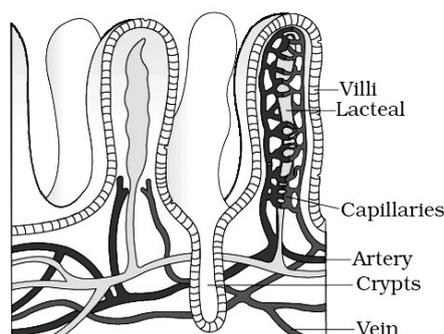
Fats $\xrightarrow{\text{Lipase}}$ Fatty acids + Glycerol

➤ Summary of digestion of food in various parts of alimentary canal of man

Region	Secretion (Source gland)	Enzymes	Nutrient (Substrate)	Product of digestion	
Buccal cavity	Saliva (Salivary glands)	(i) Ptyalin (Salivary amylase) (ii) Maltase	Starch, Maltose	Maltose, Glucose	
Oesophagus	None	–	–	–	
Stomach	Gastric juice & Hydrochloric and (Gastric glands)	Pepsin Rennin (Not found in adult humans)	Proteins Milk protein or casein	Proteoses and peptones Crudling of milk, caseinogen	
Small Intestine	Duodenum	Bile (Liver)	None	Emulsifies fats, food made alkaline	
		Pancreatic juice (Pancrease)	Pancreatic analayse Trypsin Lipase	Strach Proteins Emulsified fats	Maltose Proteoses, peptones, peptides Fatty acids and glycerol
	Ileum	Intestinal juice (Intenstinal glands between villi)	Maltase	Maltose	Glucose
			Sucrase (Invertase)	Sucrose	Glucose and fructose
Large Intestine	Colon	None	–	Absorbs water and some remnants of digested food	
	Rectum	None	–	Temporarily stores undigested food and faeces.	

➤ ABSORPTION :

- Diffusion of digested food through the internal lining of alimentary canal into the blood is called **absorption**.
- Very little absorption takes place through the internal lining of stomach.
- Maximum absorption takes place through the internal lining of small intestine (ileum).
- To bring about efficient absorption, the small intestine contains longitudinal folds (**villi**) which increase the surface area for absorption, Moreover, in each villus there is an elaborate network of blood capillaries and an unbranched lymph vessel called **lacteal**.
- Glucose, fructose, galactose, amino acids, minerals and vitamins from the digested food diffuse through the internal lining of ileum into the blood running through capillary network of each villus.
- All the blood vessels that collect blood from alimentary canal join to form the **hepatic portal vein**.
- It carries blood along with digested food to the liver.
- Fatty acids and glycerol from the chyle diffuse into the lymph running in lacteal which finally pours it into the blood stream.



A section of small intestinal mucosa showing villi

- After the absorption of digested food the remaining part of chyle in the form of liquid reaches the large intestine.

➤ ABSORPTION OF WATER IN LARGE INTESTINE

- Almost liquid - like undigested materials pass into the large intestine.
- Water from the undigested material is absorbed into the blood through the internal lining of colon.
- The undigested material is converted into semi-solid **faeces**.
- Semi-solid faeces are pushed into the rectum from where they are passed out of the body through the anus. The process of passing out faeces is called **egestion** or **defaecation**.

➤ ASSIMILATION OF FOOD :

- Conversion of digested food into the living protoplasm of cells is called **assimilation**.
- Digested food is supplied to every cell by the blood stream.
- From the digested food which reaches any cell, most of the glucose is oxidized during metabolic activities.
- The remaining monosaccharides are converted into polysaccharides, the amino acids are converted into proteins and fatty acid and glycerol into fats.

➤ EGESTION

- Removal of undigested food out of the body is called **egestion** or **defaecation**.
- Undigested materials in the form of faeces are eliminated from the body.

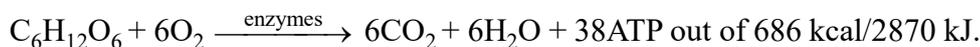
➤ SOME DISEASES

1. **Peptic Ulcer:** A lesion on the inner membrane of the stomach, because of higher acidity of gastric juice.
2. **Dental Caries:** Gradual softening of enamel and dentine. Bacteria acts on sugars and produce acid which **demineralises** the enamel.
Masses of bacterial cells together with food particles stick to the teeth to form dental plaque.

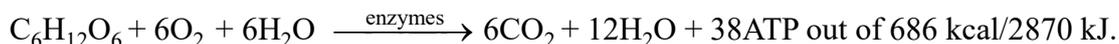
RESPIRATION

➤ Definition :

- Respiration is a multistep, enzyme mediated biochemical process of oxidative breakdown of organic compounds inside living cells releasing small packets of energy at various steps.
- It is, therefore, a catabolic and exergonic process.
- Energy liberated during oxidative breakdown of respiratory substrate is partly stored in ATP (adenosine triphosphate). The rest is dissipated as heat.



➤ Recent Equation :

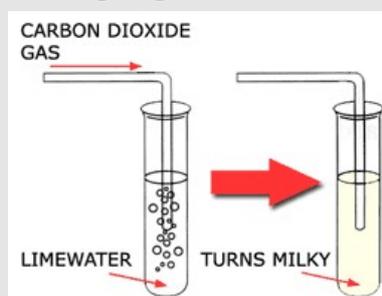


Differences Between Respiration and combustion

	Respiration	Combustion
1. Cellular	It is a cellular process which occurs inside living cells.	It is a non-cellular process.
2. Temperature	Temperature does not rise above 40°C.	Combustion produces temperature of 600-2000°C.
3. Control	It is under biological control	It is an uncontrolled process.
4. Steps	It is a multistep reaction.	It is single step involved
5. Enzymes	A number of enzymes take part in reaction.	No enzyme is involved.
6. Energy	It is released in small packets in several steps.	It is released in large amount in one step.
7. Heat and Light	About 50% of energy is liberated as heat. Light is not produced.	Whole energy is produced as heat and light.
8. Storage of Energy	50% of liberated energy is stored as ATP molecules.	There is no storage of energy.
9. Intermediates	Several intermediates are produced.	No intermediates are produced.
10. Oxidation	It is terminal where oxygen combines with hydrogen of reduced coenzymes.	Oxidation is direct where every oxidisable atom oxidized without relation to presence of hydrogen.

➤ ACTIVITY :-

Carbon Dioxide is produced during respiration.



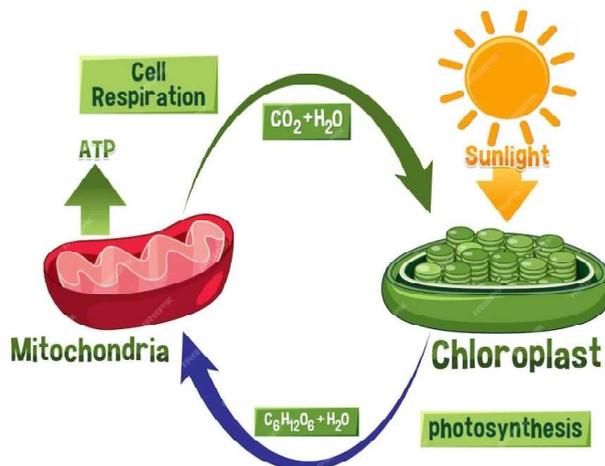
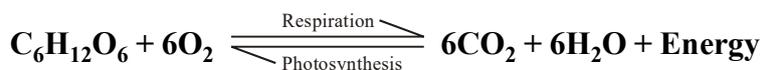
Procedure :- Pour freshly prepared lime water into a test tube upto its one third. Blow air from mouth into the lime water with the help of a glass tube. Pour a similar amount of lime water in another test tube. Blow air into it with the help of small air pump or syringe fitted with a fine rubber tubing.

Observation :- Lime water turns milky within no time when air is blown from mouth. It takes a lot of air and a long period for lime water to turn milky when fresh air is blown into it.

Inference :- Lime water turns milky only when carbon dioxide mixed with it to form calcium carbonate. Air blown from mouth is actually breathed out air. Since it turns lime water milky within no time, the exhaled air contains good concentration of carbon dioxide. It is several times more than normally present in air because fresh air blown in lime water takes a long time to turn it milky. Therefore, carbon dioxide is produced during respiration.

➤ **RESPIRATION AND PHOTOSYNTHESIS**

- Respiration and photosynthesis are the two antagonistic and complementary processes in plants involving gaseous exchanges. The substrates in one process are the end-products of the other process.



Schematic diagram to show the flow of energy in plants during photosynthesis

Differences between Photosynthesis and Respiration

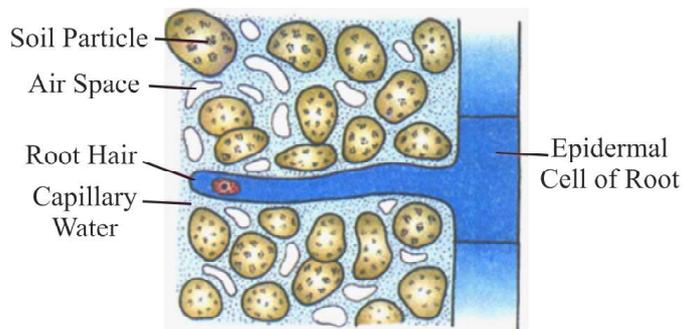
Properties	Photosynthesis	Respiration
Metabolism.	Photosynthesis is a synthetic or anabolic	Respiration is a breakdown or catabolic process.
Energy Relation.	It is an endergonic process	It is an exergonic process.
Energy Conversion.	It converts light energy into chemical energy.	It liberates chemical energy which is used as such or changed into other forms of energy.
Timing.	Photosynthesis occurs during the daytime when light is available.	Respiration occurs all the time.
Cells.	It occurs only in green cells.	It occurs in all types of living cells.
Carbon Dioxide.	It absorbs carbon dioxide.	Respiration liberates carbon dioxide.
Oxygen.	Photosynthesis liberates oxygen.	Respiration consumes oxygen.
Raw Material.	They are carbon dioxide and water.	There is no storage of energy.
End products.	They are glucose, other organic substances and oxygen.	End products are carbon dioxide and water.
Weight.	There is net gain of weight	Oxidation is direct where every oxidisable atom oxidized without relation to presence of hydrogen.

➤ **Respiration in Plants :**

- Like other living organisms, plants also exchange gases with their environment.
- However, plants do not possess any transport system for the gases.
- Different parts of plants exchange gases independently. The gases move entirely by diffusion.
- Respiration is rapid in meristematic regions (stem tips, root tips, cambia), floral buds, growing fruits and germinating seeds.
- It is slower in mature regions.

(a) Young Roots :-

- Air occurs in soil interspaces.
- Root hairs as well as epiblema cells of the young roots are in contact with them.
- They are also permeable to metabolic gases.
- Oxygen of the soil air diffuses through root hair–epiblema cells and reaches all internal cells of the young root.
- Carbon dioxide produced by root cells diffuses in the opposite direction.
- In water–logged conditions, soil air becomes deficient. In the absence of oxygen, metabolic activity of the root declines and the plant may wither.



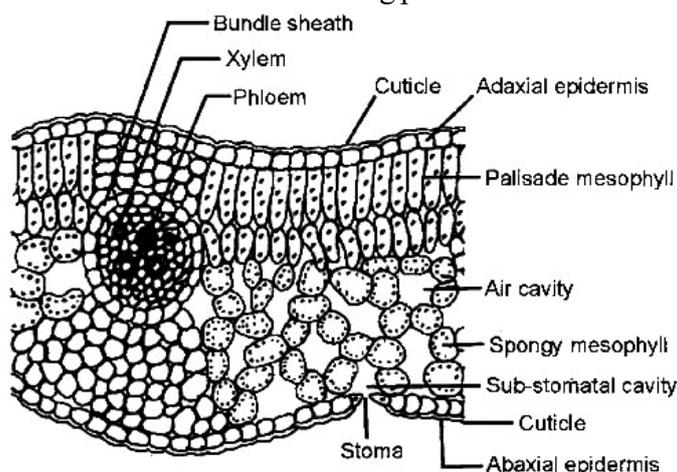
Epiblema and root hair take part in exchange of gases directly in young roots

(b) Older Roots and Stems :

- In older roots and stems, the surface tissues are impermeable to gases.
- They have permanently open pores called lenticels.
- Each lenticel contains a mass of loosely arranged complementary cells that enclose a number of intercellular spaces.
- Exchange of gases occurs through them.

(c) Leaves and Young Stems :

- Leaves and young stems are ideally suited to quick exchange of gases.
- The organs have a covering of nearly impermeable epidermis for reducing loss of water.
- The epidermis bears a number of aerating pores called **stomata**.



Section of leaf to show intercellular spaces and stomata.

- Each aerating or stomatal pore is bordered by a pair of guard cells.
- In most of the plants, the guard cells are kidney or bean shaped with inner walls being thicker and less elastic than the outer walls.
- Guard cells contain chloroplasts which are absent in other epidermal cells.
- Opening and closing of stomata are regulated.

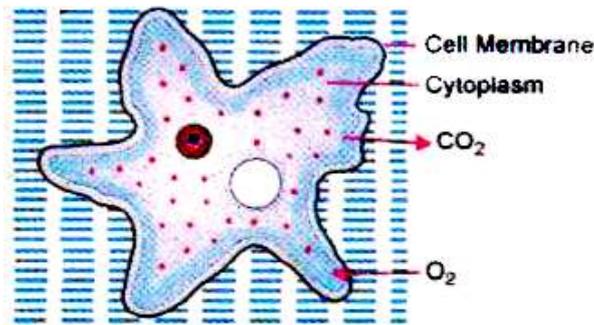
➤ Respiration in animals :

Respiratory organs :-

- Various animals possess different organs for the exchange of gases. (Except endoparasites, such as, *Taenia* (tape worm), *Ascaris*, etc. which respire anaerobically, most of the animals respire aerobically.)
- These respiratory organs found in different animals are designed to suit their habitat.
- The following organs act as respiratory organs in different animals.

(a) General body surface :

- In lower organisms, such as, protists, sponges, cnidarians (**Protozoa, *Hydra*, *Planaria*, etc.**) exchange of gases occurs through the body surface via the cell membrane by simple diffusion.



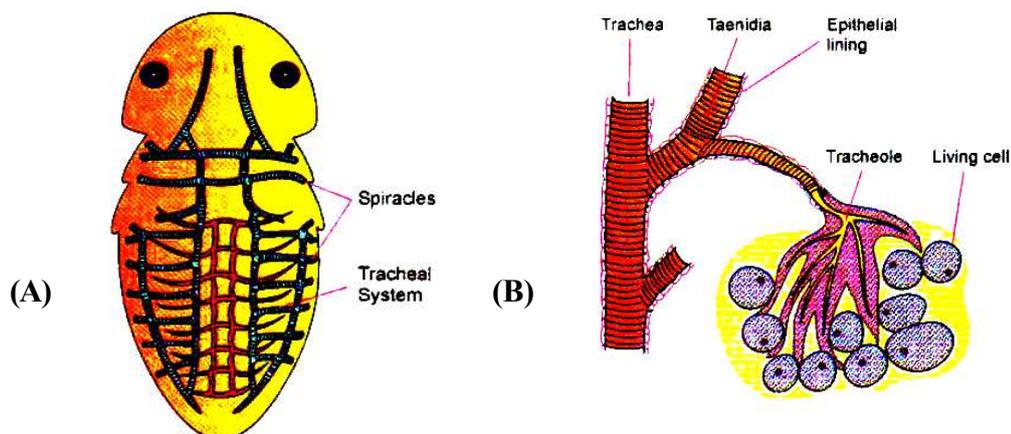
Cell surface exchange of gases in Amoeba

(b) Skin or body surface :

- The skin or general body surface or epidermis acts as respiratory organ in some animals, such as, **annelids** and **amphibian** that live in semiaquatic habitat.
- This type of respiration in which exchange of gases occurs through the skin is called cutaneous respiration.

(c) Tracheae (air tubes) :

- Terrestrial arthropods, such as, **insects, millipedes** and **centipedes** have thick impermeable integument to minimize loss of water from their body surface by evaporation.
- They have evolved a complex system of whitish, shining, intercommunicating air tubes called **tracheae**.
- The exchange of gases with the help of tracheae is termed **tracheal respiration**.

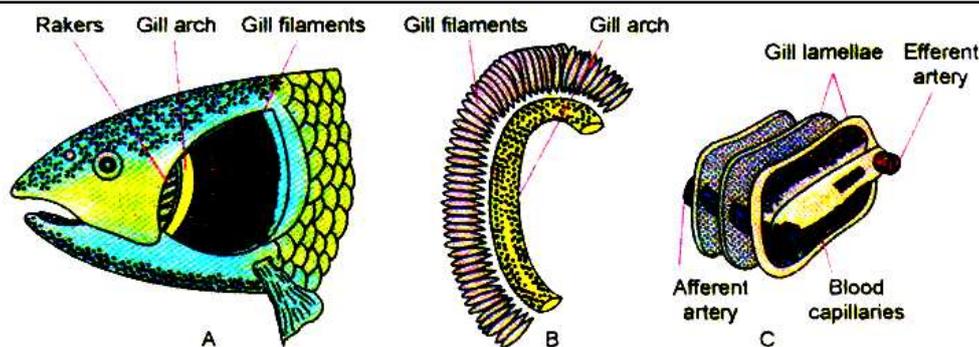


Tracheal respiratory system in Cockroach.

A. Tracheal system. B. Branches of trachea

➤ Gills :

- Aquatic animals, such as, prawns, mussels, fishes and tadpoles, breathe water.
- They draw oxygen dissolved in water and release carbon dioxide into water.
- The organs used for breathing water are called **gills**.
- The exchange of gases in the gills is known as **branchial respiration**.



Gill respiration in Fish. A. gill chamber with operculum removed. B. gill filaments. C. gill lamellae.

➤ **Activity :**

Study of Branchial Respiration in Fish

Observe a fish in the aquarium. Find out that it is regularly opening and closing its mouth as well as operculum. Place a few small crystals of potassium permanganate carefully in front of the mouth of a fish. They enter the mouth of the fish. Coloured water is observed to come out from the lower part of operculum indicating that water regularly enters the mouth, passes into gill chambers and comes out through opening of operculum.

In gill chambers exchange of gases occurs between water and blood capillaries contained in gill lamellae. Count the number of times the fish opens and closes its mouth per minute. Compare it with your breathing rate. It is very rapid because water has low oxygen content than the content of oxygen present in air.

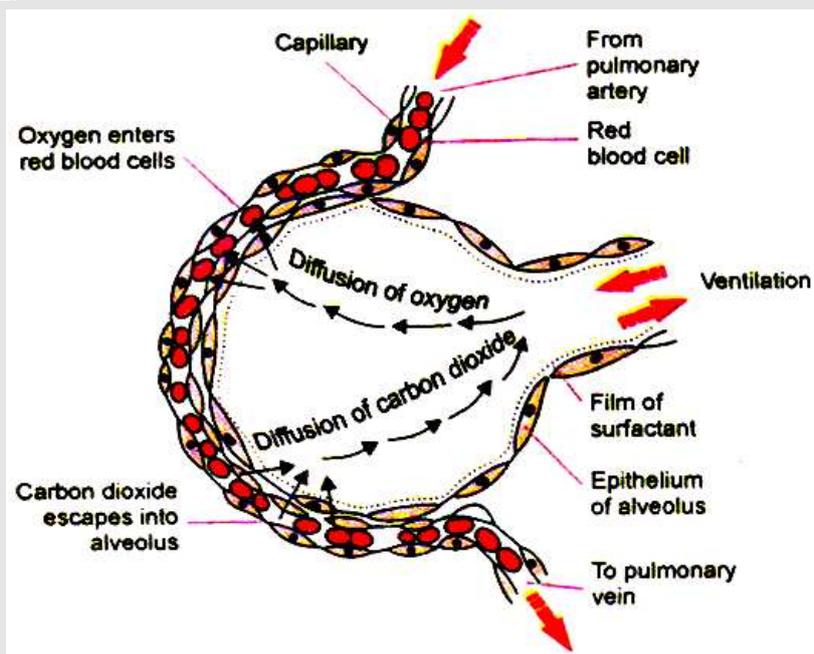


Fig. Exchange of gases in alveolus.

➤ **Lungs :**

- Land animals, namely, reptiles, birds and mammals breathe atmospheric air with lungs.
- Their skin is not respiratory because it is impermeable to minimise the loss of water by evaporation.
- The amphibians also have lungs for pulmonary respiration. But, they have cutaneous respiration too with their permeable skin.
- Amphibians and reptiles have sac-like lungs with small infoldings that increases surface area for gas exchange.
- Birds and mammals have spongy lungs, consisting of millions of microscopic, capillary-surrounding air sacs. This maximizes the respiratory surface.

➤ Depending upon the oxidation of food in the presence or absence of oxygen, respiration is of two types:

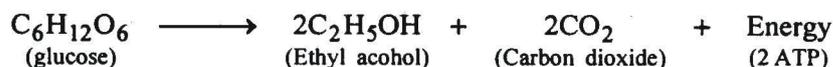
1. Aerobic respiration

2. Anaerobic respiration

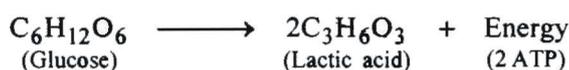
- Both types of respiration have a common pathway called glycolysis.
- Glycolysis does not need oxygen and takes place in the cytoplasm.
- During glycolysis, the glucose molecule is broken down to 2 molecules of pyruvic acid.
- Further breakdown of pyruvic acid depends on the presence or absence of oxygen.
- In the presence of oxygen (aerobic respiration), the pyruvic acid enters the Krebs cycle and is broken down to carbon dioxide and water.
- In the absence of oxygen (anaerobic respiration), pyruvic acid is broken down to ethyl alcohol or lactic acid.

1. Anaerobic Respiration

- Anaerobic respiration occurs in the absence of oxygen and is catalysed by enzymes present in the cytoplasm
 - It results in incomplete oxidation of food (glucose).
 - It takes place in lower organisms like yeast, certain bacteria and fungi.
 - It also occurs in higher plants and animals under certain conditions, when O_2 is limiting.
 - In humans, during vigorous muscular exercise, when the demand of O_2 is more than what is supplied by respiration, muscle cells start respiring anaerobically temporarily.
 - It is less efficient than aerobic respiration as only 2 ATP molecules are released from one glucose molecule.
 - During anaerobic respiration, glucose is first broken down to 2 molecules of pyruvic acid by glycolysis.
 - Further breakdown of pyruvic acid continues but differs in plants and animals as they contain different enzymes.
- (a) In yeast, bacteria (microbes) and plants, pyruvic acid is broken down to ethyl alcohol and carbon dioxide is released. In these, anaerobic respiration is also known as fermentation.



- (b) In animals, pyruvic acid is broken down to lactic acid.

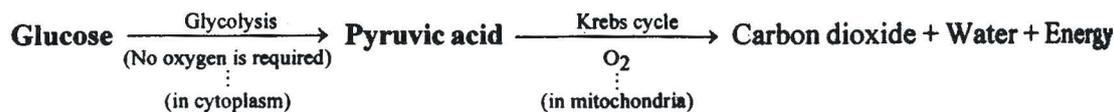


- The lactic acid produced accumulates in the muscles and causes muscle fatigue. During resting period, when oxygen becomes available, slowly lactic acid is removed from the muscles.

2. Aerobic Respiration

- Aerobic respiration needs the presence of oxygen and occurs in mitochondria.
- The food (glucose) is completely broken down to carbon dioxide (CO_2) and water (H_2O).
- It occurs in all higher organisms (both plants and animals).
- It is highly efficient in comparison to anaerobic respiration and releases 38 ATP molecules from one glucose molecule.
- Aerobic respiration is completed in two major phases given below:
 - A. Anaerobic phase or glycolysis :**
 - It is the first phase and does not require oxygen.
 - It takes place in the cytoplasm.
 - The glucose molecule is broken down to 2 molecules of pyruvic acid.
 - B. Aerobic phase :**
 - It is the second phase that takes place in the presence of oxygen.
 - It takes place in mitochondria.
 - The pyruvic acid molecules formed during glycolysis are completely broken down to carbon dioxide and water.
 - It is also called as **Krebs cycle**.

➤ **An overall equation of aerobic respiration :**



➤ **RESPIRATORY SYSTEM OF MAN**

- All the organs in an animals that provide free O_2 and help in the removal of CO_2 collectively constitute the **respiratory system**. When the respiratory organs are lungs, it is called **pulmonary respiration**.
- In man pulmonary respiration is present. The respiration in man and other animals having pulmonary respiration can be studied in two parts :

1. Respiratory tract

2. Respiratory organs

1. Respiratory tract :

- The path through which O_2 reaches up to the lungs and CO_2 is removed from the lungs is called **respiratory tract**. In man it consists of :
(a) **Nose**, (b) **Pharynx**, (c) **Larynx**, (d) **Trachea** (e) **Bronchi**.
- (a) **The Nose** :– It consists of two nostrils which are lined with hair and mucous to filter dust and other small particles.



Let's know

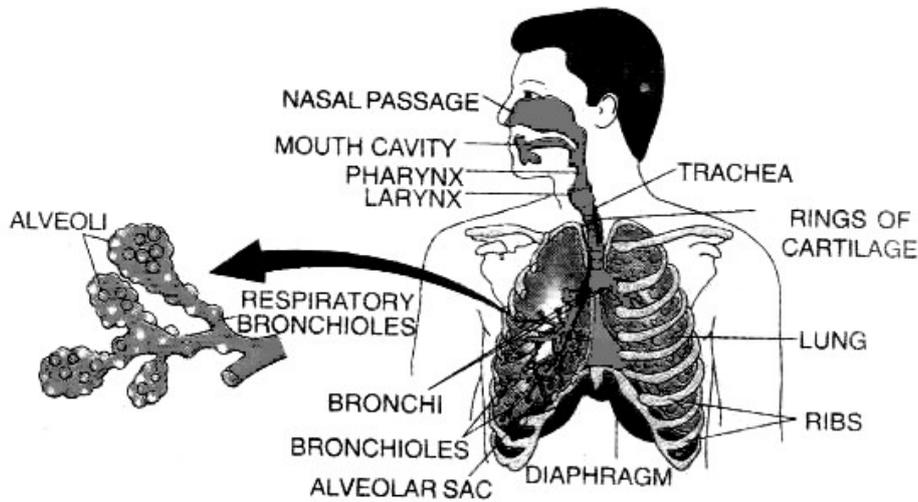
Nose breathing is better than mouth breathing as in the nose occurs

- filtration of air by the hair. The dust particles and other large particles are not allowed to enter the lungs.
 - Sterilization of air by trapping the bacteria and other pathogens in mucus.
 - Moistening of air by the addition of mucus and
 - Warming of air radiating heat.
- (b) **The Pharynx** :– The nose opens into the pharynx which leads into two tubes, i.e., larynx and oesophagus, through **glottis** and **gullet** respectively. The glottis is guarded by a flaplike **epiglottis**. It does not allow anything other than air to enter into the larynx.
Pharynx serves as a common path both for the air and food.
- (c) **The larynx (Voice box)** : It is the upper slightly swollen part of trachea or wind pipe. It is more prominent in men as compared to women and is called “Adam’s apple”. In the larynx is present a pair of vocal cords which help in the production of sound. Hence, it is also called voice box. During swallowing of food or liquid, the larynx moves upwards, so that its opening – glottis is closed by epiglottis and food does not enter into the larynx.
- (d) **The trachea** : The trachea or wind pipe is a long, narrow, whitish tube. It extends through the neck. It enters the thorax where it divides into a pair of branches called **primary bronchi**. The walls of trachea are supported by “C”-shaped cartilagenous rings that keep it always distended.
- (e) **The primary bronchi** : These are a pair of tubular structures formed as a result of bifurcation of the trachea. These are right and left primary bronchi that enter into the corresponding lung. These are also supported by cartilagenous rings.

2. Respiratory organs :

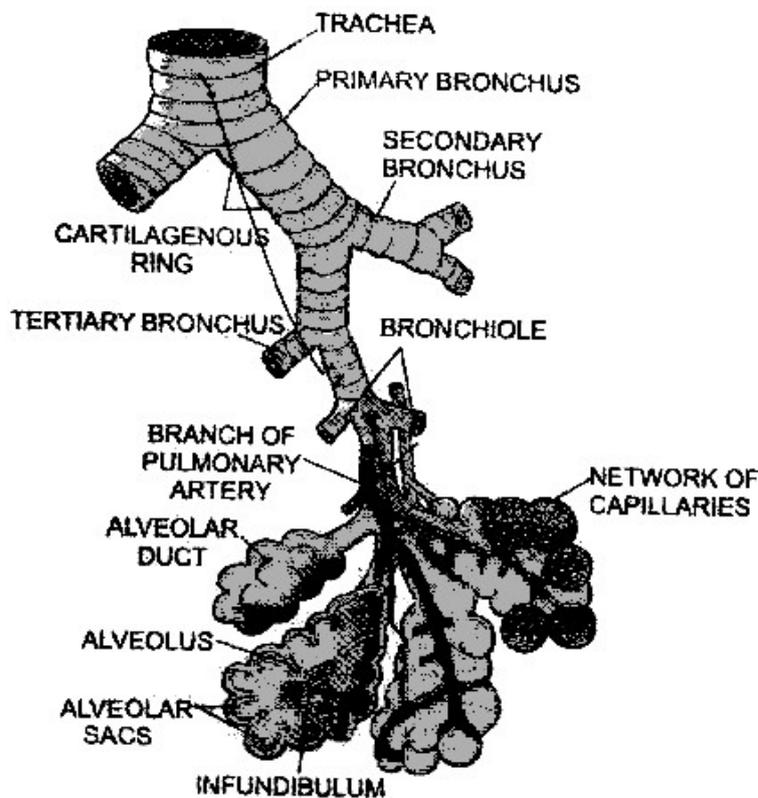
The Lungs :

- The respiratory organs in man are a pair of lungs.
- These are thin walled, elastic, spongy, pinkish, triangular and highly distensible structures known as left and right lungs.
- The lungs occupy most of the thoracic cavity.
- They are well protected by bony thoracic cage.
- Each lung is enclosed in a double-walled pleural sac.
- In between the two layers is present a fluid called **pleural fluid**.



Human respiratory system.

- The pleural fluid is secreted by the pleural sac and performs the following functions:
 - (i) It protects the lungs from any kind of mechanical injury and shock.
 - (ii) It lubricates the lungs for free expansion and relaxation.
 - (iii) It keeps the lungs moist for proper functioning.
- Each primary bronchus, after entering into the corresponding lung, divides repeatedly to form a network of very fine tubes.
- The primary bronchus divides into **secondary bronchi** that give rise to **tertiary bronchi**.
- The tertiary bronchi divide into bronchioles which give rise to alveolar ducts that open into blind end sacs called **alveoli**.



Branching of bronchion the lungs.

➤ **PHYSIOLOGY OF RESPIRATION :**

- The process of respiration is a complex and continuous process. It is completed in four steps :
 - (1) Breathing
 - (2) External respiration
 - (3) Internal or tissue respiration, and
 - (4) Cellular respiration.

1. **Breathing :**

- Have you felt that your thorax alternately expands and contracts.
- When it is expanding you are drawing fresh air into the lungs and when it is becoming normal, you are releasing foul air from lungs.
- This movement of fresh air from outside into the lungs through respiratory tract and foul air in the opposite direction is called breathing.
- The process of breathing is an apparent and mechanical part of respiration.

➤ **Mechanism of breathing :**

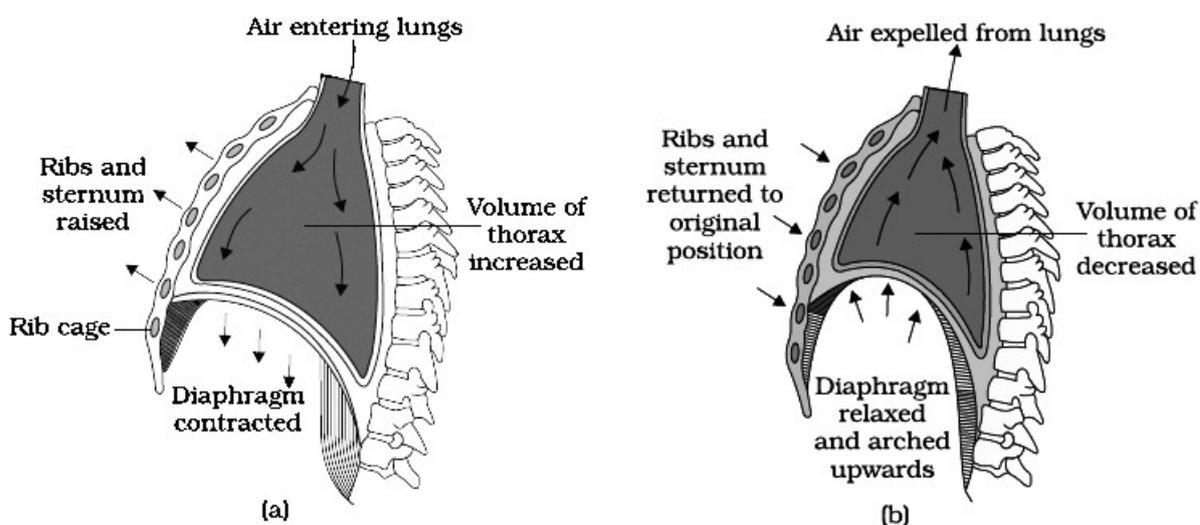
- Breathing is brought about by changing the volume of thoracic cavity, where lungs are present.
- The mechanism of breathing can be studied in two steps :

(a) Inspiration (Inhalation) and

(b) Expiration (Exhalation)

(a) Inspiration or (Inhalation)

Movement of fresh air into the lungs is called inspiration. During inspiration volume of the thoracic cavity is increased by the combined movements of sternum, ribs and diaphragm. The sternum and ribs move upwards, forwards and outwards.



Process of breathing in man.

- Expansion of the thoracic cavity results in the expansion of lungs.
- Due to the increase in the volume of lungs pressure inside decreases as compared to the atmospheric pressure.
- Therefore, fresh atmospheric air, which is at higher pressure, rushes into the lungs through the respiratory tract to equalize the pressure.
- Exchange of O_2 and CO_2 will take place between the alveoli and blood. Now the lungs will be full of foul air.

(b) Expiration (or Exhalation)

- The movement of foul air from the lungs to outside is called expiration or exhalation.
- During expiration volume of the thoracic cavity is decreased by the inward and downward movements of the ribs and sternum and by upward bulging of the diaphragm.
- All these movements are brought about by the simple relaxation of muscles that were contracted during inspiration.
- An adult man breathes 12–14 times per minute at rest.



Let's know

- If diffusion were to move oxygen in our body, it is estimated that it would take 3 years for a molecule of oxygen to get to our toes from our lungs. Aren't you glad that we have haemoglobin?
- Process of breathing and swallowing of food cannot go together.
- Rate of breathing is minimum when a person is sleeping.
- Painful breathing is called **dyspnoea**.
- Cessation of breathing is called **apnoea**.
- Normal comfortable breathing is called **eupnoea**.
- In the lungs of man are present 750 million alveoli.
- Total surface area of the alveoli is about 100 m² which is 50 times more than the external surface area.

2. External respiration :

- **Exchange of O₂ and CO₂ between the inhaled air and blood through the surface of respiratory organ is called external respiration.**
- Exchange of gases takes place because of higher partial pressure of O₂ in the inhaled air and that of CO₂ in the blood supplied to the lungs.
- As a result O₂ diffuses into the blood from the alveoli of lungs and CO₂ in the opposite direction.
- Exchange of gases always takes place in the solution form. That is why, surface of respiratory organ is always kept moist.

➤ **Transportation of O₂ :**

The O₂ that diffuses into the blood from the lungs is transported to various body tissues in the following form:

- About 97% of the O₂ that diffuses into the blood combines with haemoglobin of RBCs forming an unstable compound, oxyhaemoglobin.
- The remaining 3% O₂ dissolves into water of plasma.

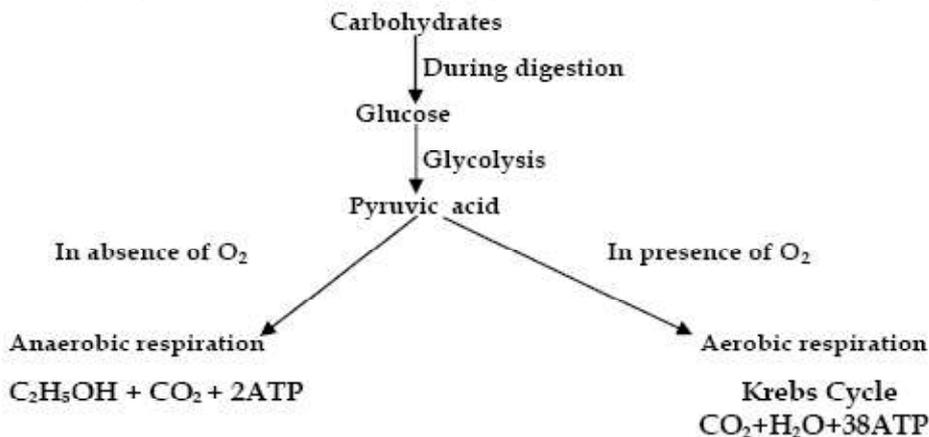
3. Internal or Tissue respiration :

- Exchange of O₂ and CO₂ between the blood and body tissues is called **internal** or **tissue respiration**.
- The O₂ from the blood diffuses into the body tissues whereas CO₂ from tissues to the blood because of higher concentration of CO₂ in the body tissues, produced due to cellular respiration.

4. Cellular Respiration :

- As this process is at cellular level so it is called **cellular respiration**.
- As this process is at cellular level so it is called cellular respiration.
- It takes place in three steps :
- It refers to the oxidation of food taking place inside the cell.
- It takes place in three in 3 steps :

- Glycolysis**
- Krebs Cycle**
- Electron Transport System**





Let's know

The net gain of ATP molecules during respiration is 38ATP molecules among them,
 8ATP from glycolysis
 6ATP from conversion of pyruvic acid into acetyl CO. A
 24ATP from kreb cycle
 besides this CO₂ and H₂O are also released.

➤ MECHANISM OF GASEOUS EXCHANGE BETWEEN TISSUES AND BLOOD :

- When the air enters into the lungs through nostrils, trachea and bronchi it enters into the bronchioles, from bronchioles it moves into thin walled alveolar sacs or alveoli.
- Alveoli are rich in blood capillaries, at this place oxygen from air diffuses into the blood and reaches to all the cells and tissues of body this oxygen now diffuses into the cell and is utilized for the oxidation of food and production of energy in mitochondria as a result of this carbon dioxide is produced in cells, due to this increased concentration of CO₂, it diffuses into the blood and is brought back to alveoli and expelled out of the lungs through trachea and nostrils.

➤ Control of Respiration :

- Respiration is controlled by the respiratory centre situated in medulla oblongata of brain.
 - (i) Breathing occurs involuntarily.
 - (ii) Under normal conditions rate of breathing is 12-14 times per minute. During vigorous exercise the demand for oxygen increases due to which rate of breathing increases by about 20-25 times.
 - (iii) The total area for gas exchange covered through 300 million alveoli is about 36-72 m² in each lung.
 - (iv) Respiratory quotient : It is defined as the ratio of the volumes of CO₂ liberated and O₂ used during respiration.

➤ Some Respiratory Disorders :

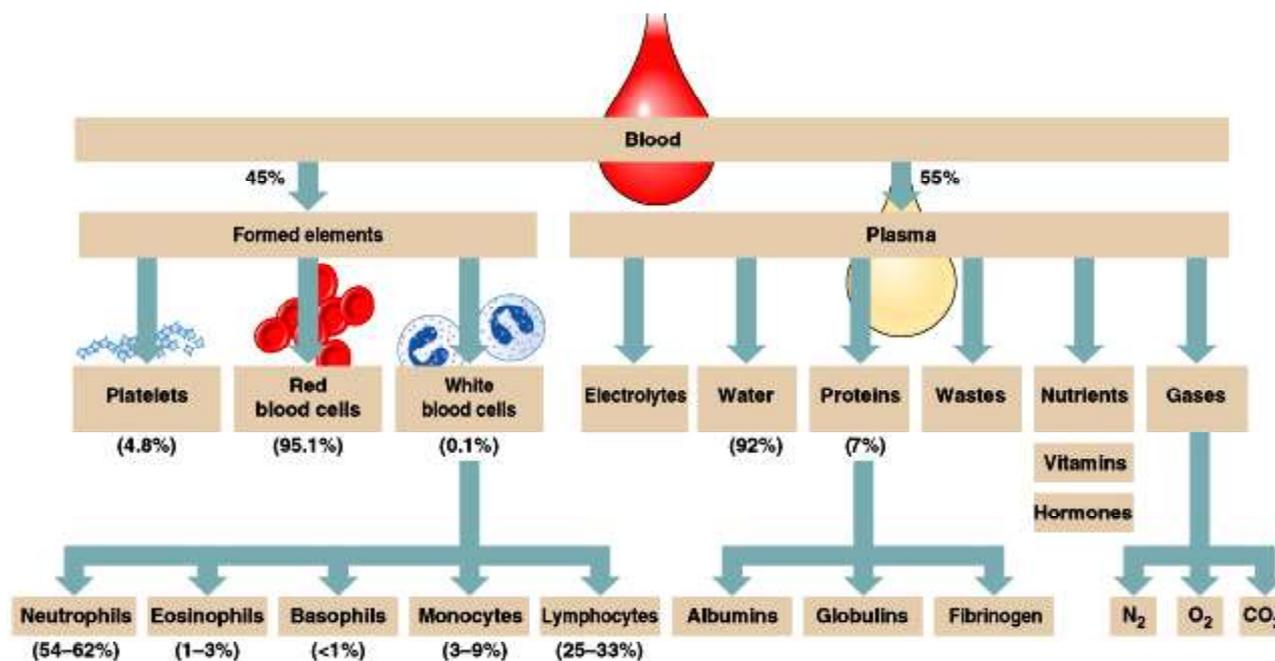
- **Emphysema** : It occurs due to infection, smoking etc. It occurs due to obstructions in bronchioles caused by breaking of alveolar septa. Bronchodilator and O₂ therapy are used, for curing this disease.
- **Asthma** : Air passages are narrowed and lead to obstruction in breathing.
- **Pneumonia** : Lymph and mucous accumulate in alveoli and bronchioles. It occurs due to bacterial and viral infection.
- **Bronchitis** : Swelling in living membranes of respiratory tract due to excessive smoking.
- **Tuberculosis** : Bacterial infection in lungs.
- **Pleurisy** : Inflammation of lung membrane called as **pleurisy**.
- Sudden contraction of diaphragm along with loud closure of glottis causes Hiccough.
- Sudden and violent expulsion of air through mouth and nose is called a sneezing.

Difference Between Aerobic and Anaerobic Respiration

Properties	Aerobic Respiration	Anaerobic Respiration
Method.	It is the common method of respiration (Inhale and exhale).	It occurs permanently only in a few organism. In others it may occur as a temporary measure to overcome shortage of oxygen.
Steps.	It is completed in 3 steps – glycolysis, Krebs cycle and terminal oxidation.	There are two steps – glycolysis and anaerobic breakdown of pyruvic acid.
Oxygen.	It requires oxygen.	Oxygen is not required.
Breakdown.	Respiratory substrate is completely broken down.	Respiratory substrate is incompletely broken down.
End Products.	They are inorganic.	Atleast one end product is organic. Inorganic products may or may not be present.
Toxicity.	End products show little toxicity.	The organic end product is generally toxic.
Occurance.	It occurs partly in cytoplasm and partly in mitochondria.	Anaerobic respiration is carried out entirely in cytoplasm. Mitochondria are not required.
E.T.C.	An electron transport chain is required.	ETC is not required.
Energy.	In release 686 kcal or 2870 kJ of energy per mole of glucose.	Energy liberated is 36-50 kcal or 150-210 kJ per mole of glucose.
ATP.	The liberated energy issued in forming 36-38 ATP molecule per mole of glucose.	The liberate energy is used in synthesis of 2ATP mole.

CIRCULATION AND TRANSPORTATION

- The circulatory system may differ in various animals but carries out the same basic functions.
1. **Transport of nutrients.** :- It transports all the soluble food compounds from the area of absorption (like intestine in man) to different parts of the body for storage, assimilation or synthesis of new components.
 2. **Transport of waste products** :- It transports all the excretory products produced as a result of cellular activities from all over the body to the organs of excretion (like kidney in mammals).
 3. **Transport of intermediate metabolites** :- It transports all the by products or intermediate products from the tissue they are produced to the organ where they can be fully metabolised (like lactic acid produced in muscles is transported to liver for oxidation).
 4. **Transport of hormones** :- Since hormones are produced by ductless endocrine glands, they are transported through the circulating fluid to their target organs.
 5. **Uniform distribution of heat** :- Since circulatory fluid connects all parts of the body it picks up heat from one part and dissipates it on the surface bringing about the uniform distribution.
 6. **Transport of water, inorganic ions and various chemicals** is also done by circulating fluid so as to maintain a uniform distribution.
 7. **Defence against diseases** :- The circulating fluid contains phagocytes which engulf and digest bacteria and play an important role in defending the body against disease.
 8. **Transport of respiratory gases** :- In some animals the circulatory fluid contains respiratory pigments which may be dissolved in plasma like in snails, crustaceans or cephalopods or present in cells like in all vertebrates including man. The O₂ is transported from respiratory organs to tissues while CO₂ is carried from tissues to respiratory organs. Some animals like insects have a tracheal system for respiration and circulating system is not directly associated with respiration. More so it lacks any respiratory pigments.
- **CLOSED CIRCULATORY SYSTEM IN VERTEBRATES**
- Vertebrates have a highly specialised closed circulatory system that consists of blood vessels - arteries, arterioles, capillaries, venules and veins containing blood and heart that pumps blood and drives it rapidly into the blood vessels.
 - Vertebrates also have lymphatic system which helps in the activities of blood vascular system.
 - There are two circulatory systems in humans:
 - (i) **Blood circulatory system**
 - (ii) **Lymphatic circulatory system**
- **Blood Circulatory System in Human Beings**
- It comprises –**
- Blood
 - Blood Vessels
 - Heart or Pumping organ
- **BLOOD**
- Blood is fluid connective tissue which comprises of



➤ Plasma Cells

- Fluid part of blood in which corpuscles or cells are suspended.
- It contains water and dissolved substances such as proteins, nutrients, nitrogenous waste etc.
- Plasma transport food, carbon dioxide and nitrogenous waste in dissolved form.
- **Blood contains:**
 1. **Erythrocytes/RBC** (Red Blood Cell) having iron containing pigment haemoglobin for transport of oxygen to various parts of body as oxyhaemoglobin.
 2. **Leukocytes/WBC** or white blood cell helps in fighting against infections by showing phagocytosis and producing antibodies against germs. So, WBCs are called **natural soldiers of human body**.
 3. **Platelets** or blood dust are cell fragments that helps in blood clotting.

KNOW MORE :

Mature RBC (Erythrocytes) lacks nucleus and other organelles in mammals.

Blood Vessels

1. Types of blood vessels :-

- As the oxygenated blood is pumped by muscular heart, it flows through arteries which are thick walled.
 - Arteries branch out into arterioles and then capillaries. From capillaries the deoxygenated blood flows through venules, then to veins and is finally poured back into the heart.
- (a) **Arteries** : These are thick walled and deep seated blood vessels which generally carry the oxygenated blood away from the heart to various body parts.
 - (b) **Veins** : These are thin walled and superficially located blood vessels which generally carry deoxygenated blood from the body parts to heart.
 - (c) **Capillaries** : The capillaries are thin walled and extremely narrow tubes or blood vessels which connects arteries to veins. The exchange of various materials like oxygen, food , carbon dioxide, etc. between the blood and the body cells takes place through capillaries.

Table : Difference between artery and vein

S.NO.	Characters	Artery	Vein
1.	Direction of blood flow	Away from the heart.	Towards the heart.
2.	Nature of blood	Generally oxygenated.	Generally deoxygenated.
3.	Position	Deep seated.	Superficial.
4.	Nature of wall	Thicker & more elastic	Thinner & less elastic.
5.	Pressure & speed of blood.	At higher pressure & faster.	At low pressure & slower.
6.	Valves	Absent	Present

➤ HEART

Heart is muscular involuntary organ, which is as big as our fist. It is made up of cardiac muscles which work rhythmically. Heart is situated in middle of chest cavity but it is tilted towards left. Heart is divided into chambers. Number of chambers varies in different animals:

- Fishes** - **2 chambered heart (1 auricle, 1 ventricle)**
Amphibian & most reptiles - **3 chambered heart (2 auricles, 1 ventricle)**
Birds and mammals - **4 chambered heart (2 auricles, 2 ventricles)**

Note : (Crocodile - 3 and half chambered heart)

- **Structure of Heart:** Blood circulatory system → discovered by William Harvey.
- Outer covering pericardium
- External structure
Upper two chambers - auricles.
lower two chambers - ventricles.
- Auricles and ventricles are separated by atria ventricular sulcus.
- Atria/auricles are separated by inter auricular septum. Left atrium is smaller than right atrium.
- Superior vena cava, inferior vena cava, coronary sinus open into right atrium.
- Superior vena cava collect blood from upper body part, inferior vena cava collects blood from lower body regions, coronary sinus collects blood from wall of heart.

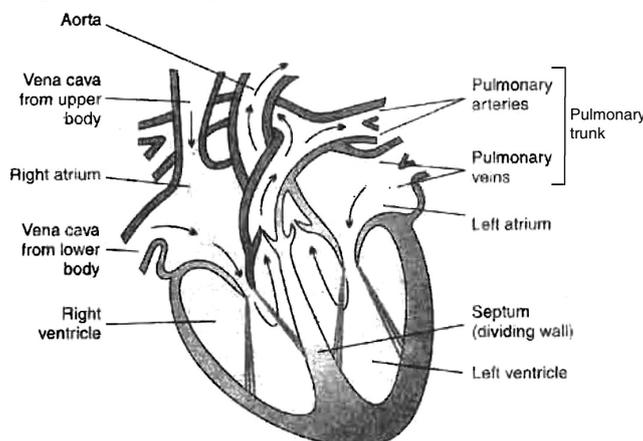


Fig. Internal structure of Human Heart

- Ventricles → left ventricle is longer & narrower than a right, left ventricle has thickest wall. Ventricles are separated by inter-ventricular septum.
- Pulmonary trunk arises from right ventricle & divides into right & left pulmonary arteries that carry deoxygenated blood to lungs. Opening of inferior vena cava is guarded by **eustachian valve**.
- At the base of pulmonary trunk & aorta semi-lunar valves are present.
- In right atrium adjoining to interatrial septum an oval depression, the fossa ovalis is present.
- At fossa ovalis the two atria are in communication with each other during foetal life but in adult it persists as depression. Bicuspid or mitral valve found between L.A and L.V.
- Tricuspid valve found between R.A and R.V.



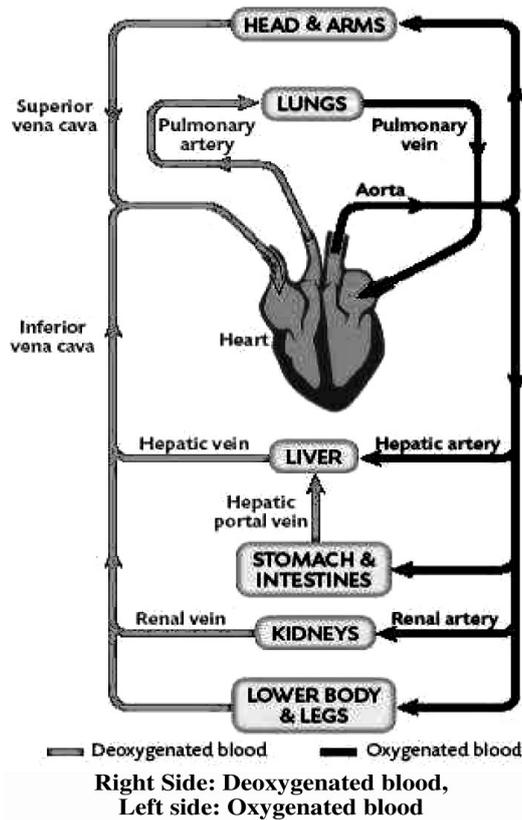
Let's know

- Attached to flaps of bicuspid & tricuspid valve are special **chordae tendineae** which are joined to other end of ventricular wall because of **papillary muscles**.
- Chordae tendineae prevent valves from collapsing back into atria during powerful ventricular contraction.

➤ **Flow of Blood**

- Vena cava brings de-oxygenated blood to right atrium.
- When right atrium is filled with blood it contract causing tricuspid valve to open. Blood is pushed into right ventricle.
- When right ventricle is filled, it contract and push blood into pulmonary artery (Tricuspid close, Pulmonary SLV open).
- Pulmonary artery carry blood to lungs for oxygenation (Pulmonary SLV prevents back flow).
- Oxygenated blood returns to heart by pulmonary vein.
- Pulmonary vein brings oxygenated blood to left auricle.
- Left auricle contract, blood passed to left ventricle (Bicuspid open).
- Left ventricle put blood into aorta, the largest artery (bicuspid close, aortic SLV open) which supplies to tissues.

➤ **Double circulation –**



- It was first discovered by **William Harvey (1578-1657)**. Circulatory system of most terrestrial animals consists of two phase's. Blood passes from heart twice in one complete cycle, and it is called double circulation.
- It involves (a) Pulmonary circulation (b) Systemic circulation. Former is related to right side of heart and later related to left side of heart.
- Double Circulation prevents mixing of oxygenated blood present in left side and deoxygenated blood present in right side of heart.

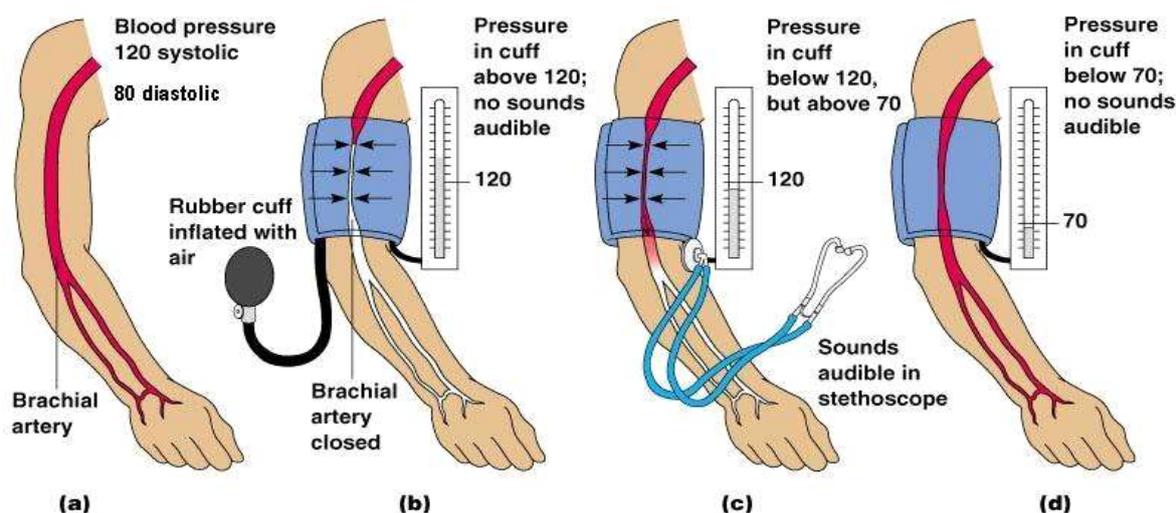
Note : Fish have a single circulation system because they lack lungs and their heart has only two chambers with deoxygenated blood.

➤ BLOOD PRESSURE

Blood pressure (BP) is the pressure exerted by circulating blood upon the walls of arteries, and is one of the principal vital signs. Contraction of heart called **systole** and relaxation called **diastole**. During each heartbeat, BP varies between a maximum (systolic) when heart contracts (120 mm Hg) and a minimum (diastolic) pressure when heart expands (80 mm Hg). Blood Pressure is measured with help **Sphygmomanometer**.



A Sphygmomanometer



Steps of Measurement of Blood Pressure

➤ KNOW MORE

Path of conduction of Impulses :

S.A node (sinoatrial node / pacemaker) → situated in R.A near opening of superior vena cava.

↓

A.V node (atrioventricular node or pacesetter) → situated in RA near or base of interatrial septum

↓

Bundle of his → present in ventricles

↓

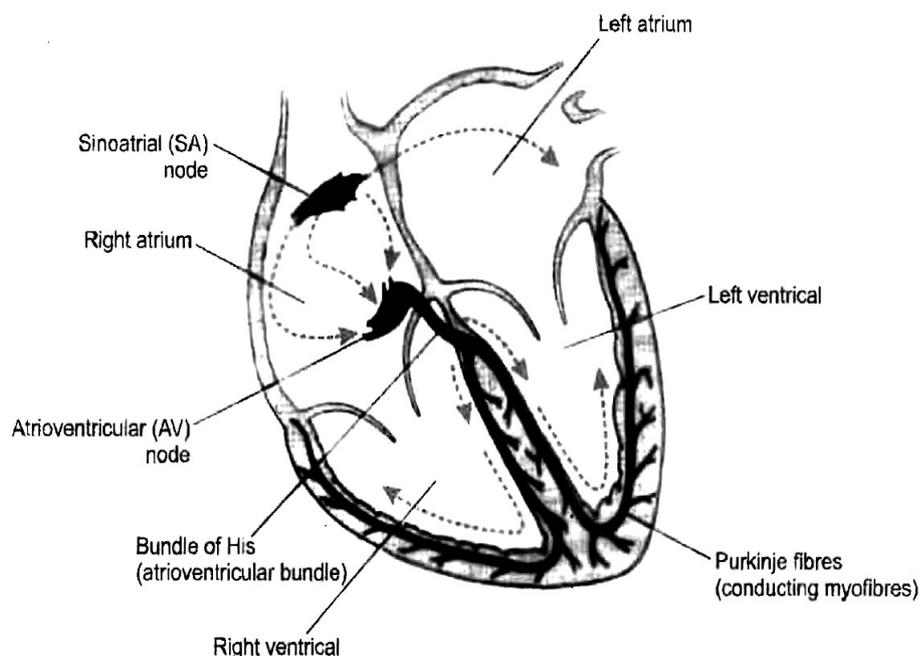
Purkinje fibre → found in wall of heart

Cardiac cycle → cardiac cycle consists of one heart beat. Time taken in one cycle is 0.8 sec.

Out of which atrial systole is of 0.1 sec

Ventricular systole is of 0.3 sec.

Complete diastole is of 0.4 sec.



- **ECG** - A graphic record of the spread of the cardiac impulse through the heart is called **electrocardiogram**, process refer as **electrocardiography**.
- **Heart Beat** : Rhythmic expansion and contraction of heart is called **heart beat**. The relaxation is called diastole while the contraction is known as systole. The rate of heart beat is 70-72 / min in adult human males and 80/min in females. Heart beat is listened with the help of **stethoscope**.

➤ **Heart Sounds:**

There is low pitched sound of longer duration called lubb and a high pitched sound of shorter duration known as **dupp**.

- (i) The first sound “LUBB” is produced when the atrio-ventricular valves get closed sharply at the start of ventricular systole.
- (ii) The second sound “DUPP” is produced when at the beginning of ventricular diastole, the semilunar valves at the roots of aorta and. pulmonary artery get closed.

➤ **LYMPH CIRCULATORY SYSTEM :**

It includes – lymph, lymph nodes and lymph vessels & capillaries

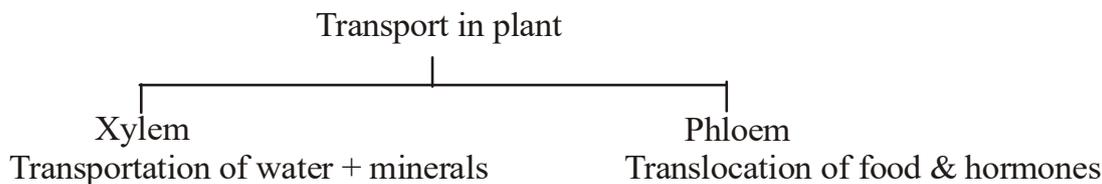
1. **Lymph** some amount of plasma, proteins and blood cells escape into intercellular space in the tissues to form the tissue fluid or lymph. Lymph (Blood - RBC) is an extra cellular, colourless fluid which moves in lymphatic system (Runs parallel to veins, towards heart).

➤ **Functions of Lymph**

- (a) Carry digested and absorbed fat from intestine back into blood.
 - (b) It contains lymphocytes which help in killing germs.
2. **Lymph nodes** are kidney shaped structure. They are rich in lymphocytes.
 3. **Lymph vessels and capillaries** – Tubular structure in which lymph flows, these vessels open into large veins of the body.

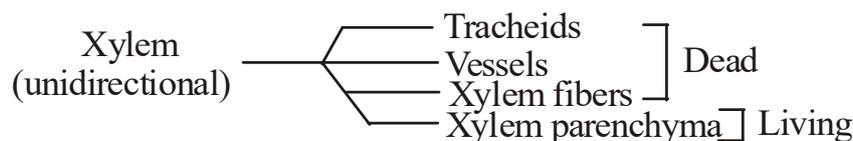
➤ TRANSPORT IN PLANTS :

- Plants transport system helps in movement of food energy stored in leaves and raw materials from roots to various parts of plant.
- They perform conduction with help of vascular tissues (xylem and phloem).



(1) Transportation of water -

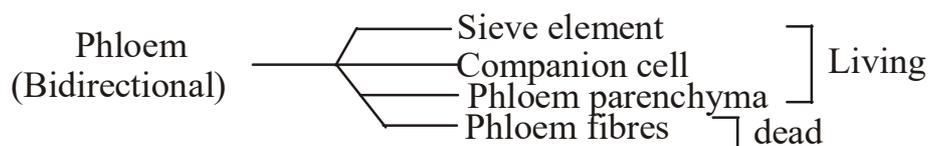
- Xylem is a complex permanent tissue that performs unidirectional transport and comprise of following components :



- Ascent of Sap (upwards movement of water and mineral in Xylem from root to various parts of plant)**
- Vessels and tracheids in xylem of root, stem and leaves are interconnected to form a continuous system.
- Root absorbs water from soil through root hairs.
- There are various theories to explain movement of water from roots to upper parts of plant.
- Most accepted theory of ascent of sap is cohesion tension theory.**
- Dixon and Jolly** proposed that water is pulled up in plant by tension (negative pressure) from above. This suction pressure is created by **transpiration**
- Water is continually being lost from leaves by transpiration.
- Loss of water in the leaves exerts a pull on the water in the xylem ducts and draws more water into the leaf.
- A water molecule clings to each other by hydrogen bond (**cohesion**) which maintains strength in column.
- Because of the critical role of cohesion, the transpiration-pull theory is also called the cohesion theory.
- The rate of ascent of water is 10 – 75 **cm/min**.

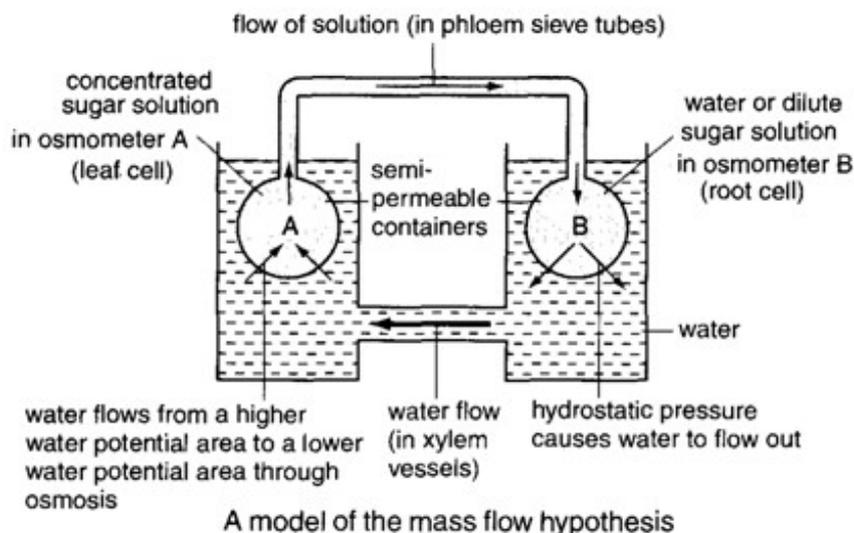
(2) Translocation of food :

- Food synthesized mainly in leaves and hormones synthesized at tip of root and shoots are transported by Phloem.
- Phloem uses energy for bidirectional transfer. It comprise of



- Translocation of Food is best explained by **Munch hypothesis**.
- Food is produce in leaves (**source**) and used by other parts like root (**sink**).

- Sucrose is transferred into **sieve tube** of phloem using ATP.
- This increase osmotic pressure of tissue causing water to move inside phloem.
- In the phloem, there is a continuous input of solute from source tissues (high pressure) and a continuous efflux at the sink (Low pressure).
- This input and output at the two ends will **maintain a pressure differential** that will keep liquid flowing.
- Thus, the driving force for solute transport is a **pressure gradient between the source and sink regions**. Speed of food transport is 60 – 100 cm / hour.



Difference in Xylem and Phloem

Xylem	Phloem
Mainly transport water and minerals	Mainly translocate food
Most part is dead.	Most part is living
Flow is unidirectional (Roots to Apex)	Flow is Bidirectional (Leaves to all parts)
No energy required (Physical force involved)	Energy is required
Located Superficially	Located Deeply

EXCRETION

➤ Introduction :

- The different chemical activities in the body produce many by-products several of which are wastes.
- These waste products if allowed to accumulate will turn out to be toxic and affect the physiological activities of the body.
- These wastes have to be expelled out or it may eventually result in the death of the organism.

➤ Definition :

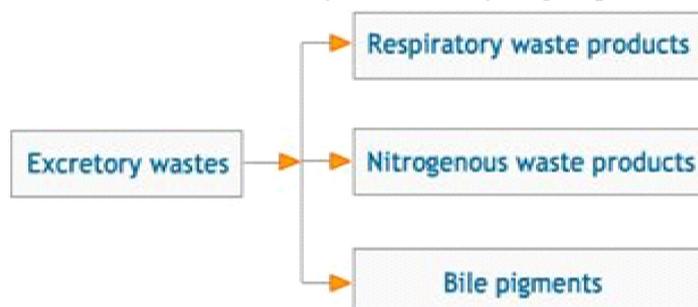
- The removal of harmful and unwanted toxic waste products of metabolism is known as excretion.
- **Excretory System** is a system of organs and tissue that take part in separation, collection & Avoiding the waste produced.

➤ Osmoregulation :

- The process by which the water content and the ion concentration is regulated and kept constant in the cells is known as osmoregulation.
- This process results in maintaining the osmotic pressure in the blood and tissue fluids.
- The two physiological processes, excretion and osmoregulation are interconnected as they both are responsible for bringing about homeostasis in the body.
- The physiological mechanisms involved are intimately bound with each other, so much so, in higher vertebrates like mammals, kidneys perform both functions, excretion and osmoregulation.
- The terms secretion and egestion are often confused with excretion. Hence it is important to understand clearly what they mean.

➤ Substances Excreted in Animals :

The metabolic wastes which are excreted by animals may be grouped as follows:



1. Respiratory Waste Products :

- Carbon dioxide and water are the by-products of catabolism of all varieties of foodstuffs.
- In lower animals carbon dioxide is eliminated directly into the environment through the body surface.
- In higher animals it is excreted out along with the exhaled air through the lungs.
- Excess water is excreted in the form of urine and sweat.

2. Nitrogenous Waste Products :

The following are the nitrogenous waste products produced by animals:

(i) Ammonia :

This is the main nitrogenous compound produced due to oxidative or deamination of amino acids during protein metabolism. Ammonia is highly toxic and it is important that it is expelled out of the body as and when it is formed as it can cause severe harm to the organism. i.e. **ammonotelism**. Eg. Fish, Amphibia.

(ii) Urea :

In higher animals ammonia combines with carbon dioxide in the liver and forms a less toxic substance called urea which is periodically flushed out of the system of the animal. Man eliminates nitrogenous waste in the form of urea. i.e. **ureotelism**. Eg. Human, animal (goat, dog and cow).

(iii) Uric Acid :

This is non-toxic and almost insoluble in water. Thus excretion of uric acid takes place with minimum loss of water. In man small quantities of uric acid is excreted in urine. In birds and reptiles, uric acid is excreted as a thick white paste or in the form of pellets. This enables these animals to conserve water. i.e. **uricotelism**. Eg. Reptiles and Aves.

➤ Excretion in Unicellular Organisms :

- Specific excretory organs are absent.
- Waste products (e.g., Ammonia, CO₂) generally pass out from the surface of the body into surrounding water by simple diffusion.
- Fresh water unicellular forms also possess an osmoregulatory organelle called **contractile vacuole**, e.g., Amoeba, Paramecium.
- Contractile vacuole collects water and some wastes from the body, swells up (undergoes diastole), reaches the surface and bursts (undergoes systole) to release its contents to the outside.
- Osmoregulation is required in fresh water forms as fresh water has a tendency to enter their bodies due to higher internal osmotic concentration.

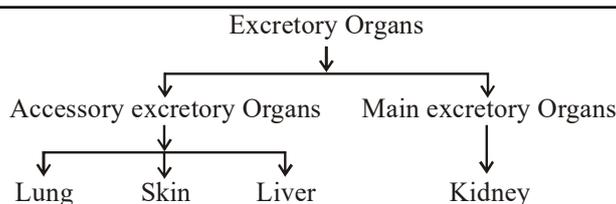
➤ Excretion in Multicellular Organisms :

- Sponges and coelenterates do not have specific excretory organs as water bathes almost all their cells.
- Excretory structures appear for the first time in flatworms (platyhelminthes). They are flame cells.
- Nephridia are excretory organs of annelids, green glands in crustaceans, Malpighian tubules in insects, and kidneys in molluscs.
- Kidneys form a urinary system in vertebrates.
- Some accessory excretory organs of vertebrates including human beings are skin, lungs and large intestine.

Table : Excretory Organs of different Animal groups		
S.No.	Animal Groups	Excretory Organs
1	Protozoans (e.g. Amoeba, Paramecium)	Plasma membrane
2.	Sponges (e.g. Sycon)	Plasma membrane of each cell.
3.	Cnidaria (e.g. Hydra)	Plasma membrane of each cell.
4.	Platyhelminthes (e.g. Planaria)	Flame cells (Solenocytes)
5.	Nemathelminthes (e.g. Ascaris)	H-shaped excretory system of canals and renette cells.
6.	Annelids (e.g. Neries, Earthworm)	Nephridia; chloragogen cells (yellow cells) in earthworm.
7.	Arthropods (a) Prawn (b) Most insects (c) Scorpion and Spiders	Antennar / Green glands Malpighian tubules Malpighian tubules, coxal glands, hepatopancreas and nephrocytes.
8.	Molluscs (e.g. Unio, Pila)	Kidney. In Unio, kidney are called as organ of Bojanus .
9.	Echinoderms (e.g. Starfish)	Dermal branchiae and tube feet.
10.	Hemichordates (e.g. Balanoglossus)	Glomerulus.

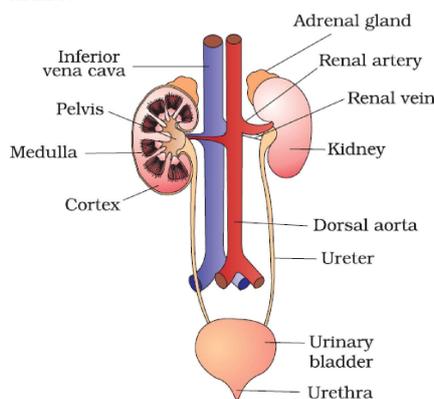
Excretion and Osmoregulation in Man :

- Man is a highly evolved vertebrate and so the excretory organs are well developed.



Main Excretory Organ Kidneys :

- The kidneys are the principal excretory organs in man through which the nitrogenous metabolic wastes are eliminated in the form of urine.



Human Excretory System



Let's know

- The kidneys function as a pair of filters through which about one litre of blood circulates each minute.
- The entire blood in the body passes through them in 5 - 6 minutes. In a day it filters 1800 litres of blood which is 400 times the blood volume.
- Tea, coffee and alcohol are beverages that increase the formation of urine. They are termed diuretics.
- The human kidney contains more than 1.2 million nephrons.
- When a kidney is damaged or diseased, the other kidney is able to compensate for it. So a person can lead a normal life with only one kidney.
- A normal adult excretes 1 - 1.8 litres of urine per day.
- An artificial kidney (dialysing machine) is used for dialysis. When the kidneys of a patient stop functioning, life can be prolonged through dialysis.
- Kidney transplants have had good success rates and have given fresh lease of life to patients.

Structure of kidneys :

- The kidneys are reddish brown, bean-shaped organs situated in the abdominal cavity, one on either side of the vertebral column in the lumbar region of the body.
- They lie asymmetrically, the right kidney being lower than the left as the right side of the abdominal cavity is occupied by the liver.
- Each kidney is 10 cm long, 6 cm wide and 4 cm thick and weighs 200 - 250 g in adults.
- A thin, tough, fibrous whitish capsule envelops each kidney.
- The outer surface of each kidney is convex while the inner surface is concave.
- Associated with the kidneys are the following:

1. Ureter :

The ureter, a tube, runs from each kidney downwards into the lower part of the abdomen connecting each kidney to the urinary bladder. Its function is to transport the urine from the kidneys to the urinary bladder. The oblique entrance of the ureter into the bladder acts like a valve, preventing the back flow of urine from the bladder into the ureter.

2. Urinary Bladder :

This is a large muscular storage sac that collects urine from both the kidneys through the ureters. As the urine gets drained into the bladder its volume increases. The mouth of the bladder is guarded by a tight ring of muscle called the sphincter which regulates the opening or closing of the bladder. When the sphincter relaxes, urine is released out through the urethra.

3. Urethra :

This is a short muscular tube that carries urine at intervals from the urinary bladder to the outside. The base of the urethra is also guarded by a sphincter which keeps the urethra closed except while passing urine.

➤ **Microscopic Structure of a Nephron :**

The nephron is the structural and functional unit of the kidney. Each nephron functions as an independent unit and produces a miniscule quantity of urine. The nephron can be differentiated into the following regions.

➤ **Malpighian Corpuscle :**

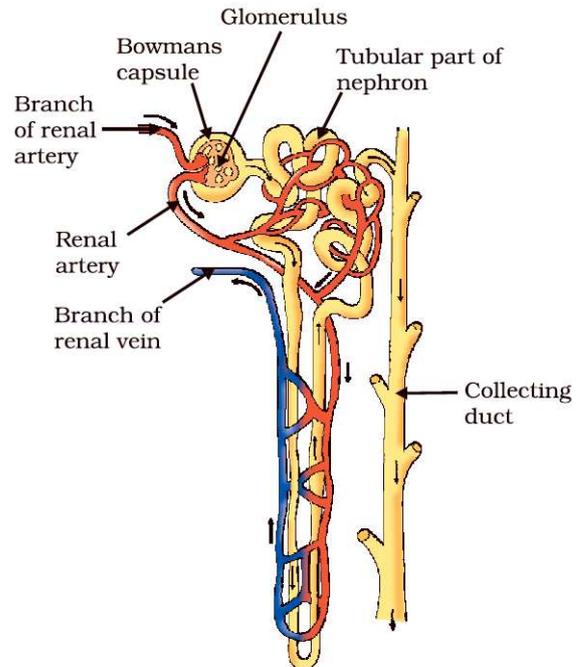
This consists of two parts :

1. Bowman's Capsule :

This is a cup - shaped structure which is double walled in the hollow of which is a net work of capillaries called the **glomerulus**. (This is a knotted mass of blood capillaries formed by the afferent arteriole (incoming) and the efferent arteriole (outgoing)).

2. Renal Tubule :

This is the remaining part of the nephron, continuous with the Bowman's capsule. It is lined with ciliated epithelium and differentiated into the following regions :



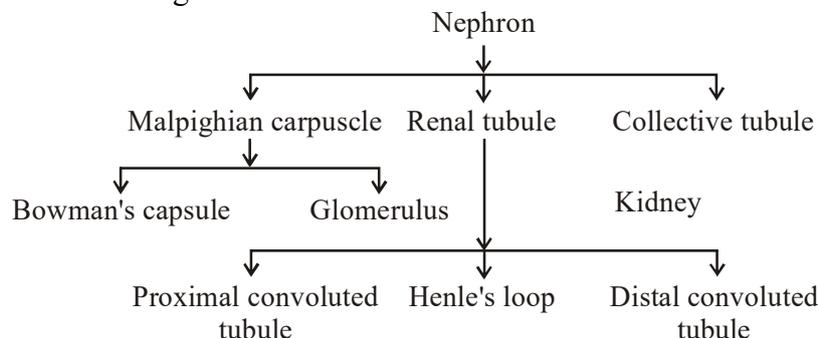
Structure of a nephron

(a) Proximal Convoluted Tubule (PCT) :

This is the region behind the Bowman's capsule and consists of a coiled tube that descends to form the Henle's loop. The proximal convoluted tubule is present in the cortex region.

(b) Henle's loop :

This is continuous with the proximal convoluted tubule and is U-shaped having a narrow descending limb and a thick ascending limb. This part of the nephron descends from the cortex into the medulla region.



Distal Convoluted Tubule (DCT) This is another coiled and twisted tubule that continues from the ascending limb of loop of Henle found in the renal cortex.

(c) Collecting Tubule :

The distal convoluted tubule continues to form the collecting tubule.

(d) Collecting Ducts :

Several collecting tubules fuse to form large collecting ducts which pass downwards from the cortex to the medulla region.

➤ Blood Flow In Kidney

Renal artery → Afferent arteriole → Glomerulus → Efferent arteriole → Venule → Renal vein

➤ Micturition (Urination) :

- Urge for micturition occurs when urinary bladder comes to have 300-400 ml of urine.
- The stretched bladder stimulates nerve endings to develop the reflex.
- However, urine can be retained in the urinary bladder till it gets filled upto maximum capacity, 700 – 800 ml. At this time the urge becomes painful.
- Voluntary micturition can be carried any time.
- Total amount of urine excreted per day is about 1.6 – 1.8 litres.
- The quantity increases with larger intake of fluids and decreases with lesser intake of them.

➤ URINE

- It is a transparent fluid produced by urinary system.
- Urine has an amber colour due to presence of urochrome.
- Urine contains 96% water, 2.5% organic substances and 1.5% inorganic solutes.
- Reaction is acidic in the beginning but becomes alkaline on standing due to decomposition of urea to form ammonia.

Water - 96%

Organic Substances – 2.5%, e.g., urea, uric acid, creatine, creatinise, water soluble vitamins, hormones, oxalate.

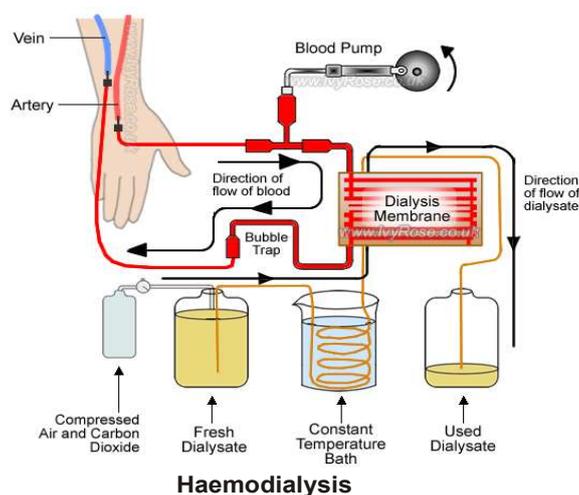
Inorganic Solutes – 1.5%, e.g., sodium, chloride, phosphate, sulphate, magnesium, calcium, iodine.

➤ Functions of Kidneys/Urinary or Excretory System :

- Waste Products** - Excretion of nitrogenous and other waste products.
- Toxic Chemicals** - The system takes part in expelling toxic chemicals that happen to enter the body.
- Water Balance** - Maintenance of water balance in the body by producing dilute urine in excess when water intake is high and concentrated urine in case of lesser water intake or excessive sweating.
- Excess Materials** - Elimination of excess water soluble vitamins, drugs and other substances.
- Regulation of Salt Content** - Regulation of salt content in body by excreting salts when in excess and retaining them when deficient.
- Maintenance of pH** - pH of body fluids is maintained by excretion or non-excretion of H^+ ion.
- Regulation of Blood Pressure** - By controlling the fluid content, kidneys regulate blood pressure.

➤ ARTIFICIAL KIDNEY OR HAEMODIALYSIS

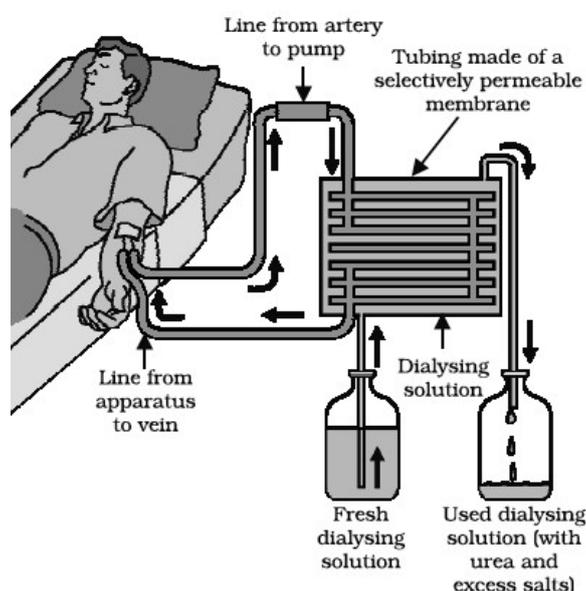
A machine that uses dialysis to remove impurities and waste products from the blood stream before returning the blood to the patient's body is called **Haemodialyzer**.



Kidneys are most vital organs for survival of the organisms. Though the kidneys remain active throughout the life. Its efficiency gradually declines with normal ageing process. The other causes of decline in the normal functioning of kidneys are diseases such as kidney infection, injury or restricted blood flow to kidneys.

These abnormalities result in kidney damage and malfunctioning. A general term for decline in the performance of kidney due to a disease is **kidney failure**.

There are two alternatives of kidney failure (i) A matching kidney from a healthy person may be transplanted, or (ii) An 'artificial kidney' machine may be employed in order to get rid of metabolic wastes from the blood and to maintain normal levels of water and mineral ions in body fluids. The artificial kidney functions on the same principle as the normal kidney and the procedure is called **haemodialysis**. The blood is pumped out of the body and made to flow into the dialysis machine. Heparin is added to the blood to prevent clotting. The blood circulates slowly through the long cellulose tubes coiled in a tank filled with dialysing solution. The cellulose membrane allows ions, very small molecules and water to diffuse through it. The blood corpuscles, platelets and protein molecules are too large and do not pass through the membrane. Finally the clean blood is pumped back into patient.



Artificial Kidney – Dialysis

➤ EXCRETION IN PLANTS :

- Plants do not produce nitrogenous wastes like urea and uric acid because extra amino acids and nucleotides are not formed.
 - They produce other types of waste products, called secondary metabolites, e.g., alkaloids, tannins, aromatic oils.
 - Excess of water is got rid off through transpiration. Excess of oxygen formed during day in photosynthesis organs can be considered as waste.
 - It passes out through diffusion.
 - The other wastes of plant metabolism are as follows :
- (i) **Nitrogen Waste Products** - They are byproducts of general metabolism. The common ones are alkaloids, e.g., quinine, morphine, atropine.
 - (ii) **Organic Acids** - They are metabolic intermediates. Some of them are without any other use. Rather on accumulation they may prove toxic, e.g., oxalic acid.
 - (iii) **Tannins** - They are complex aromatic compounds which are formed as secondary metabolites.
 - (iv) **Latex** - It is an emulsion of varied composition which is excreted by special tubular cells called laticifers.
 - (v) **Resins** - They are oxidation products of aromatic oils.
 - (vi) **Gums** - They are degradation products of cell wall.

In saline habitats, the plants have to absorb excess salts that are required to be eliminated.

➤ **Mechanism :**

Plants do not have any mechanism to collect, transport and throw out their waste products. They have adopted varied strategies to protect their living cells from waste products.

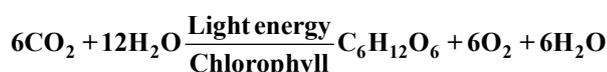
- (i) **Old leaves** - Waste products are stored in older leaves which soon fall off.
- (ii) **Old xylem** - Resins, gums, tannins and other waste products are deposited in the old xylem which soon becomes non-functional, e.g., heart wood.
- (iii) **Bark** - Bark consists of dead cells which is peeled off periodically. Tannins and other wastes are deposited in the bark. Incidentally, tannins are raw material for dyes and inks.
- (iv) **Central Vacuole** - Most plant waste products are stored in central vacuole of their cells. They are unable to influence the working of cytoplasm due to presence of a selectively permeable membrane called tonoplast.
- (v) **Root Excretion** - Some waste substances are actually excreted by the plants in the region of their roots.
- (vi) **Detoxification** - The toxic oxalic acid is detoxified by formation of calcium oxalate which gets crystallised into needle (raphides), prism (prismatic crystals), stars (sphaeraphides) and crystal sand. Excess of calcium is also precipitated as calcium carbonate crystals, e.g., cystolith.
- (vii) **Salt Glands** - They excrete excess salts obtained from the habitat. Hydrathodes also have an excretory function.



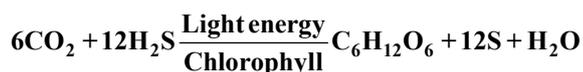
LET'S RECALL

1. Diaphragm becomes flat during inspiration and becomes convex during expiration.
2. **Tidal volume** : Volume of air inspired or expired in relaxed position. It is around 500 ml.
3. **Residual volume** : Air left in the whole respiratory tract after forceful expiration. It is 1.5 litres.
4. **Total lung capacity** : Maximum amount of air the lungs can hold after forceful inspiration. It is about 5-6.0 litres.
5. **Vital capacity** : Maximum amount of air which can be breathed out through forceful expiration after a forceful inspiration. It is 3.4-4.8 litres.
6. Vital Capacity is more in athletes, mountain dwellers, non smokers.
7. The total area for gas exchange provided by our 750 million alveoli in two lungs in 100 S. m.
8. In the cycle of inhalation and exhalation, repeated 15 to 18 times in a minutes about 500 ml of air is breathed in and out. In 24 hours, we breath in 1500 litres of air.
9. Blood is the medium for the transport of oxygen from the respiratory organ to the different tissues and carbon dioxide from tissues to the respiratory organs. As much as 97 percent of the oxygen is transported from the lungs to the tissues in combination with hemoglobin and only 2 percent is transported in dissolved condition by the plasma.
10. A normal person has about 15 grams of hemoglobin per 100 ml of blood. One gram of hemoglobin binds about 1.34 ml of O₂. Thus, 100 ml of blood carries about 20 ml of oxygen.
11. Carbon dioxide is also transported by hemoglobin. When a respiring tissue release carbon-dioxide, it is first diffused in the plasma. From here it diffuses into the red blood cells. Carbon-dioxide is transported from the tissues to the lungs in the form of bicarbonates dissolved in water.
12. About 23% of carbon dioxide entering into the erythrocytes combines with the globin (protein) part of haemoglobin to form carbaminohaemoglobin, which is transported to the lungs.
13. Carbon monoxide binds with hemoglobin about 230 times more readily than oxygen. When a person inhales carbon monoxide, it diffuses from the alveolar air to the blood and binds to haemoglobin forming carboxyhemoglobin. The latter is a relatively stable compound and cannot bind with oxygen molecules. So, the amount of hemoglobin available for oxygen transport is reduced. The resulting deficiency of oxygen cases headache, dizziness, nausea and even death.
14. **Mountain sickness** : It is also known as altitude sickness. At sea level the concentration of oxygen is about 21% and the barometric pressure averages 760 mm Hg. As altitude increases, the concentration remains the same but the number of oxygen molecules per breath is reduced. AT 12,000 feet the barometric pressure is only 483 mm Hg, so there are roughly 40% fewer oxygen molecules per breath. In order to oxygenate the body effectively, breathing rate (even while at rest) has to be increased. This extra ventilation increases the oxygen content in the blood, but not sea level concentration. The fall in oxygenation of blood produced the symptoms of mountain sickness. These symptoms include breathlessness, headache, dizziness, nausea, vomiting, mental fatigue and a bluish tinge on the skin, nails and lips.
15. The ability to perform the basic life processes distinguishes a living organism from a nonliving one.
16. Life processes are the vital processes carried out by living organisms in order to maintain and sustain life. Molecular movements are essential to carry out the various life processes.
17. Specialised body parts perform the various life processes in multicellular organisms. No such organs are present in unicellular organisms.
18. Energy required to carry out the different life processes, is obtained from carbon-based food sources through nutrition.

19. Depending on the mode of obtaining nutrition, organisms are classified as autotrophs or heterotrophs.
- Autotrophs can prepare their own food from simple inorganic sources like carbon dioxide and water. (eg- green plants, some bacteria)
 - Heterotrophs cannot synthesize their own food and is dependent on the autotrophs for obtaining complex organic substances for nutrition. (eg. – animals)
20. Green plants prepare their food by the process of photosynthesis. Here, they utilize CO₂, H₂O and sunlight, with the help of chlorophyll, giving out O₂ as a byproduct.
21. In the light reaction of photosynthesis, light energy is absorbed and converted to chemical energy in the form of ATP. Also water molecules are split into hydrogen and oxygen.
22. Photosynthesis involves light-dependent reaction having non-cyclic and cyclic photophosphorylation and dark reaction where energy is utilised.
23. In 1941, by using Van Niel's hypothesis and the rare isotope of oxygen O₂, water labelled with O₂ was used. The experiment proved that **all oxygen evolved comes from water only** and hence the modified equation of photosynthesis is written as given.



24. In sulphur bacteria, he found that sulphur was released, not oxygen meaning that CO₂ was not split rather H₂S was broken down, and hydrogen reduced the CO₂.



25. By 1950 it was well established that both the reactions occur in separate areas, the light reaction takes place on the chloroplast membranes and the dark reaction in the stroma region.
26. Desert plants as an exception, opens stomata in night to absorb CO₂ and form intermediate compound i.e. malate which is stored in vacuole. During day it is converted into sugar.
27. The parasite, the one that draws nourishment often lacks digestive system as it feeds on nutrients already in solution form or digested form, from the host as in the case of gut parasites like tapeworm and round worm.
28. Commercially for curdling of milk the **Rennet tablets** are used which contain renin extracted from the calf gastric mucosa.
29. Carbon dioxide is reduced to carbohydrates in the dark phase of photosynthesis.
30. Plants carry out gaseous exchange with surrounding through stomata.
31. Heterotrophs may be herbivores, carnivores, parasites or saprophytes.
32. In Amoeba, digestion occurs in the food vacuole, formed by the engulfing of food by its pseudopodia.
33. In humans, digestion of food takes place in the alimentary canal, made up of various organs and glands.
34. In mouth, food is crushed into small particles through chewing and mixed with saliva, which contains amylase for digesting starch.
35. On swallowing, food passes through pharynx and oesophagus to reach stomach. The gastric juice contains pepsin (for digesting proteins), HCl and mucus.
36. Liver secretes bile which emulsifies fat.
37. Pancreatic juice contains enzymes amylase, trypsin and lipase for digesting starch, proteins and fats respectively.
38. In the small intestine, carbohydrate, proteins and fats are completely digested into glucose, amino acids, and fatty acids and glycerol respectively.
39. The villi of small intestine absorb the digested food and supply it to every cell of the body.

40. The undigested food is egested from the body through anus.
41. During respiration, the digested food materials are broken down to release energy in the form of ATP.
42. Depending on the requirement of oxygen, respiration may be
 - a. Aerobic - occurring in presence of oxygen or
 - b. Anaerobic – occurring in absence of oxygen.
43. The end-products are lactic acid or ethanol + CO₂, in anaerobic respiration or CO₂ and water in aerobic respiration. Large amount of energy is released in aerobic respiration as compared to anaerobic respiration.
44. Plants release CO₂ at night and oxygen during the day.
45. Terrestrial organisms use atmospheric oxygen for respiration whereas aquatic organisms use the dissolved oxygen in water.
46. In humans, air takes the following path on entering the nostrils.
Nostrils → Nasal passage → Pharynx → Larynx → Trachea → Bronchus → Bronchiole → Alveolus.
47. The alveoli of lungs are richly supplied with blood and are the sites where exchange of gases (O₂ and CO₂) occurs between blood and atmosphere.
48. In humans, the respiratory pigment haemoglobin, carry oxygen from lungs to different tissues of the body.
49. Acetyl Co-A is a important molecule in metabolism. It main function is to convey the carbon atom with in acetyl group to the citric acid cycle to be oxidized to produced energy.
50. In humans, the circulatory system transports various materials throughout the body and is composed of the heart, blood and blood vessels.
51. Human heart has 4 chambers – 2 atria (right and left) and 2 ventricles (right and left). Right half of the heart receives deoxygenated blood whereas the left half receives oxygenated blood.
52. Cockroach has 13 hearts.
53. Ventricular walls are much thicker than atrial walls.
54. Arteries carry blood from heart to different parts of the body whereas veins deliver the blood back to the heart. Arteries are connected to veins by thin capillaries, wherein materials are exchanged between blood and cells.
55. Humans show double circulation and complete separation of oxygenated and deoxygenated blood.
56. Blood platelets are essential for clotting of blood at the place of injury and thus preventing blood loss.
57. Lymphatic system consists of lymph, lymph nodes, lymphatic capillaries and lymph vessels which drain into larger veins. Lymph is also important in the process of transportation.
58. In plants, water is transported through the xylem tissue, from roots to the aerial parts of the plant. Root pressure and transpiration pull are the major forces involved in pulling water up the xylem.
59. Translocation of food is carried out through phloem tissue from leaves and storage organs to other parts of the plant. This process requires energy from ATP.
60. During excretion, the harmful metabolic nitrogenous wastes generated are removed from the body.
61. In humans, a pair of kidneys, a pair of ureters, urinary bladder and urethra constitutes the excretory system.
62. Nephrons are the basic filtration units of kidneys. They carry out filtration, selective reabsorption and tubular secretion to form urine in kidney, which is then passed out through the urethra, via the ureters and urinary bladder.
63. Plants do not have an excretory system and carries out excretion in various ways like transpiration, releasing wastes into surrounding soil, losing the leaves and storing in cell vacuoles and in old xylem.
64. **Ornithine cycle** – Ornithine cycle is the process of converting ammonia into urea by combining with CO₂ in liver.

EXERCISE-I

NCERT Solutions



Q.1 Why is diffusion insufficient to meet the oxygen requirements of multi-cellular organisms like humans?

Sol. Multicellular organisms such as humans possess complex body designs. They have specialised cells and tissues for performing various necessary functions of the body such as intake of food and oxygen. Unlike unicellular organisms, multicellular cells are not in direct contact with the outside environment. Therefore, diffusion cannot meet their oxygen requirements.

Q.2 What criteria do we use to decide whether something is alive?

Sol. Any visible movement such as walking, breathing, or growing is generally used to decide whether something is alive or not. However, a living organism can also have movements, which are not visible to the naked eye. Therefore, the presence of life processes is a fundamental criterion that can be used to decide whether something is alive or not.

Q.3 What are outside raw materials used for by an organism?

Sol. An organism uses outside raw materials mostly in the form of food and oxygen. The raw materials required by an organism can be quite varied depending on the complexity of the organism and its environment.

Q.4 What processes would you consider essential for maintaining life?

Sol. Life processes such as nutrition, respiration, transportation, excretion, etc. are essential for maintaining life.

Q.5 What are the differences between autotrophic nutrition and heterotrophic nutrition?

	Autotrophic nutrition	Heterotrophic nutrition
(i)	Food is synthesised from simple inorganic raw materials such as CO ₂ and water.	Food is obtained directly or indirectly from autotrophs. This food is broken down with the help of enzymes.
(ii)	Presence of green pigment (chlorophyll) is necessary.	No pigment is required in this type of nutrition.
(iii)	Food is generally prepared during day time.	Food can be prepared at all times.
(iv)	All green plants and some bacteria have this type of nutrition.	All animals and fungi have this type of nutrition.

Sol.

Q.6 Where do plants get each of the raw materials required for photosynthesis?

Sol. The following raw materials are required for photosynthesis :

- The raw material CO₂ enters from the atmosphere through stomata.
- Water is absorbed from the soil by the plant roots.
- Sunlight, an important component to manufacture food, is absorbed by the chlorophyll and other green parts of the plants.

Q.7 What is the role of the acid in our stomach?

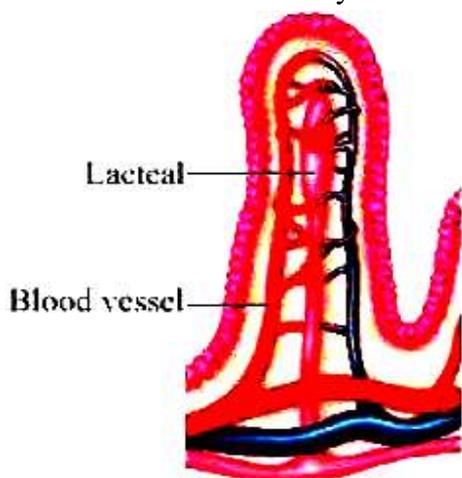
Sol. The hydrochloric acid present in our stomach dissolves bits of food and creates an acidic medium. In this acidic medium, enzyme pepsinogen is converted to pepsin, which is a protein-digesting enzyme.

Q.8 What is the function of digestive enzymes?

Sol. Digestive enzymes such as amylase, lipase, pepsin, trypsin, etc. help in the breaking down of complex food particles into simple ones. These simple particles can be easily absorbed by the blood and thus transported to all the cells of the body.

Q.9 How is the small intestine designed to absorb digested food?

Sol. The small intestine has millions of tiny finger-like projections called villi. These villi increase the surface area for more efficient food absorption. Within these villi, many blood vessels are present that absorb the digested food and carry it to the blood stream. From the blood stream, the absorbed food is delivered to each and every cell of the body.



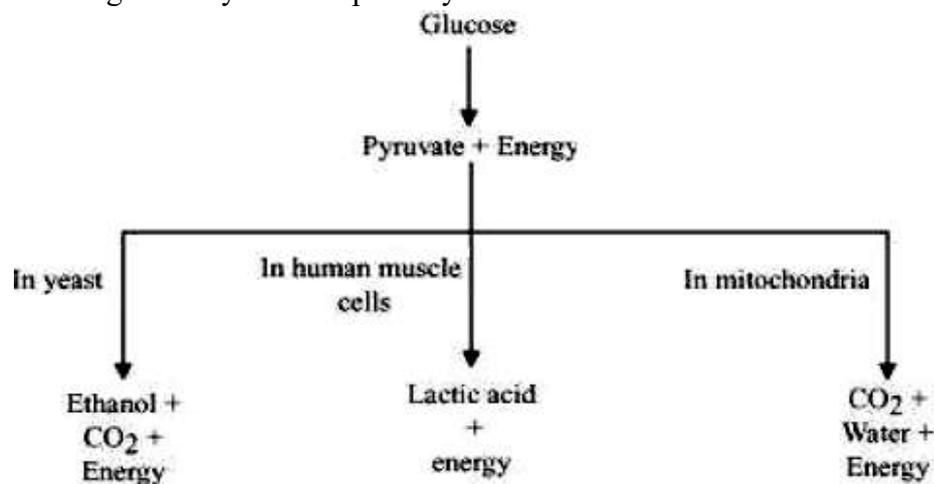
Enlarged view of a villus

Q.10 What advantage over an aquatic organism does a terrestrial organism have with regard to obtaining oxygen for respiration?

Sol. Terrestrial organisms take up oxygen from the atmosphere whereas aquatic animals need to utilize oxygen present in the water. Air contains more O_2 as compared to water. Since the content of O_2 in air is high, the terrestrial animals do not have to breathe faster to get more oxygen. Therefore, unlike aquatic animals, terrestrial animals do not have to show various adaptations for better gaseous exchange.

Q.11 What are the different ways in which glucose is oxidized to provide energy in various organisms?

Sol. Glucose is first broken down in the cell cytoplasm into a three carbon molecule called pyruvate. Pyruvate is further broken down by different ways to provide energy. The breakdown of glucose by different pathways can be illustrated as follows.

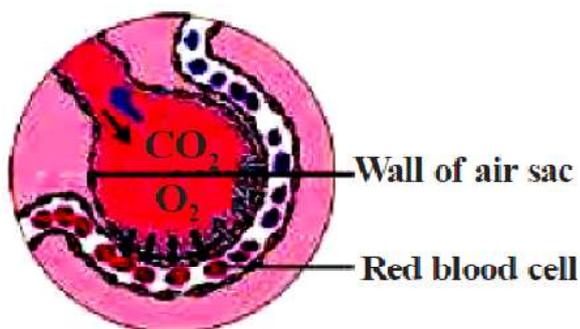


In yeast and human muscle cells, the breakdown of pyruvate occurs in the absence of oxygen whereas in mitochondria, the breakdown of pyruvate occurs in the presence of oxygen.

Q.12 How is oxygen and carbon dioxide transported in human beings?

Sol. Haemoglobin transports oxygen molecule to all the body cells for cellular respiration. The haemoglobin pigment present in the blood gets attached to four O_2 molecules that are obtained from breathing. It thus forms oxyhaemoglobin and the blood becomes oxygenated. This oxygenated blood is then distributed to all the body cells by the heart. After giving away O_2 to the body cells, blood takes away CO_2 which is the end product of cellular respiration. Now the blood becomes de-oxygenated.

Since haemoglobin pigment has less affinity for CO_2 , CO_2 is mainly transported in the dissolved form. This de-oxygenated blood gives CO_2 to lung alveoli and takes O_2 in return.



Transportation of O_2 and CO_2 in blood.

Q.13 How are the lungs designed in human beings to maximize the area for exchange of gases?

Sol. The exchange of gases takes place between the blood of the capillaries that surround the alveoli and the gases present in the alveoli. Thus, alveoli are the site for exchange of gases. The lungs get filled up with air during the process of inhalation as ribs are lifted up and diaphragm is flattened. The air that is rushed inside the lungs fills the numerous alveoli present in the lungs. Each lung contains 300-350 million alveoli. These numerous alveoli increase the surface area for gaseous exchange making the process of respiration more efficient.

Q.14 What are the components of the transport system in human beings? What are the functions of these components?

Sol. The main components of the transport system in human beings are the heart, blood, and blood vessels.

- Heart pumps oxygenated blood throughout the body. It receives deoxygenated blood from the various body parts and sends this impure blood to the lungs for oxygenation.
- Being a fluid connective tissue, blood helps in the transport of oxygen, nutrients, CO_2 , and nitrogenous wastes.
- The blood vessels (arteries, veins, and capillaries) carry blood either away from the heart to various organs or from various organs back to the heart.

Q.15 Why is it necessary to separate oxygenated and deoxygenated blood in mammals and birds?

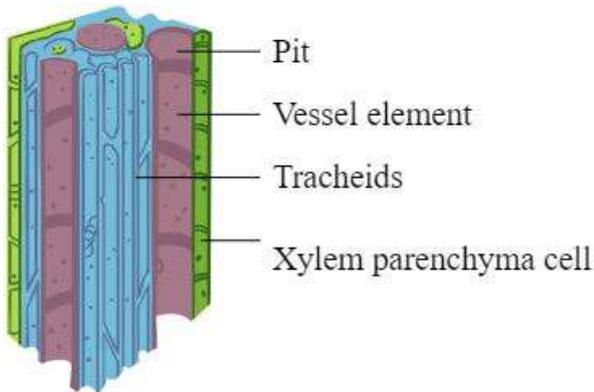
Sol. Warm-blooded animals such as birds and mammals maintain a constant body temperature by cooling themselves when they are in a hotter environment and by warming their bodies when they are in a cooler environment. Hence, these animals require more oxygen (O_2) for more cellular respiration so that they can produce more energy to maintain their body temperature. Thus, it is necessary for them to separate oxygenated and de-oxygenated blood, so that their circulatory system is more efficient and can maintain their constant body temperature.

Q.16 What are the components of the transport system in highly organised plants?

Sol. In highly organised plants, there are two different types of conducting tissues - xylem and phloem. Xylem conducts water and minerals obtained from the soil (via roots) to the rest of the plant. Phloem transports food materials from the leaves to different parts of the plant body.

Q.17 How are water and minerals transported in plants?

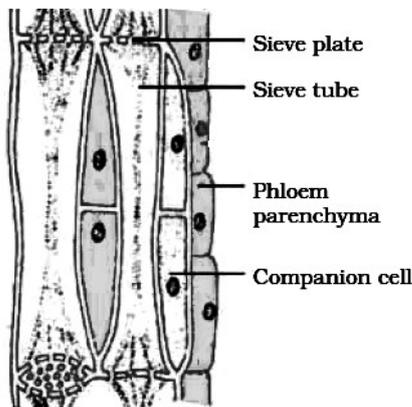
Sol. The components of xylem tissue (tracheids and vessels) of roots, stems, and leaves are interconnected to form a continuous system of water-conducting channels that reaches all parts of the plant. Transpiration creates a suction pressure, as a result of which water is forced into the xylem cells of the roots. Then there is a steady movement of water from the root xylem to all the plant parts through the interconnected water-conducting channels.



Components of xylem tissue

Q.18 How is food transported in plants?

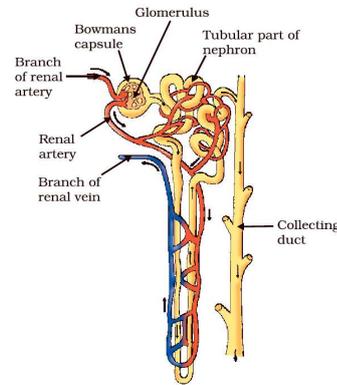
Sol. Phloem transports food materials from the leaves to different parts of the plant body. The transportation of food in phloem is achieved by utilizing energy from ATP. As a result of this, the osmotic pressure in the tissue increases causing water to move into it. This pressure moves the material in the phloem to the tissues which have less pressure. This is helpful in moving materials according to the needs of the plant. For example, the food material, such as sucrose, is transported into the phloem tissue using ATP energy.



Components of phloem tissue

Q.19 Describe the structure and functioning of nephrons.

Sol. Nephrons are the basic filtering units of kidneys. Each kidney possesses large number of nephrons, approximately 1-1.5 million. The main components of the nephron are glomerulus, Bowman’s capsule, and a long renal tubule.



Structure of a nephron

Functioning of a nephron :

- The blood enters the kidney through the renal artery, which branches into many capillaries associated with glomerulus.
- The water and solute are transferred to the nephron at Bowman’s capsule.
- In the proximal tubule, some substances such as amino acids, glucose, and salts are selectively reabsorbed and unwanted molecules are added in the urine.
- The filtrate then moves down into the loop of Henle, where more water is absorbed.
- From here, the filtrate moves upwards into the distal tubule and finally to the collecting duct. Collecting duct collects urine from many nephrons.
- The urine formed in each kidney enters a long tube called ureter. From ureter, it gets transported to the urinary bladder and then into the urethra.

Q.20 What are the methods used by plants to get rid of excretory products?

Sol. Plants can get rid of excess of water by transpiration. Waste materials may be stored in the cell vacuoles or as gum and resin, especially in old xylem. It is also stored in the leaves that later fall off.

Q.21 How is the amount of urine produced regulated?

Sol. The amount of urine produced depends on the amount of excess water and dissolved wastes present in the body. Some other factors such as habitat of an organism and hormone such as Antidiuretic hormone (ADH) also regulates the amount of urine produced.

Q.22 The kidneys in human beings are a part of the system for
 (a) nutrition. (b) respiration.
 (c) excretion. (d) transportation.

Sol. (c) In human beings, the kidneys are a part of the system for excretion.

Q.23 The xylem in plants are responsible for
 (a) transport of water.
 (b) transport of food.
 (c) transport of amino acids.
 (d) transport of oxygen.

Sol. (a) In a plant, the xylem is responsible for transport of water.

Q.24 The autotrophic mode of nutrition requires
 (a) carbon dioxide and water.
 (b) chlorophyll.
 (c) sunlight.
 (d) all of the above.

Sol. (d) The autotrophic mode of nutrition requires carbon dioxide, water, chlorophyll and sunlight.

Q.25 The breakdown of pyruvate to give carbon dioxide, water and energy takes place in
 (a) cytoplasm. (b) mitochondria.
 (c) chloroplast. (d) nucleus.

Sol. (b) The breakdown of pyruvate to give carbon dioxide, water and energy takes place in mitochondria.

Q.29 What are the differences between aerobic and anaerobic respiration? Name some organisms that use the anaerobic mode of respiration.

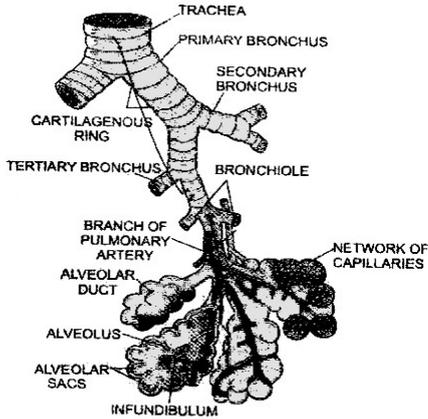
Properties	Aerobic Respiration	Anaerobic Respiration
Method.	It is the common method of respiration (Inhale and exhale).	It occurs permanently only in a few organism. In others it may occur as a temporary measure to overcome shortage of oxygen.
Steps.	It is completed in 3 steps – glycolysis, Krebs cycle and terminal oxidation.	There are two steps – glycolysis and anaerobic breakdown of pyruvic acid.
Oxygen.	It requires oxygen.	Oxygen is not required.
Breakdown.	Respiratory substrate is completely broken down.	Respiratory substrate is incompletely broken down.
End Products.	They are inorganic.	Atleast one end product is organic. Inorganic products may or may not be present.
Toxicity.	End products show little toxicity.	The organic end product is generally toxic.
Occurance.	It occurs partly in cytoplasm and partly in mitochondria.	Anaerobic respiration is carried out entirely in cytoplasm. Mitochondria are not required.
E.T.C.	An electron transport chain is required.	ETC is not required.
Energy.	In release 686 kcal or 2870 kJ of energy per mole of glucose.	Energy liberated is 36-50 kcal or 150-210 kJ per mole of glucose.
ATP.	The liberated energy issued in forming 36-38 ATP molecule per mole of glucose.	The liberate energy is used in synthesis of 2ATP mole.

Sol.

Anaerobic respiration occurs in the roots of some waterlogged plants, some parasitic worms, animal muscles, and some micro-organisms such as yeasts.

Q.30 How are the alveoli designed to maximise the exchange of gases?

Sol. The alveoli are the small balloon-like structures present in the lungs. The walls of the alveoli consist of extensive network of blood vessels. Each lung contains 300-350 million alveoli, making it a total of approximately 700 million in both the lungs. The alveolar surface when spread out covers about 80 m² area. This large surface area makes the gaseous exchange more efficient.



Alveoli and capillaries

Q.31 What would be the consequences of a deficiency of haemoglobin in our bodies?

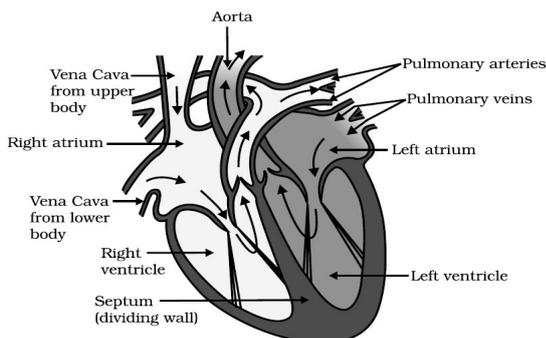
Sol. Haemoglobin is the respiratory pigment that transports oxygen to the body cells for cellular respiration. Therefore, deficiency of haemoglobin in blood can affect the oxygen supplying capacity of blood. This can lead to deficiency of oxygen in the body cells. It can also lead to a disease called anaemia.

Q.32 Describe double circulation in human beings. Why is it necessary?

Sol. The human heart is divided into four chambers - the right atrium, the right ventricle, the left atrium, and the left ventricle.

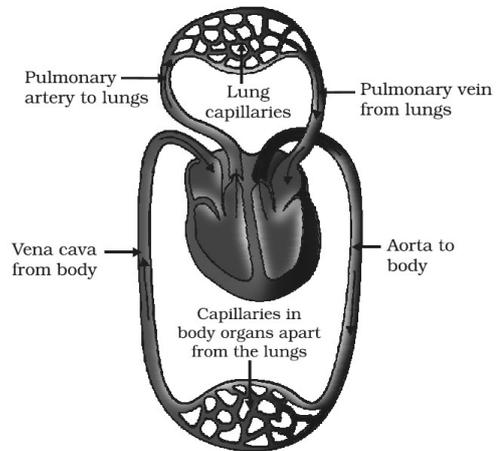
Flow of blood in the heart

- The heart has superior and inferior vena cava, which carries de-oxygenated blood from the upper and lower regions of the body respectively and supplies this de-oxygenated blood to the right atrium of the heart.



Flow of blood in the heart

- The right atrium then contracts and passes the de-oxygenated blood to the right ventricle, through an auriculo-ventricular aperture.
- Then the right ventricle contracts and passes the de-oxygenated blood into the two pulmonary arteries, which pumps it to the lungs where the blood becomes oxygenated. From the lungs, the pulmonary veins transport the oxygenated blood to the left atrium of the heart.
- Then the left atrium contracts and through the auriculo-ventricular aperture, the oxygenated blood enters the left ventricle.
- The blood passes to aorta from the left ventricle. The aorta gives rise to many arteries that distribute the oxygenated blood to all the regions of the body.



Schematic diagram of blood circulation in humans

- Therefore, the blood goes twice through the heart. This is known as double circulation.

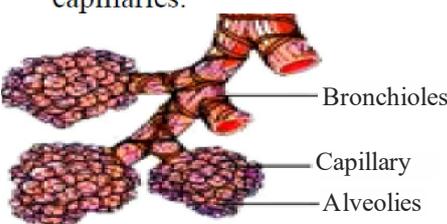
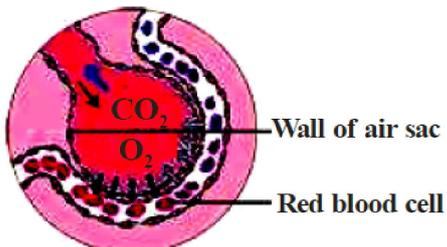
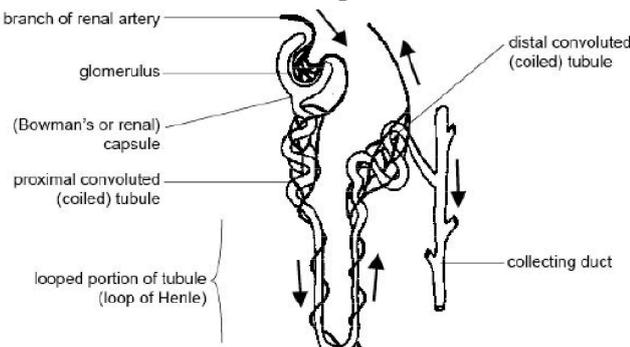
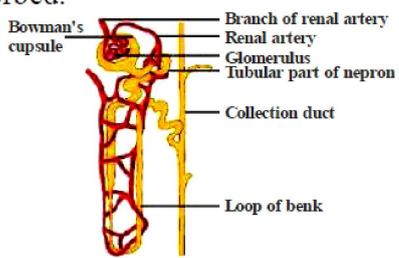
Importance of double circulation :

- The separation of oxygenated and de-oxygenated blood allows a more efficient supply of oxygen to the body cells. This efficient system of oxygen supply is very useful in warm-blooded animals such as human beings.
- As we know, warm-blooded animals have to maintain a constant body temperature by cooling themselves when they are in a hotter environment and by warming their bodies when they are in a cooler environment. Hence, they require more O₂ for more respiration so that they can produce more energy to maintain their body temperature. Thus, the circulatory system of humans is more efficient because of the double circulatory heart.

Q.33 What are the differences between the transport of materials in xylem and phloem?

	Transport of materials in xylem	Transport of materials in phloem
Sol.	(i) Xylem tissue helps in the transport of water and minerals.	Phloem tissue helps in the transport of food.
	(ii) Water is transported upwards from roots to all	Food is transported in both upward and downward directions.
	(iii) Transport in xylem occurs with the help of simple physical forces such as transpiration pull.	Transport of food in phloem requires energy in the form of ATP.

Q.34 Compare the functioning of alveoli in the lungs and nephrons in the kidneys with respect to their structure and functioning.

Alveoli	Nephron
<p>Structure</p> <p>(i) Alveoli are tiny balloon-like structures present inside the lungs.</p> <p>(ii) The walls of the alveoli are one cell thick and it contains an extensive network of blood capillaries.</p>  <p>Function</p> <p>(i) The exchange of O₂ and CO₂ takes place between the blood of the capillaries that surround the alveoli and the gases present in the alveoli.</p> <p>Blood flow</p>  <p>(ii) Alveoli are the site of gaseous exchange.</p>	<p>Structure</p> <p>(i) Nephrons are tubular structures present inside the kidneys.</p> <p>(ii) Nephrons are made of glomerulus, Bowman's capsule, and a long renal tube. It also contains a cluster of thin walled capillaries.</p>  <p>Function</p> <p>(i) The blood enters the kidneys through the renal artery which branches into many capillaries in the glomerulus. The water and solute are transferred to the nephron at Bowman's capsule. Then the filtrate moves through the proximal tubule and then down into the loop of Henle. From Henle's loop, filtrate passes into the distal tubule and then to the collecting duct. The collecting duct collects the urine from many nephrons and passes it to the ureter. During the flow of filtrate, some substances such as glucose, amino acids, and water are selectively reabsorbed.</p>  <p>(ii) Nephrons are the basic filtration unit.</p>

Sol.

EXERCISE - II

Knowledge Vault



MCQ BASED QUESTION :

- Q.1** Artificial removal of metabolic wastes from the body is called as –
 (A) Ultra filtration (B) Dialysis
 (C) Osmoregulation (D) None of these
- Q.2** Human kidney resembles contractile vacuole of Amoeba in expelling out –
 (A) Excess H₂O (B) Salts
 (C) Glucose (D) Urea
- Q.3** The units of a mammalian kidney are –
 (A) Nephrons
 (B) Seminiferous tubules
 (C) Uriniferous tubules
 (D) Ureters
- Q.4** NH₃ converted to urea in –
 (A) Kidney (B) Liver
 (C) Spleen (D) Heart
- Q.5** Glomerular filtrate normally contain –
 (A) Glucose (B) NaCl
 (C) Amino acids (D) All of these
- Q.6** Man is –
 (A) Uricotelic (B) Ureotelic
 (C) Ammonotelic (D) None of these
- Q.7** Which is not excretory organ?
 (A) Skin (B) Kidney
 (C) Liver (D) Pancreas
- Q.8** Special excretory organ is lacking in :
 (A) Earthworm (B) Amoeba
 (C) Man (D) Insects
- Q.9** Which of the following is not a excretory product in plant –
 (A) Terpentine oil
 (B) Latex
 (C) Glucose produced during photosynthesis
 (D) Oxygen
- Q.10** Sweat is an excretory waste because it contains
 (A) N₂ waste (B) excess H₂O
 (C) Salts (D) All of the above
- Q.11** Urea cycle occur in
 (A) Nephron (B) Spleen
 (C) Pancreas (D) Liver
- Q.12** Henle's loop is short or absent in
 (A) Fresh water fish (B) Birds
 (C) Mammals (D) All of the above
- Q.13** The white matter in a bird's dropping is
 (A) CaCO₃ (B) CaSO₄
 (C) Uric acid (D) Urea
- Q.14** Identify the uricotelic animal
 (A) Pisces (B) Amphibia
 (C) Man (D) Aves
- Q.15** Organic acids which may be poisonous to a plant are stored in –
 (A) Vacuoles (B) Palisade cell
 (C) Mesophyll (D) Xylem vassels
- Q.16** The urinary bladder of a man empties outside by means of
 (A) Ureter (B) Urethra
 (C) Vagina (D) Glands
- Q.17** Which of the following needs large amount of water for excretion?
 (A) Urea (B) Ammonia
 (C) Uric acid (D) Amino acids
- Q.18** Photosynthesis is maximum in which light
 (A) Red light
 (B) Green light
 (C) Low light intensity
 (D) High light intensity
- Q.19** Cell organelle associated with conversion of light energy to chemical energy.
 (A) Chloroplast (B) Mitochondria
 (C) Ribosome (D) ER
- Q.20** Stomata of desert plant/succulent plant are
 (A) always open
 (B) open during the day and close during the night
 (C) Open during the night and close during the day
 (D) Never open

FILL IN THE BLANKS :

- Q.21** Glucose is broken down to provide energy in the form of _____.
- Q.22** The circulatory system consist of the _____, _____ and _____.
- Q.23** Plant store waste in the form of _____ and _____.

Q.24 _____ help in ultrafiltration in kidney.

- Q.25** Double circulatory system of blood flow includes two distinct and separate systems. This distinction is shared by most vertebrates including amphibians, _____ and mammals. In contrast, fish have a single circulation system because they lack _____.
- (A) Birds, Lungs (B) Reptiles, lungs
(C) Artropoda, Lungs (D) Birds, Gills

MATCH THE COLUMN:

[A] [ONE TO ONE] :

Column-I and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. Only One entries of column-I may have the matching with the some entries of column-II and one entry of column-II Only one matching with entries of column-I

- Q.26**
- | Column I | Column II |
|-----------------|------------------|
| (a) Bronchiole | (p) Circulation |
| (b) Vena cava | (q) Absorption |
| (c) Glomerulus | (r) Respiration |
| (d) Villi | (s) Excretion |
- (A) (a)-(r), (b)-(p), (c)-(q), (d)-(s)
(B) (a)-(q), (b)-(s), (c)-(p), (d)-(r)
(C) (a)-(s), (b)-(r), (c)-(p), (d)-(q)
(D) (a)-(r), (b)-(p), (c)-(s), (d)-(q)

[B] [ONE TO MANY] :

Column-I and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the some entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I

- Q.27**
- | Column I | Column II |
|---------------------|---------------------------|
| (a) Lactic acid | (p) Aerobic respiration |
| (b) Ethanol | (q) Anaerobic respiration |
| (c) CO ₂ | (r) Photosynthesis |
| (d) O ₂ | (s) Transpiration |
- (A) (a)-(p,q), (b)-(q), (c)-(q), (d)-(p,q)
(B) (a)-(p,r), (b)-(s), (c)-(q), (d)-(p,q)
(C) (a)-(q), (b)-(q), (c)-(p,q,r), (d)-(p,r)
(D) (a)-(p,r), (b)-(q), (c)-(p,q), (d)-(p,q,r)

ASSERTION & REASON TYPE QUESTIONS:

Instructions: In the following questions as Assertion (A) is given followed by a Reason (R). Mark your responses from the following options.

- (A) Both Assertion and Reason are true and Reason is the correct explanation of 'Assertion'
(B) Both Assertion and Reason are true and Reason is not the correct explanation of 'Assertion'
(C) Assertion is true but Reason is false
(D) Assertion is false but Reason is true

Q.28 **Assertion :** Oxygen is absorbed by different organs in different organism.

Reason : All these organs have structure that increase surface area.

Q.29 **Assertion :** It would take 3 year for a molecule of oxygen to get to our toes from our lungs.

Reason : Diffusion is movement from high to low concentration.

CASE TYPE QUESTIONS:

Photosynthesis is a process by which green plant make there own food in the presence of sunlight, water, CO₂ and chlorophyll. If we keep a water plant in a beaker, inverted by a funnel and a test tube placed over having water than we can see bubble of gas accumulated at the bottom of the test tube. This gas down ward displaces water.

Q.30 Name the process by which this gas is produced

- (A) Respiration (B) Transpiration
(C) Photolysis (D) None

Q.31 Which among them is not an aquatic plant?

- (A) Hydrilla (B) Hydra
(C) Vallisneria (D) Lotus

Q.32 Gas that helps in formation of ozone comes out during.

- (A) Respiration (B) Photosynthesis
(C) Absorption (D) Translocation

EXERCISE -III**Subjective Stuff****VERY SHORT TYPE QUESTIONS:**

- Q.1** Write other names of the following:
(a) Alveolar sac (b) Voice box
- Q.2** What is transpiration ?
- Q.3** What is the function of valves present in auricles and ventricles ?
- Q.4** What is meant by double circulation?
- Q.5** What is the function of pancreas in the human digestive system?

SHORT TYPE QUESTIONS:

- Q.6** (i) Name any two substances that are selectively reabsorbed as the urine flows along the tube.
(ii) Name the part of the excretory system in which urine is stored for sometime.
- Q.7** Give functions of all four chambers of human heart.
- Q.8** What is the significance of residual volume of air in the lungs?
- Q.9** What causes movement of food inside the alimentary canal?
- Q.10** Name the components of excretory system of human beings.
- Q.11** Name three life processes which are essential for maintaining life and briefly explain the functioning of any one of them.
- Q.12** Define the term enzyme. State the role of saliva in human digestive system.
- Q.13** What do the following transport ?
(i) Xylem (ii) Phloem
(iii) Pulmonary vein (iv) Vena cava
(v) Pulmonary artery (vi) Aorta
- Q.14** List the events that occur during the process of photosynthesis.

LONG TYPE QUESTIONS:

- Q.15** (a) Draw a sectional view of the human heart and label on it Aorta, Right ventricle and Pulmonary veins.
(b) State the functions of the following components of transport system?
(i) Blood (ii) Lymph
- Q.16** What are stomata? What functions do they perform? With the help of a diagram explain opening and closing of stomata.
- Q.17** What is residual volume? How does it help in exchange of oxygen.
- Q.18** What is the respiratory pigment in human? What is its function?
- Q.19** Describe the step of respiration that takes place in cytoplasm.

EXERCISE-IV

Competitive Edge

**Nutrition :-**

- Q.1** Bile Juice is secreted from –
(Raj/NTSE Stage-I/2013)
(A) Salivary glands
(B) Intestinal glands
(C) Stomach
(D) Liver
- Q.2** When acidity in Stomach increases, the medicine generally used is -
(Raj./NTSE Stage-I/2013)
(A) Sodium bicarbonate
(B) Sodium Carbonate
(C) Ammonium Carbonate
(D) Ammonium bicarbonate
- Q.3** Substances necessary for autotrophic Nutrition are – (Raj/NTSE Stage-1/2013)
(A) CO₂ and H₂O (B) Chlorophyll
(C) Sun light (D) All of the above
- Q.4** Consider following chemical reaction

$$6\text{CO}_2 + 12\text{H}_2\text{O} \xrightleftharpoons[\text{Chlorophyll}]{\text{Light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}$$
 (Haryana/NTSE Stage-I/2013)
 (a) CO₂ is oxidized to glucose
 (b) CO₂ is reduced to glucose
 (c) H₂O is oxidized to O₂
 (d) H₂O is reduced to O₂
 which answer is correct.
 (A) a and d (B) b and c
 (C) b and d (D) a and c
- Q.5** Hydrochloric acid facilitates the action of which enzyme ?
(Chandigarh/NTSE Stage-I/2013)
(A) salivary amylase (B) pepsin
(C) trypsin (D) Lipase
- Q.6** In an experiment where two potted plants kept in a dark room are used to demonstrate that carbondioxide is essential for photosynthesis potassium hydroxide is used because it :
(Karnataka /NTSE Stage-I/2013)
(A) Releases oxygen
(B) Absorbs carbondioxide
(C) Releases carbon dioxide
(D) Absorbs oxygen
- Q.7** Organisms capable of synthesizing their own food are called :
(Mizoram/NTSE Stage-I/2013)
(A) heterotrophs (B) autotrophs
(C) decomposers (D) parasites
- Q.8** Which one of the following enzymes is present in saliva ?
(Mizoram/NTSE Stage-1/2013)
(A) Pepsin (B) Chymotrypsin
(C) Trypsin (D) Ptyalin
- Q.9** Which one of the following compound contains two carbon atoms?
(Orrisa/NTSE Stage-I/2013)
(A) Ethanol (B) Pyruvic acid
(C) Lactic acid (D) Glucose
- Q.10** Read the following two statements and choose the correct answer.
(Orrisa/NTSE Stage-I/2013)
 i. Stomata regulates the temperature in plants.
 ii. Stomata helps in the absorption of minerals from the soil.
 (A) i is true but ii is false
 (B) i is false but ii is true
 (C) Both i and ii are true
 (D) Both i and ii are false
- Q.11** Which part of the human alimentary canal, is the site for complete digestion of carbohydrates.
(Punjab/NTSE Stage-I/2013)
(A) Stomach (B) Small Intestine
(C) Large Intestine (D) Rectum
- Q.12** In which one of the following alternatives the correct order of processes is given ?
(Maharashtra/NTSE Stage-I/2013)
 (A) Assimilation → Absorption → Digestion → Ingestion → Egestion
 (B) Absorption → Digestion → Ingestion → Assimilation → Egestion
 (C) Digestion → Ingestion → Assimilation → Absorption → Egestion
 (D) Ingestion → Digestion → Absorption → Assimilation → Egestion
- Q.13** This part of alimentary canal absorbs maximum amount of water and minerals :
(Maharashtra/NTSE Stage-I/2013)
(A) Small intestine (B) Large intestine
(C) Stomach (D) Oesophagus

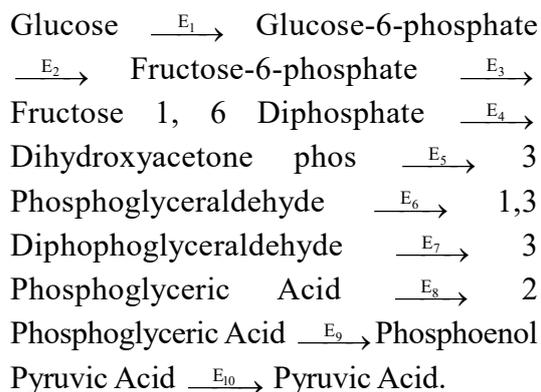
- Q.14** Food becomes _____ due to bile juice .
(Maharashtra/NTSE Stage-I/2013)
(A) Acidic
(B) Alkaline
(C) Neutral
(D) First neutral and then acidic
- Q.15** Which of the following enzymes is related with digestion of protein ?
(Raj/NTSE Stage-I/2013)
(A) Lipase (B) Pepsin
(C) Sucrase (D) Amylase
- Q.16** What does liver secrete ?
(Gujarat/NTSE Stage-1/2013)
(A) Insulin (B) Bile
(C) Gastric juice (D) Mucus
- Q.17** Which of the following plant is a parasite ?
(Gujarat/NTSE Stage-I/2013)
(A) Cuscuta (B) Mushroom
(C) Giloe (D) Fern
- Q.18** Which two plant species obtain nutrition as symbionts in Lichens ?
(M.P./NTSE Stage-I/2013)
(A) Rhizobium and Drosera
(B) Fungi and Rose plant
(C) Algae and Virus
(D) Algae and Fungi
- Q.19** In photosynthesis, the function of stomata is to let : (Karnataka/NTSE Stage-I/2013)
(A) CO₂ in to the leaf from atmosphere
(B) O₂ in to the leaf from atmosphere
(C) Out CO₂ from the leaf to atmosphere
(D) Out O₂ from the leaf to atmosphere
- Q.20** Assertion : Photosynthesis in minimum in green light (Haryana/NTSE Stage-I/2013)
Reason : Chlorophylls are green in colour.
Direction :
(A) Both assertion and reason are true and reason is correct explanation of assertion.
(B) Both assertion and reason are true but reason is not correct explanation of assertion
(C) Assertion is true but reason is False
(D) Assertion is false but reason is true.
- Q.21** The substance essential for photosynthesis is (Raj./NTSE Stage-I/2015)
(A) glucose (B) oxygen
(C) nitrogen (D) water
- Q.22** Which of the following products of light dependent phase are used during light independent phase of photosynthesis ?
(W.B./NTSE Stage-I/2015)
(A) RUBP and ATP
(B) H₂O and O₂
(C) NADPH₂ and ATP
(D) ATP and O₂
- Q.23** Chlorophyll contains.....
(M.P./NTSE Stage-I /2015)
(A) Potassium (B) Iron
(C) Manganese (D) Magnesium
- Q.24** Which of the following is an example of Insectivorous plant -
(M.P./NTSE Stage-I/2015)
(A) Cuscuta (B) Rafflesia
(C) Drosera (D) Tulsi
- Q.25** Photosynthesis is an important mode of autotrophic nutrition. The event which does not occur in photosynthesis is :
(Delhi/NTSE Stage-I/2015)
(A) Conversion of light energy to chemical energy
(B) Reduction of carbon dioxide to carbohydrate
(C) Oxidation of carbon to carbon dioxide
(D) Absorption of light energy by chlorophyll
- Q.26** The substance not essential for photosynthesis is :
(Raj./NTSE Stage-I/2017)
(A) Sunlight (B) Chlorophyll
(C) Nitrogen (D) Carbon dioxide
- Q.27** Raw banana has bitter taste, while ripe banana has sweet taste. It happens because of the conversion of
(NTSE Stage-II/2018)
(A) Starch to sugar
(B) Sucrose to fructose
(C) Amino acids to sugar
(D) Amino acids to protein
- Q.28** The gaseous byproduct of a process in plants is essential for another vital process that releases energy. Given below are four combinations of processes and products. Choose the correct combination.
(NTSE Stage-II/2018)
(A) Photosynthesis and oxygen
(B) Respiration and carbon dioxide
(C) Transpiration and water vapour
(D) Germination and carbon dioxide

- Q.29** The parts of large intestine are
(Raj. NTSE Stage-I/2019)
(A) Duodenum, Ileum, Colon
(B) Caecum, Colon, Rectum
(C) Duodenum, Jejunum, Ileum
(D) Jejunum, Ileum, Caecum
- Q.30** The light reaction occurs in which part of the chloroplast ?
(Raj. NTSE Stage-I/2020)
(A) Stroma (B) Outer wall
(C) Grana (D) None of the above
- Q.31** Example of fat digesting enzyme is-
(Raj. NTSE Stage-I/2020)
(A) Amylase (B) Pepsin
(C) Lipase (D) Nucleases
- Q.32** The opening and closing of the stomata depends upon :
(Delhi/NTSE Stage-I/2020)
(A) Oxygen
(B) Temperature
(C) Carbon dioxide
(D) Water in guard cells
- Q.33** **Assertion (A) :** No carbon dioxide is released during the day in plants.
Reason (R): Only photosynthesis occurs during the day.
(Delhi/NTSE Stage-I/2020)
(A) 'A' is true and 'R' is false
(B) 'A' is false and 'R' is true
(C) Both 'A' and 'R' are false
(D) Both 'A' and 'R' are true but 'R' is not the correct explanation of 'A'
- Q.34** Synthesis of bile juice take place in which the following part of body?
(MP./NTSE Stage-I/2020)
(A) Gall Bladder (B) Liver
(C) Nephron (D) Hypothalamus
- Q.35** Which of the following pH is acidic in nature? (MP./NTSE Stage-I/2020)
(A) Gastric Juice
(B) Bile Juice
(C) Pancreatic Juice
(D) Intestinal Juice
- Q.36** The breakdown of glucose to form pyruvate take place in - (STSE//2022)
(A) Mitochondria (B) Cytoplasm
(C) Nucleus (D) Chloroplast

Respiration :-

- Q.37** Which reaction take place in Mitochondria ?
(West Bengal/NTSE Stage-I/2013)
(A) Oxidative phosphorylation
(B) Photolysis
(C) Photophosphorylation
(D) Starch synthesis
- Q.38** The sequence of process related with respiration is (M.P./NTSE Stage-I/2013)
(A) Kreb's cycle → Glycolysis → Electrontransport system
(B) Glycolysis → Kreb's cycle → Electrontransport system
(C) Electrontransport system → Kreb's cycle → Glycolysis
(D) None of above
- Q.39** Rings of cartilage are present in the following : (Haryana/NTSE Stage-I/2015)
(A) Oesophagus (B) Trachea
(C) Throat (D) Duodenum
- Q.40** The volume of air breathe in and out during normal respiration is known as :
(Bihar/NTSE Stage-I/2015)
(A) Vital capacity (B) Vital volume
(C) Ideal volume (D) Tidal volume
- Q.41** Which scientist discovered "Tricarboxylic acid" ? (M.P./NTSE Stage-I/2015)
(A) Krab (B) Watson and Crick
(C) Sanger (D) Edison
- Q.42** During lack of oxygen in tissues of our body, the pyruvate is converted into lactic acid in :
(Delhi/NTSE Stage-I/2015)
(A) Mitochondria (B) Nucleus
(C) Cytoplasm (D) Ribosome
- Q.43** Under which condition stated below, the six carbon glucose molecule is broken down into three carbon molecules pyruvate and lactic acid ? (NTSE Stage-II/2018)
(A) Aerobic condition in muscle cells
(B) Anaerobic condition in yeast cells
(C) Aerobic condition in mitochondria
(D) Anaerobic condition in muscle cells
- Q.44** Tracheal ring in Human consist of following (M.P./NTSE Stage-I/2020)
(A) Hyaline Carilage
(B) Fibrous Cartilage
(C) Bone
(D) Muscle

Q.45 In following EMP pathway, enzymes catalyzing the reactions are numbered E_1 to E_{10} . At which enzyme levels, ATPs are generated at substrate level ?



(STSE-2022)

- (A) E_1 and E_3 (B) E_3 and E_6
(C) E_7 and E_{10} (D) E_6 and E_{10}

Q.46 The powerhouse of the cell is-

(STSE-2022)

- (A) Plastid (B) Lysosome
(C) Golgi Apparatus (D) Mitochondria

Transportation :-

Q.47 When the right ventricle of heart of man contracts, then blood is pumped into

(Raj/NTSE Stage-I/2005)

- (A) Superior vena cava
(B) Dorsal aorta
(C) Pulmonary artery
(D) Pulmonary vein.

Q.48 In necessity Y donates his blood to X. The blood group of both are same. Besides this the agglutination of RBCs took place. The possible reason of this would be -

(Raj/NTSE Stage-I/2005)

- (A) blood groups of both Rh^{-ve}
(B) blood groups of both Rh^{+ve}
(C) blood group of X is Rh^{+ve} and that of Y is Rh^{-ve}
(D) blood group of X is Rh^{-ve} and that of Y is Rh^{+ve}

Q.49 In heart pacemaker is situated in

(Raj/NTSE Stage-I/2007)

- (A) Right Ventricle (B) Left Ventricle
(C) Right Auricle (D) Left Auricle

Q.50 Universal donor blood group is :

(Raj/NTSE Stage-I/2007)

- (A) O^{+ve} (B) O^{-ve}
(C) AB^{+ve} (D) AB^{-ve}

Q.51 Blood is a type of connective tissue, which has – (Raj/NTSE Stage-I/2013)

- (A) R.B.C.
(B) W.B.C.
(C) Platelets
(D) All of the above

Q.52 Blood Pressure is measured with an instrument called –

(Raj/NTSE Stage-I/2013)

- (A) Thermometer
(B) Stethoscope
(C) Sphygmomanometer
(D) Clinical Thermometer

Q.53 Phloem tissues in plants are responsible for –

(Raj/NTSE Stage-I/2013)

- (A) Transportation of water
(B) Transportation of food
(C) Transportation of Amino Acids
(D) Transportation of Oxygen

Q.54 Which part of the heart receives deoxygenated blood ?

(Chandigarh/NTSE Stage-I/2013)

- (A) Right atrium
(B) Right ventricle
(C) Left atrium
(D) Left ventricle

Q.55 The normal systolic and diastolic pressure in human beings is :

(Karnataka /NTSE Stage-I/2013)

- (A) 80 / 120 mm of Hg
(B) 130 / 90 mm of Hg
(C) 120 / 80 mm of Hg
(D) 140 / 80 mm of Hg

Q.56 The total volume of blood in an adult body is about : (Mizoram/NTSE Stage-I/2013)

- (A) 6 to 7 litres (B) 4 to 5 litres
(C) 5 to 6 litres (D) 7 to 8 litre

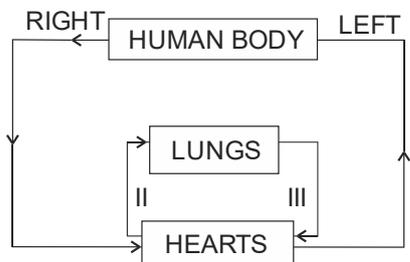
Q.57 Where is the bicuspid valve found in human heart ? (Gujrat/NTSE Stage-I/2013)

- (A) Between two atria
(B) Between two ventricles
(C) Between right atrium and right ventricle
(D) Between left atrium and left ventricle

- Q.58** What is lacking in human mature red blood corpuscles ?
(Gujrat/NTSE Stage-I/2013)
(A) Nucleus
(B) Golgi bodies
(C) Endoplasmic reticulum
(D) All the three
- Q.59** What imparts red colour to blood ?
(Gujrat/NTSE Stage-I/2013)
(A) Erythrocytes (B) Blood plasma
(C) Leucoplast (D) Thrombocytes
- Q.60** Water absorption by roots takes place under the influence of :
(Haryana/NTSE Stage-I/2015)
(A) Evaporation pull
(B) Transpiration pull
(C) Availability of soil water
(D) Availability of soil air
- Q.61** In plants the cells necessary for exchange of gases from atmosphere are
(Raj./NTSE Stage-I/2015)
(A) subsidiary cells
(B) bark cells
(C) guard cells
(D) phloem parenchyma cells
- Q.62** Sphygmomanometer measures
(Raj./NTSE Stage-I/2015)
(A) wall pressure
(B) blood pressure
(C) diffusion pressure
(D) air pressure
- Q.63** Transpiration will be faster when the day is
(W.B./NTSE Stage-I/2015)
(A) hot, humid and windy
(B) hot, dry and windy
(C) cold, humid and windy
(D) hot humid and still wind
- Q.64** If the heart rate of a man is less than 60 per minute then it is called as
(W.B./NTSE Stage-I/2015)
(A) Tachycardia (B) Bradycardia
(C) Ischemia (D) Bradykinin
- Q.65** 1 gm of Haemoglobin can hold
(W.B./NTSE Stage-I/2015)
(A) 1.34 ml oxygen
(B) 13.4 ml oxygen
(C) 2.34 ml oxygen
(D) 1.5 ml oxygen
- Q.66** WBC and RBCs are found in human blood in the ratio of : (Bihar/NTSE Stage-I/2015)
(A) 1 : 60 (B) 1 : 600
(C) 1 : 6000 (D) 1 : 60000
- Q.67** Haemoglobin is a protein. It is an example of : (Bihar/NTSE Stage-I/2015)
(A) Primary structure of protein
(B) Secondary structure of protein
(C) Tertiary structure of protein
(D) Quaternary structure of protein
- Q.68** Bicuspid valve is present in the human heart in between which of the following ?
(M.P./NTSE Stage-I/2015)
(A) Right auricle and right ventricle.
(B) Left auricle and left ventricle.
(C) Right and left auricle.
(D) Left auricle and systemic aorta.
- Q.69** The following blood vessel does not contain deoxygenated blood.
(Delhi/NTSE Stage-I 2015)
(A) Pulmonary artery
(B) Vena Cava
(C) Hepatic Vein
(D) Pulmonary Vein
- Q.70** Normal human blood pressure is
(Raj./NTSE Stage-I/2016)
(A) 80/120 mm of Hg
(B) 120/80 mm of Hg
(C) 100/80 mm of Hg
(D) 80/100 mm of Hg
- Q.71** Universal donor blood group is
(Raj./NTSE Stage-I/2017)
(A) A (B) O (C) AB (D) B
- Q.72** A farmer made an observation in a backwater paddy field of coastal Kerala that the paddy plants wilt during noon onwards everyday but appear normal next morning. What would be the possible reason for wilting?
(NTSE Stage-II/2018)
(A) The rate of water absorption is less than the rate of transpiration in the afternoon.
(B) The rate of water absorption is more than the rate of transpiration in the afternoon.

- (C) The changes in the rate of water absorption and transpiration are not associated with wilting.
- (D) The rate of water absorption is not related to the rate of transpiration.

Q.73 Figure below reflects the blood circulation system in the human body



Which of the path contains oxygenated blood? **(Bihar/NTSE Stage-I/2019)**

- (A) (i) and (ii) only
 (B) (ii) and (iii) only
 (C) (i) and (iii) only
 (D) (i), (ii) and (iii) all

Q.74 Blood pressure is measured by an instrument called:-

(Delhi/NTSE Stage-I/2020)

- (A) Barometer
 (B) Sphygmomanometer
 (C) Photometer
 (D) Manometer

Q.75 Choose correct statement for human :

(Haryana/NTSE Stage-I/2020)

- (A) Arteries always carry oxygenated blood while veins always carry deoxygenated blood.
 (B) Arteries are provided with valves while veins are devoid of valves.
 (C) Arteries always carry blood away from heart, while veins always carry blood towards the heart.
 (D) Venous blood is returned to left auricle.

Q.76 It is a common observation that members of Cucurbitaceae, like bottle-gourd, pumpkin, watermelon, musk melon, etc. have large fruits while their stems are usually not more than finger thick. What helps so much food to be translocated from leaves to the fruits for storage ?

(NSEJS/2022-23)

- (A) Intra-xylary phloem
 (B) Sieve-tubes with companion cells
 (C) Bicollateral vascular bundles
 (D) Trichomes on internodes

Q.77 The phloem in plants is responsible for- **(STSE-2022)**

- (A) Transport of food
 (B) Transport of water
 (C) Transport of oxygen
 (D) Transport of carbon dioxide

Q.78 When right atrium expands then the type of blood and direction of flow is - **(STSE-2022)**

- (A) Deoxygenated from body
 (B) Deoxygenated from heart
 (C) Oxygenated from body
 (D) Oxygenated from heart

Excretion :-

Q.79 Urea synthesis occurs in

(Raj./NTSE Stage-I/2007)

- (A) Kidney (B) Liver
 (C) Brain (D) Muscles

Q.80 In birds nitrogenous waste is :

(Raj./NTSE Stage-I/2007)

- (A) Urea (B) Ammonia
 (C) Uric acid (D) Amino acids

Q.81 Contractile vacuole of amoeba is equivalent to which organ of human ?

(Raj./NTSE Stage-I/2007)

- (A) Spleen (B) Kidney
 (C) Lungs (D) Liver

Q.82 Kidney's primary function is

(Haryana/NTSE Stage-I/2013)

- (A) Excretion
 (B) Osmoregulation
 (C) Remove excess of water
 (D) All of the above

Q.83 Normally in a healthy adult the daily initial filtrate in the kidneys is :

(Chandigarh/NTSE Stage-I/2013)

- (A) 18 L (B) 18L
 (C) 180 L (D) 9L

Q.84 If the urine excreted by a person contains glucose the condition is called

(Karnataka /NTSE Stage-I/2013)

- (A) Galacturia
 (B) Diabetes mellitus
 (C) Diabetes insipidus
 (D) Glucoma

- Q.85** In which portions of the following, the Glucose concentration is highest ?
(W.B./NTSE Stage-I/2015)
(A) Glomerulus
(B) Proximal convoluted tubule
(C) Bowmans capsules
(D) Collecting tubule
- Q.86** Excretory organs of Earthworm are.....
(M.P./NTSE Stage-I/2015)
(A) Malapighian tubules
(B) Nephridia
(C) Kidneys
(D) Flame cells
- Q.87** Kidneys do not perform the function of :
(Delhi/NTSE Stage-I/2015)
(A) Regulation of blood pressure
(B) Filtration of blood
(C) Regulation of Ions concentration
(D) Secretion of antibodies
- Q.88** The example of uricotelic animals is :
(Raj./NTSE Stage-I/2017)
(A) Fishes (B) Reptiles
(C) Amphibians (D) Mammals
- Q.89** The example of uricotelic animals is
(Raj./NTSE Stage-I/2018)
(A) fishes (B) reptiles
(C) amphibians (D) mammals
- Q.90** The kidneys in human beings are a part of the system for:
(Bihar/NTSE Stage-I/2018)
(A) Nutrition (B) Respiration
(C) Excretion (D) Transportation
- Q.91** In human beings, excretory products are removed by excretory system. Which part of the excretory system help in removing nitrogenous waste such as urea or uric acid from blood ?
(Haryana/NTSE Stage-I/2020)
(A) Ureter
(B) Urethra
(C) Kidney
(D) Urinary bladder

EXERCISE-V

Board Navigator

**Nutrition :-**

Q.1 What is photosynthesis? Explain the mechanism. [CBSE-2019]

Q.2 (1) State the role played by the following in the process of digestion

(a) Enzyme trypsin

(b) Enzyme lipase

(2) List two functions of finger-like projections present in the small intestine? [CBSE-2020]

Q.3 Design an activity to show that chlorophyll is essential for photosynthesis? [CBSE-2020]

Q.4 How is the wall of small intestine adapted for performing the function of absorption of food? [CBSE-2020-21]

Q.5 State the role of pancreas in digestion of food. [CBSE-2020-21]

Q.6 State the events occurring during the process of photosynthesis. Is it essential that these steps take place one after the other immediately? [CBSE-2020-21]

Q.7 Bile Juice does not have any digestive enzyme but still play a significant role in the process of digestion justify the statement. [CBSE-2021]

Q.8 The correct statements with reference to single celled organisms are [CBSE 2021-22]

(i) complex substance are not broken down into simpler substances

(ii) simple diffusion is sufficient to meet the requirement of exchange of gases

(iii) specialised tissues perform different functions in the organism

(iv) entire surface of the organism is in contact with the environment for taking in food.

(A) (i) and (iii) (B) (ii) and (iii)

(C) (ii) and (iv) (D) (i) and (iv)

Q.9 **Assertion (A) :** Nitrogen is an essential element for plant growth and is taken up by plants in the form of inorganic nitrates or nitrites.

Reason (R) : The soil is the nearest and richest source of raw materials like nitrogen, phosphorus and other minerals for the plants. [CBSE 2021-22]

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).

(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) (A) is true but (R) is false.

(D) (A) is false but (R) is true.

Q.10 Opening and closing of stomata is due to [CBSE 2023]

(A) high pressure of gases inside the cells

(B) movement of water in and out of the guard cells

(C) stimulus of light in the guard cells

(D) diffusion of CO₂ in and out of the guard cells.

Q.11 **Assertion (A) :** The inner walls of the small intestine have finger like projections called villi which are rich in blood.

Reason (R) : These villi have a large surface area to help the small intestine in completing the digestion of food. [CBSE 2023]

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).

(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) (A) is true but (R) is false.

(D) (A) is false but (R) is true.

Q.12 Water in the root enters due to [CBSE 2023]

(A) the function of the root to absorb water

(B) difference in the concentration of ions between the root and the soil

(C) excess water present in the soil

(D) diffusion of water in the roots

Q.13 Two green plants are kept separately in oxygen free containers, one in the dark and other in sunlight. It was observed that plant kept in dark could not survive longer. Give reason for this observation. [CBSE 2023]

Q.14 List the events in proper sequence that takes place during the process of photosynthesis. [CBSE 2023]

Respiration :-

- Q.15** Name the cell organelle in which break down of pyruvate to give CO_2 , water and energy takes place. [CBSE-2015]
- Q.16** Why does the air passage not collapse when there is no air in it? [CBSE-2016]
- Q.17** Identify the parts correctly match with description given below [CBSE-2016]
 (i) Small pore present in woody plant for gaseous exchange
 (ii) Respiratory surface in human
 (iii) Respiratory surface of earthworms
 (iv) Primary organ of respiration
 (v) Cartilaginous flap
 (vi) Contraction and relaxation of these changes the thoracic volume
- Q.18** Draw a flow chart to show the break down of glucose by various pathway. [CBSE-2016]
- Q.19** Write two different ways in which glucose is oxidized to provide energy in human body. Write the product formed in each case [CBSE-2019]
- Q.20** What are the different way in which glucose is oxidised to provide energy in various organisms. [CBSE-2022]
- Q.21** The energy released during cellular respiration is used to synthesise [CBSE 2021-22]
 (A) ribosomes (B) RBC
 (C) ATP (D) mitochondria
- Q.22** **Assertion (A) :** The rate of breathing in aquatic organisms is much slower than that seen in terrestrial organisms.
Reason (R) : The amount of oxygen dissolved in water is very low as compared to the amount of oxygen in air. [CBSE 2021-22]
 (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
 (B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
 (C) (A) is true but (R) is false.
 (D) (A) is false but (R) is true.
- Q.23** The function of the lining of mucus in the nasal passage of human beings is to [CBSE 2021-22]

- (A) increase the temperature of inhaled air
 (B) move the air in and out
 (C) filter the air that we breathe in
 (D) absorb oxygen from the air

- Q.24** As compared to terrestrial organisms, the rate of breathing in aquatic organism is [CBSE 2023]
 (A) faster because they need more oxygen for their survival
 (B) faster because the amount of dissolved oxygen in water is fairly low
 (C) Slower because the amount of dissolved oxygen in water is fairly low
 (D) Slower because the capacity of water of dissolving atmospheric air is limited

Transportation :-

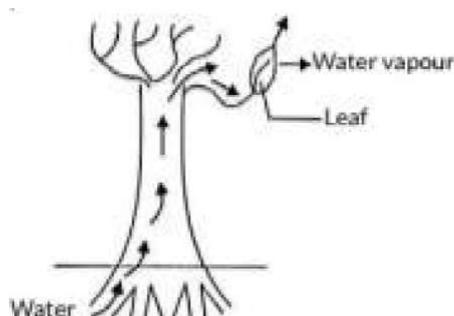
- Q.25** Write the function of each of the following component of the transport system in human being
 (i) Blood vessels
 (ii) Lymph
 (iii) Heart [CBSE-2015]
- Q.26** Give the appropriate one-word answer for the following [CBSE-2016]
 (i) Blood vessel entering from lower parts of body into right atrium
 (ii) Blood vessel leaving the right ventricles to lungs.
 (iii) Blood vessel entering into right atrium from upper parts of body.
- Q.27** (i) Mention any two components of blood
 (ii) Trace the movement of oxygenated blood in the body.
 (iii) Write the function of valves present in between atria and ventricles.
 (iv) Write the structural difference between the composition of artery and veins [CBSE-2018]
- Q.28** Write three type of blood vessels give one important feature of each. [CBSE-2019]
- Q.29** Define the term transpiration. Design an experiment to demonstrate this process [CBSE-2019]
- Q.30** Veins are thin walled and have valve. Justify. [CBSE-2020-21]
- Q.31** In birds and mammals the left and right side of the heart are separated. Give reason [CBSE-2020-21]

- Q.32** Give reason
- Ventricles have thicker muscular walls than atria
 - Transport system in plants is slow
 - Circulation of blood in aquatic vertebrates differs from that in terrestrial vertebrates.
 - During the daytime, water and minerals travel faster through xylem as compared to the night
 - Veins have valves whereas arteries do not
- [CBSE-2020-21]

- Q.33** The separation of the right side and the left side of heart is useful to [CBSE 2021-22]
- keep oxygenated blood from mixing with deoxygenated blood
 - allow a slow supply of oxygen in the body
 - supply energy to animals with low energy needs
 - often change their body temperature

- Q.34** In spring, sugar stored in root or stem tissue of plants is transported to the buds for [CBSE 2021-22]
- the energy needs of the buds to grow
 - temperature regulation
 - balancing the storage in different organs
 - diffusion process

- Q.35** Observe the following diagram and identify the process and its significance from the following options: [CBSE 2023]



- Evaporation : maintains water contents in leaf cells.
- Transpiration : creates a suction force which pulls water inside the plant.
- Excretion : helps in excreting out waste water from the plant.
- Translocation : helps in transporting materials from one cell to another.

- Q.36** The process in which loss of water in the form of vapours from the aerial parts of plants takes place is X, which helps in Y. Here, X and Y respectively are [CBSE 2023]
- transpiration and photosynthesis
 - transpiration and temperature regulation
 - translocation and movement of soluble products of photosynthesis in phloem
 - translocation and absorption of water and minerals from soil by roots

- Q.37** **Assertion (A)** : The walls of atria are thicker than those of the ventricles. [CBSE 2023]
Reason (R) : Ventricles have to pump blood into various organs at high pressure.
- Both (A) and (R) are true and (R) is the correct explanation of (A).
 - Both (A) and (R) are true but (R) is not the correct explanation of (A).
 - (A) is true but (R) is false.
 - (A) is false but (R) is true.

- Q.38** What is the other name of 'tissue fluid'? Write its two functions. [CBSE 2023]

- Q.39** What will happen if: [CBSE 2023]
- Xylem tissue in a plant is removed?
 - We are injured and start bleeding?

- Q.40** (i) What is double circulation?[CBSE 2023]
(ii) Why is the separation of the right side and the left side of the heart useful? How does it help birds and mammals?

Excretion :-

- Q.41** Name the process used by single-celled organisms for taking in food, exchange of the gaseous or removal of wastes[CBSE-2016]

- Q.42** Define excretion. Write two vital functions of kidney. [CBSE-2016]

- Q.43** (i) Define excretion [CBSE-2018]
(ii) Name the basic filtration unit present in the kidney
(iii) Draw excretory system in human beings and label the following organs of excretory system which perform following functions
- from urine
 - Is a long tube which collects urine from kidney.
 - Stores urine until it is passed out

- Q.44** Draw a diagram of human system and label the following
(i) Urinary bladder
(ii) Left Kidney
(iii) Left ureater [CBSE-2019]
- Q.45** (i) How do leaves plants help in excretion explain briefly
(ii) Describe the structure and function of a nephron [CBSE-2020]
- Q.46** Explain where and how urine is produced [CBSE-2020-21]
- Q.47** Write one specific function of each of the following organs in relation with excretion in human beings: [CBSE 2023]
(i) Renal Artery
(ii) Urethra
(iii) Glomerulus
(iv) Tubular part of nephron
- Q.48** Explain in brief two ways by which leaves of a plant help in excretion. [CBSE 2023]

ANSWER KEY

EXERCISE-II

MULTIPLE CHOICE QUESTION :

Q.1	B	Q.2	A	Q.3	A	Q.4	B	Q.5	D	Q.6	B	Q.7	D
Q.8	B	Q.9	C	Q.10	D	Q.11	D	Q.12	A	Q.13	C	Q.14	D
Q.15	A	Q.16	B	Q.17	B	Q.18	A	Q.19	A	Q.20	C		

FILL IN THE BLANKS :

Q.21	ATP	Q.22	Heart, Blood & blood vessel	Q.23	Gum and resin
Q.24	Bowman capsules	Q.25	(A) Birds, Lungs		

MATCH THE COLUMN :

Q.26	D	Q.27	C
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ASSERTION AND REASON :

Q.28	B	Q.29	B
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CASED BASED QUESTION :

Q.30	C	Q.31	B	Q.32	B
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EXERCISE-IV

Nutrition :-

Q.1	D	Q.2	A	Q.3	D	Q.4	B	Q.5	B	Q.6	B	Q.7	B
Q.8	D	Q.9	A	Q.10	A	Q.11	B	Q.12	D	Q.13	B	Q.14	B
Q.15	B	Q.16	B	Q.17	A	Q.18	D	Q.19	A	Q.20	A	Q.21	D
Q.22	C	Q.23	D	Q.24	C	Q.25	C	Q.26	C	Q.27	A	Q.28	A
Q.29	B	Q.30	C	Q.31	C	Q.32	D	Q.33	C	Q.34	B	Q.35	A
Q.36	B												

Respiration :-

Q.37	A	Q.38	B	Q.39	B	Q.40	D	Q.41	A	Q.42	C	Q.43	D
Q.44	A	Q.45	C	Q.46	D								

Transportation :-

Q.47	C	Q.48	D	Q.49	C	Q.50	B	Q.51	D	Q.52	C	Q.53	B
Q.54	A	Q.55	C	Q.56	C	Q.57	D	Q.58	D	Q.59	A	Q.60	B
Q.61	C	Q.62	B	Q.63	B	Q.64	B	Q.65	A	Q.66	B	Q.67	D
Q.68	B	Q.69	D	Q.70	B	Q.71	B	Q.72	A	Q.73	C	Q.74	B
Q.75	C	Q.76	C	Q.77	A	Q.78	A						

Excretion :-

Q.79	B	Q.80	C	Q.81	B	Q.82	D	Q.83	C	Q.84	B	Q.85	A
Q.86	B	Q.87	D	Q.88	B	Q.89	B	Q.90	C	Q.91	C		

EXERCISE-V

Nutrition :-

Q.8 C Q.9 B Q.10 B Q.11 C Q.12 B

Respiration :-

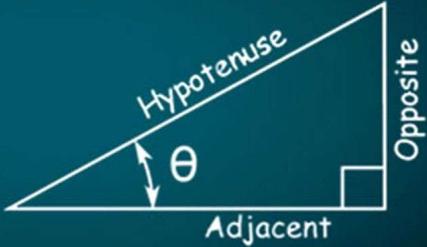
Q.21 C Q.22 D Q.23 C Q.24 B

Transportation :-

Q.33 A Q.34 A Q.35 B Q.36 B Q.37 D

1 Introduction to Trigonometry

Introduction to Trigonometry

$$\sin \theta = \frac{\text{Opposite}}{\text{Hypotenuse}}$$
$$\cos \theta = \frac{\text{Adjacent}}{\text{Hypotenuse}}$$
$$\tan \theta = \frac{\text{Opposite}}{\text{Adjacent}}$$


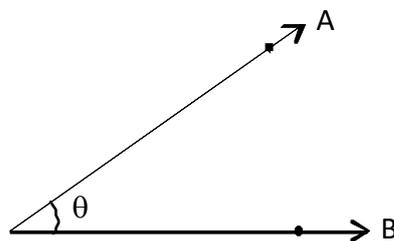
Trigonometry means, the science which deals with the measurement of triangles

1. INTRODUCTION :

The word trigonometry is originated from the Greek word 'tri' means three, 'gonia' means angle and 'metron' means to measure. Hence, the word trigonometry means three angle measure, i.e., it is the study of geometrical figures which have three angles, i.e., triangles.

- **Angle**

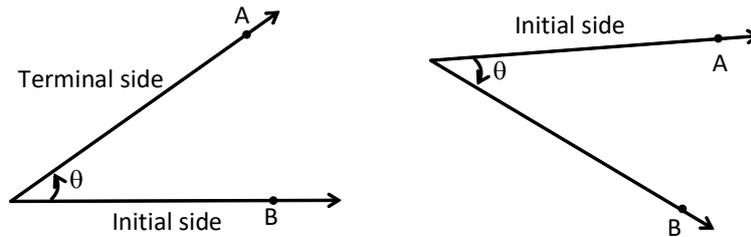
A measure formed between two rays having a common initial point is called an angle.



The two rays are called the arms or sides of the angle and the common initial point is called the vertex of the angle.

In the figure, OA is said to be the initial side and the other ray OB is said to be the terminal side of the angle.

The angle is taken positive when measured in anti-clockwise direction and is taken negative when measured in clockwise direction.



2. TRIGONOMETRIC RATIOS :

With reference to angle A in a right angled ΔABC , right angle at C.
 a is opposite side of angle $\angle A$ (Perpendicular), b is opposite side of

angle $\angle B$ and c is opposite side of angle $\angle C$. The ratio of sides $\frac{a}{c}, \frac{b}{c}, \frac{a}{b}, \frac{b}{a}, \frac{c}{b}, \frac{c}{a}$ have the following names

$\frac{a}{c}$ is called the sine of A, written as $\sin A$

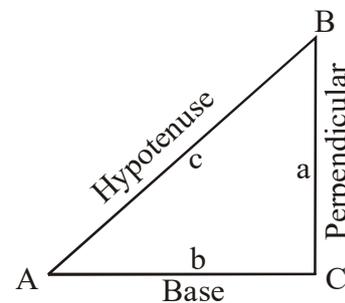
$\frac{b}{c}$ is called the co-sine of A, written as $\cos A$

$\frac{a}{b}$ is called the tangent of A, written as $\tan A$.

$\frac{b}{a}$ is called the co-tangent of A. written as $\cot A$

$\frac{c}{b}$ is called the secant of A, written as $\sec A$

$\frac{c}{a}$ is called the co-secant of A, written as $\operatorname{cosec} A$.



So there are six trigonometric Ratios :

$$\sin A = \frac{\text{Perpendicular}}{\text{Hypotenuse}} = \frac{a}{c} \quad \Rightarrow \quad \cos A = \frac{\text{Base}}{\text{Hypotenuse}} = \frac{b}{c}$$

$$\tan A = \frac{\text{Perpendicular}}{\text{Base}} = \frac{a}{b} \quad \Rightarrow \quad \cot A = \frac{\text{Base}}{\text{Perpendicular}} = \frac{b}{a}$$

$$\operatorname{cosec} A = \frac{\text{Hypotenuse}}{\text{Perpendicular}} = \frac{c}{a} \quad \Rightarrow \quad \sec A = \frac{\text{Hypotenuse}}{\text{Base}} = \frac{c}{b}$$

TRICK : SOME PEOPLE HAVE CURLY BROWN HAIR TO PRODUCE BEAUTY

• **Fundamental Relation :**

(a) **Reciprocal Relation**

$$\operatorname{cosec} A = \frac{1}{\sin A}, \quad \sin A = \frac{1}{\operatorname{cosec} A}$$

$$\sec A = \frac{1}{\cos A}, \quad \cos A = \frac{1}{\sec A}$$

$$\cot A = \frac{1}{\tan A}, \quad \tan A = \frac{1}{\cot A}$$

(b) Quotient Relation

$$\tan A = \frac{\sin A}{\cos A}$$

$$\cot A = \frac{\cos A}{\sin A}$$


EXAMPLES


Example 1 : Find trigonometric ratio:

In a triangle ABC, right-angled at B, AB = 24 cm, BC = 7 cm. Determine

- (i) $\sin A$, $\cos A$ (ii) $\sin C$, $\cos C$

Solution : In $\triangle ABC$,

$$AB^2 + BC^2 = AC^2$$

$$\Rightarrow (24)^2 + (7)^2 = AC^2$$

$$AC^2 = 625$$

$$\Rightarrow AC = 25$$

$$\text{hypotenuse} = 25 \text{ cm}$$

- (i) For $\angle A$, AB = base
Perpendicular = BC &
hypotenuse = AC

$$\sin A = \frac{\text{Perpendicular}}{\text{hypotenuse}} = \frac{BC}{AC} = \frac{7}{25}$$

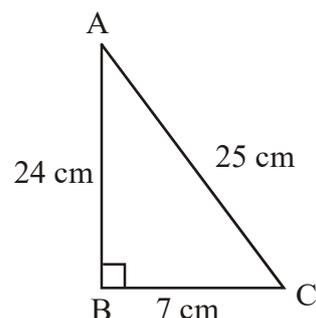
$$\cos A = \frac{\text{Base}}{\text{hypotenuse}} = \frac{24}{25}$$

- (ii) For $\angle C$, base = BC and
Perpendicular = AB and
hypotenuse = AC

$$\sin C = \frac{\text{Perpendicular}}{\text{hypotenuse}} = \frac{24}{25}$$

$$\cos C = \frac{\text{Base}}{\text{hypotenuse}} = \frac{7}{25}$$

\therefore (B)



2.1 Signs Of Trigonometry Functions In Different Quadrants

	I	II	III	IV
$\sin x$	+	+	-	-
$\cos x$	+	-	-	+
$\tan x$	+	-	+	-
$\operatorname{cosec} x$	+	+	-	-
$\sec x$	+	-	-	+
$\cot x$	+	-	+	-

3. TRIGONOMETRIC RATIOS OF SOME SPECIFIC ANGLES 0°, 30°, 45°, 60° AND 90°:

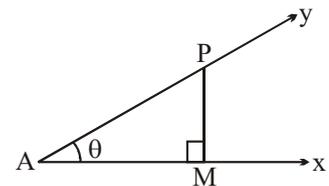
Angle \ Ratio	0°	30°	45°	60°	90°
sin	0	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2}$	1
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$	0
tan	0	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$	Not defined
cot	Not defined	$\sqrt{3}$	1	$\frac{1}{\sqrt{3}}$	0
sec	1	$\frac{2}{\sqrt{3}}$	$\sqrt{2}$	2	Not defined
cosec	Not defined	2	$\sqrt{2}$	$\frac{2}{\sqrt{3}}$	1

3.1 Trigonometric ratios of 0° and 90° :

Let $\angle XAY = \theta$ be an acute angle and let P be a point on its terminal side AY. Draw perpendicular PM from P on AX.

In ΔAMP , we have

$$\sin \theta = \frac{PM}{AP}, \cos \theta = \frac{AM}{AP} \text{ and } \tan \theta = \frac{PM}{AM}$$



It is evident from ΔAMP that as θ becomes smaller and smaller, line segment PM also becomes smaller and smaller; and finally when θ become 0° ; the point P will coincide with M. Consequently, we have $PM = 0$ and $AP = AM$

$$\therefore \sin 0^\circ = \frac{PM}{AP} = \frac{0}{AP} = 0; \cos 0^\circ = \frac{AM}{AP} = \frac{AP}{AP} = 1 \text{ and, } \tan 0^\circ = \frac{PM}{AM} = \frac{0}{AP} = 0$$

Thus, we have, $\sin 0^\circ = 0$, $\cos 0^\circ = 1$ and $\tan 0^\circ = 0$

From ΔAMP , it is evident that as θ increases, line segment AM becomes smaller and smaller and finally when θ become 90° , then point M will coincide with A. Consequently, we have

$$AM = 0, AP = PM$$

$$\therefore \sin 90^\circ = \frac{PM}{AP} = \frac{PM}{PM} = 1 \text{ and } \cos 90^\circ = \frac{AM}{AP} = \frac{0}{AP} = 0$$

Thus, we have, $\sin 90^\circ = 1$ and $\cos 90^\circ = 0$



Let's know

It is evident from the above discussion that $\tan 90^\circ = \frac{PM}{AM} = \frac{PM}{0}$ is not defined.

Similarly, $\sec 90^\circ$, $\text{cosec } 0^\circ$, $\text{cot } 0^\circ$ are not defined.

3.2 Trigonometric ratios of 30° and 60° :

Consider an equilateral triangle ABC with each side of length 2a. Since each angle of an equilateral triangle is of 60° . Therefore, each angle of ΔABC is of 60° . Let AD be perpendicular from A on BC. Since the triangle is equilateral. Therefore, AD is the bisector of $\angle A$ and D is the mid-point of BC.

∴ $BD = DC = a$ and $\angle BAD = 30^\circ$

Thus, in $\triangle ABD$, $\angle D$ is a right angle, hypotenuse $AB = 2a$ and $BD = a$.

So, by Pythagoras theorem, we have

$$AB^2 = AD^2 + BD^2$$

$$\Rightarrow (2a)^2 = AD^2 + a^2$$

$$\Rightarrow AD^2 = 4a^2 - a^2$$

$$\Rightarrow AD = \sqrt{3}a$$

3.3 Trigonometric ratios of 30° :

In right triangle ADB , in reference with the acute angle $\angle A$,

Base = $AD = \sqrt{3}a$, Perpendicular = $BD = a$, Hypotenuse = $AB = 2a$ and $\angle DAB = 30^\circ$.

$$\therefore \sin 30^\circ = \frac{BD}{AB} = \frac{a}{2a} = \frac{1}{2}$$

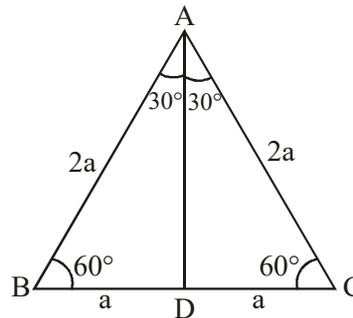
$$\cos 30^\circ = \frac{AD}{AB} = \frac{\sqrt{3}a}{2a} = \frac{\sqrt{3}}{2}$$

$$\tan 30^\circ = \frac{BD}{AD} = \frac{a}{\sqrt{3}a} = \frac{1}{\sqrt{3}};$$

$$\operatorname{cosec} 30^\circ = \frac{1}{\sin 30^\circ} = 2;$$

$$\sec 30^\circ = \frac{1}{\cos 30^\circ} = \frac{2}{\sqrt{3}};$$

$$\cot 30^\circ = \frac{1}{\tan 30^\circ} = \sqrt{3}$$



3.4 Trigonometric ratios of 60° :

In right triangle ADB , in reference with the acute angle $\angle A$,

Base = $BD = a$, Perpendicular = $AD = \sqrt{3}a$, Hypotenuse = $AB = 2a$ and $\angle ABD = 60^\circ$.

$$\therefore \sin 60^\circ = \frac{AD}{AB} = \frac{\sqrt{3}a}{2a} = \frac{\sqrt{3}}{2}$$

$$\cos 60^\circ = \frac{BD}{AB} = \frac{a}{2a} = \frac{1}{2}$$

$$\tan 60^\circ = \frac{AD}{BD} = \frac{\sqrt{3}a}{a} = \sqrt{3};$$

$$\operatorname{cosec} 60^\circ = \frac{1}{\sin 60^\circ} = \frac{2}{\sqrt{3}};$$

$$\sec 60^\circ = \frac{1}{\cos 60^\circ} = 2;$$

$$\cot 60^\circ = \frac{1}{\tan 60^\circ} = \frac{1}{\sqrt{3}}$$

3.5 Trigonometric ratios of 45° :

Consider a right triangle ABC with right angle of B such that

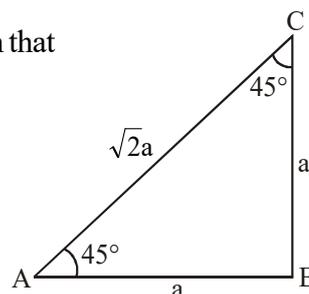
$\angle A = 45^\circ$, Then,

$$\angle A + \angle B + \angle C = 180^\circ$$

$$\Rightarrow 45^\circ + 90^\circ + \angle C = 180^\circ$$

$$\Rightarrow \angle C = 45^\circ$$

$$\therefore \angle A = \angle C$$



$\Rightarrow AB = BC$

Let $AB = BC = a$. Then, by Pythagoras theorem, we have

$$AC^2 = AB^2 + BC^2$$

$$\Rightarrow AC^2 = a^2 + a^2 \quad \Rightarrow AC^2 = 2a^2 \quad \Rightarrow AC = \sqrt{2}a$$

Thus, in ΔABC , we have

$\angle A = 45^\circ$, Base = $AB = a$, Perpendicular = $BC = a$ and Hypotenuse = $AC = \sqrt{2}a$

$$\therefore \sin 45^\circ = \frac{BC}{AC} = \frac{a}{\sqrt{2}a} = \frac{1}{\sqrt{2}}, \quad \cos 45^\circ = \frac{AB}{AC} = \frac{a}{\sqrt{2}a} = \frac{1}{\sqrt{2}}$$

$$\tan 45^\circ = \frac{BC}{AB} = \frac{a}{a} = 1, \quad \operatorname{cosec} 45^\circ = \frac{1}{\sin 45^\circ} = \sqrt{2},$$

$$\sec 45^\circ = \frac{1}{\cos 45^\circ} = \sqrt{2}, \quad \cot 45^\circ = \frac{1}{\tan 45^\circ} = \frac{1}{1} = 1$$

 **EXAMPLES** 

Example 2 : Find the value of the following: $4\cos^2 60^\circ + 4\sin^2 45^\circ - \sin^2 30^\circ$

Solution : $4\cos^2 60^\circ + 4\sin^2 45^\circ - \sin^2 30^\circ$

$$4\left(\frac{1}{2}\right)^2 + 4\left(\frac{1}{\sqrt{2}}\right)^2 - \left(\frac{1}{2}\right)^2 = 4 \times \frac{1}{4} + 4 \times \frac{1}{2} - \frac{1}{4} = \frac{11}{4}$$

3.6 Signs of trigonometric functions

Trigonometric Function \ Point/Angle	sin	cos	tan	cot	cosec	sec
$-x$	$-\sin x$	$\cos x$	$-\tan x$	$-\cot x$	$-\operatorname{cosec} x$	$\sec x$
$\frac{\pi}{2} - x$	$\cos x$	$\sin x$	$\cot x$	$\tan x$	$\sec x$	$\operatorname{cosec} x$
$\frac{\pi}{2} + x$	$\cos x$	$-\sin x$	$-\cot x$	$-\tan x$	$\sec x$	$-\operatorname{cosec} x$
$\pi - x$	$\sin x$	$-\cos x$	$-\tan x$	$-\cot x$	$\operatorname{cosec} x$	$-\sec x$
$\pi + x$	$-\sin x$	$-\cos x$	$\tan x$	$\cot x$	$-\operatorname{cosec} x$	$-\sec x$

4. TRIGONOMETRIC RATIOS OF COMPLEMENTARY ANGLES :

• **Trigonometric Ratios of $(90^\circ - \theta)$:**

$$\begin{aligned} \sin(90^\circ - \theta) &= \cos \theta; & \cos(90^\circ - \theta) &= \sin \theta \\ \tan(90^\circ - \theta) &= \cot \theta; & \cot(90^\circ - \theta) &= \tan \theta \\ \operatorname{cosec}(90^\circ - \theta) &= \sec \theta; & \sec(90^\circ - \theta) &= \operatorname{cosec} \theta \end{aligned}$$

• **Trigonometric Ratios of $(90^\circ + \theta)$:**

$$\begin{aligned} \sin(90^\circ + \theta) &= \cos \theta; & \cos(90^\circ + \theta) &= -\sin \theta \\ \tan(90^\circ + \theta) &= -\cot \theta; & \cot(90^\circ + \theta) &= -\tan \theta \\ \operatorname{cosec}(90^\circ + \theta) &= \sec \theta; & \sec(90^\circ + \theta) &= -\operatorname{cosec} \theta \end{aligned}$$

• **Trigonometric Ratios of $(180^\circ - \theta)$:**

$$\begin{aligned} \sin(180^\circ - \theta) &= \sin \theta; & \cos(180^\circ - \theta) &= -\cos \theta \\ \tan(180^\circ - \theta) &= -\tan \theta; & \cot(180^\circ - \theta) &= -\cot \theta \\ \operatorname{cosec}(180^\circ - \theta) &= \operatorname{cosec} \theta; & \sec(180^\circ - \theta) &= -\sec \theta \end{aligned}$$

Trigonometric Ratios of $(180^\circ + \theta)$:

$$\begin{aligned} \sin(180^\circ + \theta) &= -\sin \theta; & \cos(180^\circ + \theta) &= -\cos \theta \\ \tan(180^\circ + \theta) &= \tan \theta; & \cot(180^\circ + \theta) &= \cot \theta \\ \operatorname{cosec}(180^\circ + \theta) &= -\operatorname{cosec} \theta; & \sec(180^\circ + \theta) &= -\sec \theta \end{aligned}$$

Similarly, the trigonometric ratios of $270^\circ \pm \theta$ and $360^\circ \pm \theta$ can be written.



Let's know

The trigonometric ratios of $(-\theta)$ are the same as the trigonometric ratios of $(360^\circ - \theta)$.

So, $\sin(-\theta) = \sin(360^\circ - \theta) = -\sin \theta$ and so on.

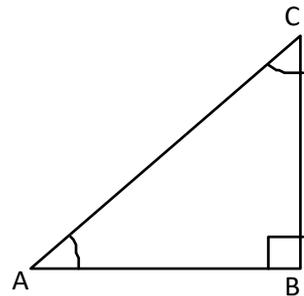
(Two angles are said to be complementary, if their sum is equal to 90° .)

In right angled $\triangle ABC$,

If $\angle B = 90^\circ$, then $\angle A + \angle C = 90^\circ$

[\because in a triangle, $\angle A + \angle B + \angle C = 180^\circ$]

i.e., $\angle A$ and $\angle C$ form a pair of complementary angles.



For all values of $\angle A$ or A lying between 0° and 90° , we have following relations between different trigonometric ratios.

$$\begin{aligned} \sin(90^\circ - A) &= \cos A \\ \cos(90^\circ - A) &= \sin A \\ \tan(90^\circ - A) &= \cot A \\ \cot(90^\circ - A) &= \tan A \\ \sec(90^\circ - A) &= \operatorname{cosec} A \\ \operatorname{cosec}(90^\circ - A) &= \sec A \end{aligned}$$

Example 3 : If A and B are acute angles such that $\sin A = \cos B$, prove that $(A + B) = 90^\circ$.

Solution : $\sin A = \cos B \Rightarrow \sin A = \sin(90^\circ - B)$
 $\Rightarrow A = 90^\circ - B$ [$\because A$ and $(90^\circ - B)$ are acute angles]
 $\therefore A + B = 90^\circ$ **Hence proved.**

Example 4: Evaluate:-

$$\text{(i) } \frac{\sin 41^\circ}{\cos 49^\circ} \qquad \text{(ii) } \frac{\tan 29^\circ}{\cot 61^\circ} \qquad \text{(iii) } \frac{\operatorname{cosec} 70^\circ}{\sec 20^\circ}$$

Solution : (i) $\frac{\sin 41^\circ}{\cos 49^\circ} = \frac{\sin(90^\circ - 49^\circ)}{\cos 49^\circ} = \frac{\cos 49^\circ}{\cos 49^\circ} = 1$ [$\because \sin(90^\circ - \theta) = \cos \theta$]

(ii) $\frac{\tan 29^\circ}{\cot 61^\circ} = \frac{\tan(90^\circ - 61^\circ)}{\cot 61^\circ} = \frac{\cot 61^\circ}{\cot 61^\circ} = 1$ [$\because \tan(90^\circ - \theta) = \cot \theta$]

$$(iii) \frac{\operatorname{cosec} 70^\circ}{\sec 20^\circ} = \frac{\operatorname{cosec}(90^\circ - 20^\circ)}{\sec 20^\circ} = \frac{\sec 20^\circ}{\sec 20^\circ} = 1 \quad [\because \operatorname{cosec}(90^\circ - \theta) = \sec \theta]$$

Example 5: Evaluate $\frac{\tan 50^\circ + \sec 50^\circ}{\cot 40^\circ + \operatorname{cosec} 40^\circ} + \cos 40^\circ \operatorname{cosec} 50^\circ$.

Solution : Given expression $\frac{\tan 50^\circ + \sec 50^\circ}{\cot 40^\circ + \operatorname{cosec} 40^\circ} + \cos 40^\circ \operatorname{cosec} 50^\circ$.

$$= \frac{\tan 50^\circ + \sec 50^\circ}{\cot(90^\circ - 50^\circ) + \operatorname{cosec}(90^\circ - 50^\circ)} + \cos 40^\circ \operatorname{cosec}(90^\circ - 40^\circ)$$

$$= \frac{\tan 50^\circ + \sec 50^\circ}{\tan 50^\circ + \sec 50^\circ} + \cos 40^\circ \sec 40^\circ \quad [\because \cot(90^\circ - \theta) = \tan \theta, \operatorname{cosec}(90^\circ - \theta) = \sec \theta]$$

$$= (1 + 1) = 2$$

Example 6: Evaluate $\frac{\sin 70^\circ}{\cos 20^\circ} + \frac{\operatorname{cosec} 36^\circ}{\sec 54^\circ} - \frac{2 \cos 43^\circ \operatorname{cosec} 47^\circ}{\tan 10^\circ \tan 40^\circ \tan 50^\circ \tan 80^\circ}$

Solution : $\frac{\sin 70^\circ}{\cos 20^\circ} + \frac{\operatorname{cosec} 36^\circ}{\sec 54^\circ} - \frac{2 \cos 43^\circ \operatorname{cosec} 47^\circ}{\tan 10^\circ \tan 40^\circ \tan 50^\circ \tan 80^\circ}$

$$= \frac{\sin(90^\circ - 20^\circ)}{\cos 20^\circ} + \frac{\operatorname{cosec}(90^\circ - 54^\circ)}{\sec 54^\circ} - \frac{2 \cos 43^\circ \operatorname{cosec}(90^\circ - 43^\circ)}{\tan(90^\circ - 80^\circ) \tan(90^\circ - 50^\circ) \tan 50^\circ \tan 80^\circ}$$

$$= \frac{\cos 20^\circ}{\cos 20^\circ} + \frac{\sec 54^\circ}{\sec 54^\circ} - \frac{2 \cos 43^\circ \sec 43^\circ}{\cot 80^\circ \cot 50^\circ \tan 50^\circ \tan 80^\circ}$$

$[\because \sin(90^\circ - \theta) = \cos \theta, \operatorname{cosec}(90^\circ - \theta) = \sec \theta, \tan(90^\circ - \theta) = \cot \theta]$

$$= 1 + 1 - \frac{2 \cos 43^\circ \cdot \frac{1}{\cos 43^\circ}}{\frac{1}{\tan 80^\circ} \cdot \tan 80^\circ \cdot \frac{1}{\tan 50^\circ} \cdot \tan 50^\circ} \quad \left[\because \tan \theta = \frac{1}{\cot \theta}, \sec \theta = \frac{1}{\cos \theta} \right]$$

$$= 2 - \frac{2 \times 1}{1 \times 1} = 2 - 2 = 0.$$

5. TRIGONOMETRIC IDENTITIES

If two expressions are equal for all values of the variables, then the relation is called an identity.

For example, $\frac{x+2}{3} + x = \frac{4x+1}{3}$ is an identity since L.H.S. = R.H.S for all real value of x.

There are three fundamental trigonometric identities

(i) $\cos^2 A + \sin^2 A = 1$ (ii) $1 + \tan^2 A = \sec^2 A$

(iii) $1 + \cot^2 A = \operatorname{cosec}^2 A$

Trigonometric Identities :

An equation involving trigonometric ratios of an angle is called a **trigonometric identity**, if it is true for all values of the angle(s) involved.

In $\triangle ABC$, right-angled at B (see Fig.), we have:

$$AB^2 + BC^2 = AC^2 \quad \dots(1)$$

Dividing each term of (1) by AC^2 , we get

$$\frac{AB^2}{AC^2} + \frac{BC^2}{AC^2} = \frac{AC^2}{AC^2}$$

i.e., $\left(\frac{AB}{AC}\right)^2 + \left(\frac{BC}{AC}\right)^2 = \left(\frac{AC}{AC}\right)^2$

i.e., $(\cos A)^2 + (\sin A)^2 = 1$

i.e., $\cos^2 A + \sin^2 A = 1 \quad \dots(2)$

This is true for all A such that $0^\circ \leq A \leq 90^\circ$. So, this is a trigonometric identity.

Let us now divide (1) by AB^2 . We get

$$\frac{AB^2}{AB^2} + \frac{BC^2}{AB^2} = \frac{AC^2}{AB^2} \quad \text{or,} \quad \left(\frac{AB}{AB}\right)^2 + \left(\frac{BC}{AB}\right)^2 = \left(\frac{AC}{AB}\right)^2$$

i.e. $1 + \tan^2 A = \sec^2 A \quad \dots(3)$

$\tan A$ and $\sec A$ are not defined for $A = 90^\circ$. So, (3) is true for all A such that $0^\circ \leq A < 90^\circ$.

Let us now divide (1) by BC^2 . We get

$$\frac{AB^2}{BC^2} + \frac{BC^2}{BC^2} = \frac{AC^2}{BC^2} \quad \text{i.e.,} \quad \left(\frac{AB}{BC}\right)^2 + \left(\frac{BC}{BC}\right)^2 = \left(\frac{AC}{BC}\right)^2$$

i.e., $\cot^2 A + 1 = \text{cosec}^2 A \quad \dots(4)$

Note that $\text{cosec} A$ and $\cot A$ are not defined for $A = 0^\circ$. Therefore (4) is true for all A such that $0^\circ < A \leq 90^\circ$.

Using these identities, we can express each trigonometric ratio in terms of other trigonometric ratios, i.e., if any one of the ratios is known, we can also determine the values of other trigonometric ratios.

➤ **TRIGONOMETRIC RATIOS OF COMPOUND ANGLES**

1. $\sin(A + B) = \sin A \cos B + \cos A \sin B$ and $\sin(A - B) = \sin A \cos B - \cos A \sin B$
2. $\cos(A + B) = \cos A \cos B - \sin A \sin B$ and $\cos(A - B) = \cos A \cos B + \sin A \sin B$
3. $\tan(A + B) = \frac{\tan A + \tan B}{1 - \tan A \tan B}$ and $\tan(A - B) = \frac{\tan A - \tan B}{1 + \tan A \tan B}$

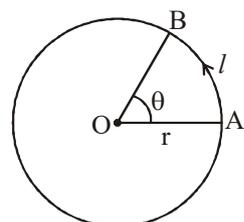
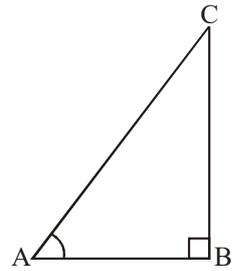
6. RELATION BETWEEN AN ARC, RADIUS AND ANGLE SUBTENDED BY THE ARC AT THE CENTRE OF THE CIRCLE :

Consider a circle with centre 'O', radius 'r', $\angle AOB = \theta$ and length of arc AB = l as shown in the figure.

Relation between θ , r and l :

$$\text{angle} = \frac{\text{arc}}{\text{radius}} ; \theta = \frac{l}{r}$$

Here θ is always in radian and unit of l and r are always same.





TRY YOURSELF

- Q.1** If $\operatorname{cosec}\theta - \sin\theta = m$ and $\sec\theta - \cos\theta = n$ then $(m^2n)^{2/3} + (mn^2)^{2/3} =$
- (A) -1 (B) 1
(C) 0 (D) None of these
- Q.2** If $7 \sin^2\theta + 3 \cos^2\theta = 4$, then $\tan\theta =$
- (A) $\pm \frac{1}{3}$ (B) $\pm \frac{1}{2}$ (C) $\pm \frac{1}{\sqrt{3}}$ (D) $\pm \frac{1}{\sqrt{2}}$
- Q.3** The value of $\frac{\sin^3 A + \cos^3 A}{\sin A + \cos A} + \frac{\cos^3 A - \sin^3 A}{\cos A - \sin A}$ is
- (A) 0 (B) 1
(C) 2 (D) None of these
- Q.4** $\frac{\cot\theta - \operatorname{cosec}\theta + 1}{\cot\theta + \operatorname{cosec}\theta - 1}$ is equal to
- (A) 1 (B) $\cot\theta + \operatorname{cosec}\theta$
(C) $\operatorname{cosec}\theta - \cot\theta$ (D) None of these
- Q.5** If $a \sec\theta + b \tan\theta = 1$ and $a^2 \sec^2\theta - b^2 \tan^2\theta = 5$, then $a^2 b^2 + 4a^2$ is equal to
- (A) $9b^2$ (B) $\frac{9}{a^2}$ (C) $\frac{-2}{b}$ (D) 9
- Q.6** If $\cos\theta + \sin\theta = \sqrt{2} \cos\theta$, then $\cos\theta - \sin\theta =$
- (A) $\sqrt{2} \sin\theta$ (B) $2 \sin\theta$ (C) $-\sqrt{2} \sin\theta$ (D) None of these
- Q.7** If $7 \operatorname{cosec}\theta - 3 \cot\theta = 7$, then the value of $7 \cot\theta - 3 \operatorname{cosec}\theta$ is equal to :-
- (A) 5 (B) 3 (C) $\frac{7}{3}$ (D) $\frac{3}{7}$
- Q.8** If each α, β, γ is a positive acute angle such that $\sin(\alpha + \beta - \gamma) = 1/\sqrt{2}$, $\operatorname{cosec}(\beta + \gamma - \alpha) = 2/\sqrt{3}$ and $\tan(\gamma + \alpha - \beta) = 1/\sqrt{3}$. What are the values of α, β, γ ?
- (A) $\left(37\frac{1}{2}^\circ, 52\frac{1}{2}^\circ, 45^\circ\right)$ (B) $(37^\circ, 53^\circ, 45^\circ)$
(C) $\left(45^\circ, 37\frac{1}{2}^\circ, 52\frac{1}{2}^\circ\right)$ (D) $\left(34\frac{1}{2}^\circ, 55\frac{1}{2}^\circ, 45^\circ\right)$

Q.9 If $\frac{\cos^4 \alpha}{\cos^2 \beta} + \frac{\sin^4 \alpha}{\sin^2 \beta} = 1$, if $\alpha = \beta$ then

$\frac{\cos^4 \beta}{\cos^2 \alpha} + \frac{\sin^4 \beta}{\sin^2 \alpha}$ is equal to:

- (A) 1 (B) 0 (C) -1 (D) None

Q.10 If $\sin A - \sqrt{6} \cos A = \sqrt{7} \cos A$, then

$\cos A + \sqrt{6} \sin A$ equal to:

- (A) $\sqrt{6} \sin A$ (B) $\sqrt{7} \sin A$
 (C) $\sqrt{6} \cos A$ (D) $\sqrt{7} \cos A$

Q.11 If $\sin \alpha = \frac{3}{5}$ and $\cos \beta = \frac{3}{5}$, $0 < \alpha, \beta < \pi/2$, then:

- (A) $\alpha = \beta$ (B) $\alpha < \beta$
 (C) $\alpha > \beta$ (D) None of these

Q.12 If $\sin \theta + \operatorname{cosec} \theta = 2$, then value of $\sin^{10} \theta + \operatorname{cosec}^{10} \theta$ is :

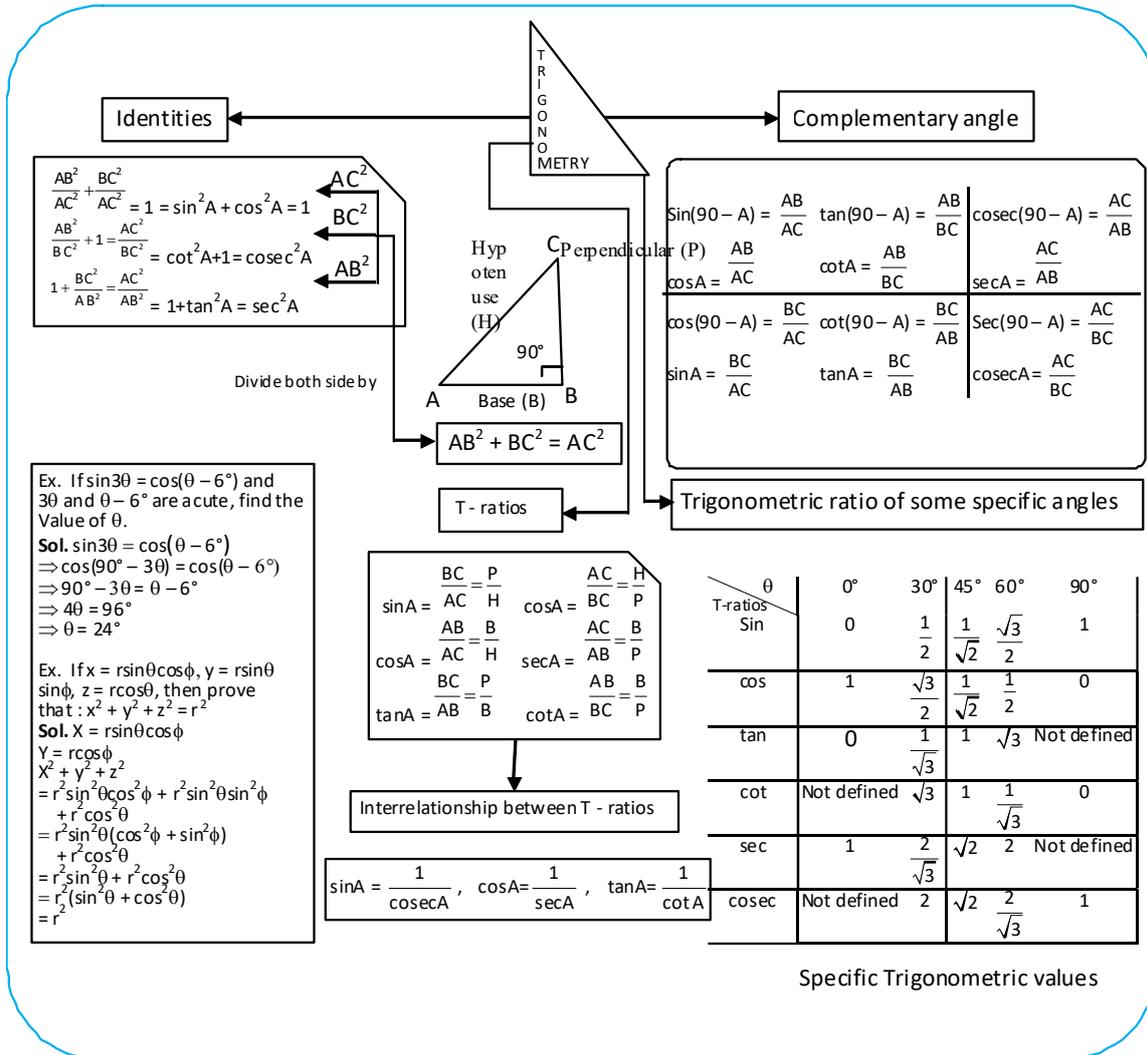
- (A) 2 (B) 2^{10} (C) 2^9 (D) 10

ANSWER KEY

Q.1	B	Q.2	C	Q.3	C	Q.4	C	Q.5	A	Q.6	A	Q.7	B
Q.8	A	Q.9	A	Q.10	B	Q.11	B	Q.12	A				



MIND MAP



EXERCISE-I

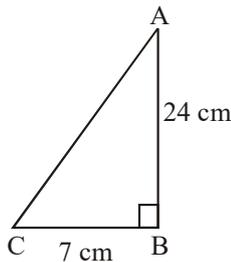
NCERT Solutions



Q.1 In ΔABC , right angled at B, $AB = 24$ cm, $BC = 7$ cm. Determine:

[NCERT, Ex 8.1, Q.1]

Sol. (i) $\sin A, \cos A$ (ii) $\sin C, \cos C$
 (i) In ΔABC ,
 $\therefore \angle B = 90^\circ$ (Given)
 $\therefore AC^2 = AB^2 + BC^2$
 (By Pythagoras theorem)
 $= (24)^2 + (7)^2 = 576 + 49 = 625$



$$\Rightarrow AC = \sqrt{625} = 25 \text{ cm}$$

$$\therefore \sin A = \frac{BC}{AC} = \frac{7}{25}$$

$$\text{and } \cos A = \frac{AB}{AC} = \frac{24}{25}$$

(ii) $\sin C = \frac{AB}{AC} = \frac{24}{25}$;

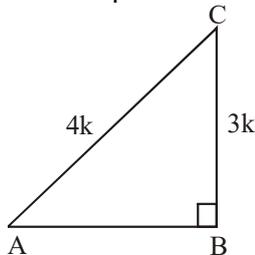
$$\cos C = \frac{BC}{AC} = \frac{7}{25}$$

Q.2 If $\sin A = \frac{3}{4}$, calculate $\cos A$ and $\tan A$.

[NCERT, Ex 8.1, Q.3]

Sol. Let us draw a right triangle ABC.

$$\sin A = \frac{3}{4} \quad (\text{Given})$$



$$\Rightarrow \frac{BC}{AC} = \frac{3}{4}$$

$$\Rightarrow \frac{BC}{3} = \frac{AC}{4} = k \text{ (say)}$$

where k is a positive number

$$\Rightarrow BC = 3k; \quad AC = 4k$$

By using the Pythagoras theorem, we have

$$AC^2 = AB^2 + BC^2$$

$$\Rightarrow (4k)^2 = AB^2 + (3k)^2$$

$$\Rightarrow 16k^2 = AB^2 + 9k^2$$

$$\Rightarrow AB^2 = 16k^2 - 9k^2$$

$$\Rightarrow AB^2 = 7k^2$$

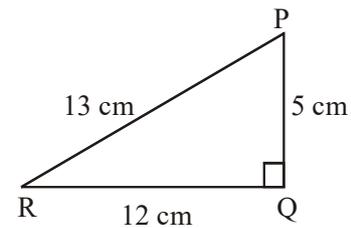
$$\Rightarrow AB = \sqrt{7}k$$

$$\text{Now, } \cos A = \frac{AB}{AC} = \frac{\sqrt{7}k}{4k} = \frac{\sqrt{7}}{4}$$

$$\text{and } \tan A = \frac{BC}{AB} = \frac{3k}{\sqrt{7}k} = \frac{3}{\sqrt{7}}$$

Q.3 In ΔPQR , right angled at Q, $PR + QR = 25$ cm and $PQ = 5$ cm. Determine the values of $\sin P, \cos P$ and $\tan P$.

[NCERT, Ex 8.1, Q.10]



Sol. In ΔPQR ,

$$\therefore \angle Q = 90^\circ \quad (\text{Given})$$

$$\therefore PR^2 = PQ^2 + QR^2$$

(By Pythagoras theorem)

$$\Rightarrow (25 - QR)^2 = (5)^2 + QR^2$$

$$(\because PR + QR = 25 \text{ (given)})$$

$$\Rightarrow 625 + QR^2 - 50QR = 25 + QR^2$$

$$\Rightarrow 50QR = 600$$

$$\Rightarrow QR = \frac{600}{50} = 12 \text{ cm}$$

$$\text{Now, } PR + QR = 25$$

$$\Rightarrow PR + 12 = 25$$

$$\Rightarrow PR = 25 - 12$$

$$\Rightarrow PR = 13 \text{ cm}$$

$$\text{So, } \sin P = \frac{QR}{PR} = \frac{12}{13};$$

$$\cos P = \frac{PQ}{PR} = \frac{5}{13} \text{ and}$$

$$\tan P = \frac{QR}{PQ} = \frac{12}{5}$$

- Q.4** State whether the following are true or false. Justify your answer.
- (i) The value of $\tan A$ is always less than 1.
 - (ii) $\sec A = \frac{12}{5}$ for some value of angle A .
 - (iii) $\cos A$ is the abbreviation used for the cosecant of angle A .
 - (iv) $\cot A$ is the product of \cot and A .
 - (v) $\sin \theta = \frac{4}{3}$ for some angle θ .

[NCERT, Ex 8.1, Q.11]

- Sol.**
- (i) **False** since $\tan A = \frac{\text{Perpendicular}}{\text{Base}}$ and perpendicular may be longer than base.
 - (ii) **True** since $\sec A = \frac{\text{Hypotenuse}}{\text{Base}}$ and hypotenuse being the longest side may be $\frac{12}{5}$ times the base.
 - (iii) **False** since $\cos A$ is the abbreviation used for the cosine of angle A .
 - (iv) **False** since $\cot A$ is used as an abbreviation for 'the cotangent' of the angle A .
 - (v) **False** since the hypotenuse is the longest side in a right triangle. As such the value of $\sin A$ is always less than 1 (or, in particular equal to 1).

Q.5 Evaluate the following

[NCERT, Ex 8.2, Q.1]

- (i)
$$\frac{\sin 30^\circ + \tan 45^\circ - \operatorname{cosec} 60^\circ}{\sec 30^\circ + \cos 60^\circ + \cot 45^\circ}$$
- (ii)
$$\frac{5 \cos^2 60^\circ + 4 \sec^2 30^\circ - \tan^2 45^\circ}{\sin^2 30^\circ + \cos^2 30^\circ}$$

Sol.

- (i)
$$\frac{\sin 30^\circ + \tan 45^\circ - \operatorname{cosec} 60^\circ}{\sec 30^\circ + \cos 60^\circ + \cot 45^\circ}$$

$$= \frac{\frac{1}{2} + 1 - \frac{2}{\sqrt{3}}}{\frac{2}{\sqrt{3}} + \frac{1}{2} + 1} = \frac{\frac{\sqrt{3} + 2\sqrt{3} - 4}{2\sqrt{3}}}{\frac{4 + \sqrt{3} + 2\sqrt{3}}{2\sqrt{3}}}$$

$$= \frac{3\sqrt{3} - 4}{4 + 3\sqrt{3}} = \frac{3\sqrt{3} - 4}{4 + 3\sqrt{3}}$$

$$= \frac{(3\sqrt{3} - 4)(4 - 3\sqrt{3})}{(4 + 3\sqrt{3})(4 - 3\sqrt{3})}$$

$$= \frac{12\sqrt{3} - 27 - 16 + 12\sqrt{3}}{16 - 27}$$

$$= \frac{24\sqrt{3} - 43}{-11} = \frac{43 - 24\sqrt{3}}{11}$$

(ii)
$$\frac{5 \cos^2 60^\circ + 4 \sec^2 30^\circ - \tan^2 45^\circ}{\sin^2 30^\circ + \cos^2 30^\circ}$$

$$= \frac{5\left(\frac{1}{2}\right)^2 + 4\left(\frac{2}{\sqrt{3}}\right)^2 - (1)^2}{\left(\frac{1}{2}\right)^2 + \left(\frac{\sqrt{3}}{2}\right)^2} = \frac{\frac{5}{4} + \frac{16}{3} - 1}{\frac{1}{4} + \frac{3}{4}}$$

$$= \frac{15 + 64 - 12}{12} = \frac{67}{12}$$

Q.6 If $\tan(A + B) = \sqrt{3}$ and $\tan(A - B) = \frac{1}{\sqrt{3}}$; $0^\circ < A + B \leq 90^\circ$; $A > B$, find A and B .

[NCERT, Ex 8.2, Q.3]

Sol. $\tan(A + B) = \sqrt{3} = \tan 60^\circ$
 $\Rightarrow A + B = 60^\circ \dots(1)$

$$\tan(A - B) = \frac{1}{\sqrt{3}} = \tan 30^\circ$$

$$\Rightarrow A - B = 30^\circ \dots(2)$$

Solving (1) and (2), we get
 $\angle A = 45^\circ$ and $\angle B = 15^\circ$

Q.7 If $\tan A = \cot B$, prove that $A + B = 90^\circ$.

[NCERT, Ex 8.3, Q.4]

Sol. $\tan A = \cot B$
 $\Rightarrow \tan A = \tan(90^\circ - B)$
 $(\because \tan(90^\circ - \theta) = \cot \theta)$
 $\Rightarrow A = 90^\circ - B$
 $(\because A \text{ and } 90^\circ - B \text{ are both acute angles})$
 $\Rightarrow A + B = 90^\circ$

Q.8 Evaluate :

[NCERT, Ex 8.3, Q.1]

- (i)
$$\frac{\tan 26^\circ}{\cot 64^\circ}$$
- (ii)
$$\operatorname{cosec} 31^\circ - \sec 59^\circ$$

Sol. (i)
$$\frac{\tan 26^\circ}{\cot 64^\circ} = \frac{\tan 26^\circ}{\cot(90^\circ - 26^\circ)}$$

$$= \frac{\tan 26^\circ}{\tan 26^\circ}$$

$$= 1 \quad (\because \cot(90^\circ - \theta) = \tan \theta)$$

(ii)
$$\operatorname{cosec} 31^\circ - \sec 59^\circ = \operatorname{cosec} 31^\circ - \sec(90^\circ - 31^\circ)$$

$$= \operatorname{cosec} 31^\circ - \operatorname{cosec} 31^\circ$$

$$= 0 \quad (\because \sec(90^\circ - \theta) = \operatorname{cosec} \theta)$$

Q.9 If $\sec 4A = \operatorname{cosec}(A - 20^\circ)$, where $4A$ is an acute angle, find the value of A .

[NCERT, Ex 8.3, Q.5]

Sol.
$$\sec 4A = \operatorname{cosec}(A - 20^\circ)$$

$$\Rightarrow \operatorname{cosec}(90^\circ - 4A) = \operatorname{cosec}(A - 20^\circ)$$

$$(\because \operatorname{cosec}(90^\circ - \theta) = \sec \theta)$$

$$\Rightarrow 90^\circ - 4A = A - 20^\circ$$

$$(\because 90^\circ - 4A \text{ and } A - 20^\circ \text{ are both acute angles})$$

$$\Rightarrow 5A = 110^\circ$$

$$\Rightarrow A = \frac{110^\circ}{5} = 22^\circ$$

Q.10 If A, B and C are interior angles of a triangle ABC , then show that $\sin\left(\frac{B+C}{2}\right)$

$$= \cos \frac{A}{2}. \quad \text{[NCERT, Ex 8.3, Q.6]}$$

Sol. L.H.S. = $\sin\left(\frac{B+C}{2}\right) = \sin\left(\frac{180^\circ - A}{2}\right)$

[$\because A + B + C = 180^\circ$ (the sum of the interior angles of a triangle is 180°)]

$$= \sin\left(90^\circ - \frac{A}{2}\right) = \cos \frac{A}{2}$$

$$(\because \sin(90^\circ - \theta) = \cos \theta)$$

= R.H.S.

Q.11 Express the trigonometric ratios $\sin A, \sec A$ and $\tan A$ in terms of $\cot A$.

[NCERT, Ex 8.4, Q.1]

Sol. (i)
$$\sin A = \frac{1}{\operatorname{cosec} A} = \frac{1}{\sqrt{\operatorname{cosec}^2 A}}$$

$$= \frac{1}{\sqrt{1 + \cot^2 A}}$$

(ii)
$$\sec A = \sqrt{\sec^2 A} = \sqrt{1 + \tan^2 A}$$

$$= \sqrt{1 + \frac{1}{\cot^2 A}} = \frac{\sqrt{1 + \cot^2 A}}{\cot A}$$

(iii)
$$\tan A = \frac{1}{\cot A}$$

Q.12 Write all the other trigonometric ratios of $\angle A$ in terms of $\sec A$. [NCERT, Ex 8.4, Q.2]

Sol.
$$\sin A = \frac{1}{\operatorname{cosec} A} = \frac{1}{\sqrt{\operatorname{cosec}^2 A}}$$

$$\frac{1}{\sqrt{1 + \cot^2 A}} = \frac{1}{\sqrt{1 + \frac{1}{\tan^2 A}}}$$

$$= \frac{1}{\sqrt{\frac{\tan^2 A + 1}{\tan^2 A}}} = \frac{1}{\sqrt{\frac{\tan^2 A + 1}{\tan A}}}$$

$$= \frac{\tan A}{\sqrt{\tan^2 A + 1}} = \frac{\tan A}{\sec A} = \frac{\sqrt{\tan^2 A}}{\sec A}$$

$$= \frac{\sqrt{\sec^2 A - 1}}{\sec A}$$

Aliter.

$$\sin A = \frac{\sin A}{1} = \frac{\frac{\sin A}{\cos A}}{\frac{1}{\cos A}} = \frac{\tan A}{\sec A}$$

$$= \frac{\sqrt{\tan^2 A}}{\sec A} = \frac{\sqrt{\sec^2 A - 1}}{\sec A};$$

$$\cos A = \frac{1}{\sec A};$$

$$\tan A = \sqrt{\tan^2 A} = \sqrt{\sec^2 A - 1};$$

$$\operatorname{cosec} A = \frac{1}{\sin A} = \frac{\sec A}{\sqrt{\sec^2 A - 1}};$$

$$\cot A = \frac{1}{\tan A} = \frac{1}{\sqrt{\sec^2 A - 1}}$$

Q.13 Prove the following identities, where the angles involved are acute angles for which the expressions are defined.

[NCERT, Ex 8.4, Q.5]

$$(i) \quad \frac{\tan \theta}{1 - \cot \theta} + \frac{\cot \theta}{1 - \tan \theta}$$

$$= 1 + \sec \theta + \operatorname{cosec} \theta$$

[Hint : Write the expression in terms of sin θ and cos θ]

$$(ii) \quad \frac{1 + \sec A}{\sec A} = \frac{\sin^2 A}{1 - \cos A}$$

[Hint : Simplify LHS and RHS separately]

$$(iii) \quad \frac{\cos A - \sin A + 1}{\cos A + \sin A - 1} = \operatorname{cosec} A + \cot A$$

using the identity $\operatorname{cosec}^2 A = 1 + \cot^2 A$

$$(iv) \quad \frac{\sin \theta - 2\sin^3 \theta}{2\cos^3 \theta - \cos \theta} = \tan \theta$$

$$(v) \quad (\operatorname{cosec} A - \sin A)(\sec A - \cos A)$$

$$= \frac{1}{\tan A + \cot A}$$

Sol. (i) L.H.S. = $\frac{\tan \theta}{1 - \cot \theta} + \frac{\cot \theta}{1 - \tan \theta}$

$$= \frac{\frac{\sin \theta}{\cos \theta}}{1 - \frac{\cos \theta}{\sin \theta}} + \frac{\frac{\cos \theta}{\sin \theta}}{1 - \frac{\sin \theta}{\cos \theta}}$$

$$= \frac{\sin^2 \theta}{\cos \theta(\sin \theta - \cos \theta)} + \frac{\cos^2 \theta}{\sin \theta(\cos \theta - \sin \theta)}$$

$$= \frac{\sin^3 \theta - \cos^3 \theta}{\sin \theta \cos \theta (\sin \theta - \cos \theta)}$$

$$= \frac{(\sin \theta - \cos \theta)(\sin^2 \theta + \cos^2 \theta + \sin \theta \cos \theta)}{\sin \theta \cos \theta (\sin \theta - \cos \theta)}$$

$$= \frac{1 + \sin \theta \cos \theta}{\sin \theta \cos \theta}$$

$$(\because \sin^2 \theta + \cos^2 \theta = 1)$$

$$= \frac{1}{\sin \theta \cos \theta} + \frac{\sin \theta \cos \theta}{\sin \theta \cos \theta}$$

$$= \frac{1}{\sin \theta} \frac{1}{\cos \theta} + 1 = \operatorname{cosec} \theta \sec \theta + 1$$

$$= 1 + \sec \theta \cdot \operatorname{cosec} \theta$$

$$= \text{R.H.S.}$$

$$(ii) \quad \text{L.H.S.} = \frac{1 + \sec A}{\sec A} = \frac{1 + \frac{1}{\cos A}}{\frac{1}{\cos A}}$$

$$= \frac{\cos A + 1}{\frac{1}{\cos A}} = \cos A + 1 = 1 + \cos A$$

$$= \frac{(1 + \cos A)(1 - \cos A)}{1 - \cos A}$$

$$= \frac{1 - \cos^2 A}{1 - \cos A} = \frac{\sin^2 A}{1 - \cos A}$$

$$(\because \sin^2 A + \cos^2 A = 1)$$

$$= \text{R.H.S.}$$

$$(iii) \quad \text{L.H.S.} = \frac{\cos A - \sin A + 1}{\cos A + \sin A - 1}$$

$$= \frac{\frac{\cos A}{\sin A} - \frac{\sin A}{\sin A} + \frac{1}{\sin A}}{\frac{\cos A}{\sin A} + \frac{\sin A}{\sin A} - \frac{1}{\sin A}}$$

[Dividing the numerator and denominator by sin A]

$$= \frac{\cot A - 1 + \operatorname{cosec} A}{\cot A + 1 - \operatorname{cosec} A}$$

$$= \frac{\cot A + \operatorname{cosec} A - 1}{\cot A - \operatorname{cosec} A + 1}$$

$$= \frac{\{(\cot A + \operatorname{cosec} A) - 1\} (\cot A + \operatorname{cosec} A)}{\{(\cot A - \operatorname{cosec} A) + 1\} (\cot A + \operatorname{cosec} A)}$$

[Multiplying both numerator and denominator by (cot A + cosec A)]

$$= \frac{\{(\cot A + \operatorname{cosec} A) - 1\} (\cot A + \operatorname{cosec} A)}{\{(\cot^2 A - \operatorname{cosec}^2 A) + (\cot A + \operatorname{cosec} A)\}}$$

$$= \frac{\{(\cot A + \operatorname{cosec} A) - 1\} (\cot A + \operatorname{cosec} A)}{\{-1 + (\cot A + \operatorname{cosec} A)\}}$$

$$(\because 1 + \cot^2 A = \operatorname{cosec}^2 A)$$

$$= \operatorname{cosec} A + \cot A = \text{R.H.S.}$$

$$(iv) \quad \text{L.H.S.} = \frac{\sin \theta - 2\sin^3 \theta}{2\cos^3 \theta - \cos \theta}$$

$$\begin{aligned}
 &= \frac{\sin \theta(1 - 2 \sin^2 \theta)}{\cos \theta(2 \cos^2 \theta - 1)} \\
 &= \frac{\sin \theta(\cos^2 \theta + \sin^2 \theta - 2 \sin^2 \theta)}{\cos \theta(2 \cos^2 \theta - \cos^2 \theta - \sin^2 \theta)} \\
 &(\because \cos^2 \theta + \sin^2 \theta = 1) \\
 &= \frac{\sin \theta(\cos^2 \theta - \sin^2 \theta)}{\cos \theta(\cos^2 \theta - \sin^2 \theta)} = \tan \theta = \text{R.H.S.}
 \end{aligned}$$

$$\begin{aligned}
 &= \frac{\frac{\sin A \cos A}{\sin^2 A} + \frac{\sin A \cos A}{\cos^2 A}}{\frac{\sin A \cos A}{\sin A \cos A} + \frac{\sin A \cos A}{\sin A \cos A}} \quad (\text{Dividing the} \\
 &\text{numerator and denominator by } \sin A \cos A) \\
 &= \frac{1}{\tan A + \cot A} \\
 &= \text{R.H.S.}
 \end{aligned}$$

(v) L.H.S. = $(\operatorname{cosec} A - \sin A)(\sec A - \cos A)$

$$\begin{aligned}
 &= \left(\frac{1}{\sin A} - \sin A \right) \left(\frac{1}{\cos A} - \cos A \right) \\
 &= \frac{1 - \sin^2 A}{\sin A} \cdot \frac{1 - \cos^2 A}{\cos A} \\
 &= \frac{\cos^2 A}{\sin A} \cdot \frac{\sin^2 A}{\cos A} \quad (\because \sin^2 A + \cos^2 A = 1) \\
 &= \frac{\sin A \cos A}{1} = \frac{\sin A \cos A}{\sin^2 A + \cos^2 A} \\
 &(\because \sin^2 A + \cos^2 A = 1)
 \end{aligned}$$

EXERCISE - II

Knowledge Vault



MCQ BASED QUESTIONS:

- Q.1** If $\sin \theta + \cos \theta = \sqrt{2} \cos (90^\circ - \theta)$ then $\cot \theta$ is equal to
 (A) $\frac{1}{\sqrt{2}}$ (B) $\frac{\sqrt{3}}{2}$
 (C) $\frac{1}{\sqrt{2}-1}$ (D) $\sqrt{2}-1$
- Q.2** If $\sec \theta + \tan \theta = x$ then the value of $\sec \theta - \tan \theta$ is equal to
 (A) $-x$ (B) $\frac{1}{x}$ (C) $-\frac{1}{x}$ (D) \sqrt{x}
- Q.3** If $x = a \sin \theta$ and $y = b \cos \theta$, then the value of $b^2x^2 + a^2y^2$ is
 (A) a^2b^2 (B) ab
 (C) $\frac{1}{a^2b^2}$ (D) $\frac{1}{ab}$
- Q.4** An equation is called an identity if
 (A) It is true for all values of variable
 (B) Not for all values of variables but some values of variables
 (C) Exactly one value of variables
 (D) Exactly two value of variables
- Q.5** If $x = (\sec A + \tan A)(\sec B + \tan B)(\sec C + \tan C)$ & $y = (\sec A - \tan A)(\sec B - \tan B)(\sec C - \tan C)$ and $x = y$ then x & y is equal to
 (A) ± 1 (B) 0
 (C) ± 2 (D) None of these
- Q.6** If $x = \cot^2 \theta - \frac{1}{\sin^2 \theta}$, then the value of x is
 (A) 1 (B) -1
 (C) ± 1 (D) zero
- Q.7** $2(\sin^6 \theta + \cos^6 \theta) - 3(\sin^4 \theta + \cos^4 \theta)$ is equal
 (A) zero (B) 1
 (C) -1 (D) None of these
- Q.8** $\sqrt{\frac{1+\sin \theta}{1-\sin \theta}}$ is equal to
 (A) $\sec \theta + \tan \theta$ (B) $\sec \theta - \tan \theta$
 (C) $\sec^2 \theta + \tan^2 \theta$ (D) $\sec^2 \theta - \tan^2 \theta$
- Q.9** $\sec^4 A - \sec^2 A$ is equal to
 (A) $\tan^2 A - \tan^4 A$ (B) $\tan^4 A - \tan^2 A$
 (C) $\tan^4 A + \tan^2 A$ (D) $\sec^2 A + \tan^4 A$
- Q.10** $\cos^4 A - \sin^4 A$ is equal to
 (A) $2 \cos^2 A + 1$ (B) $2 \cos^2 A - 1$
 (C) $2 \sin^2 - 1$ (D) $2 \sin^2 A + 1$
- Q.11** $P = (1 + \cot \theta - \operatorname{cosec} \theta)(1 + \tan \theta + \sec \theta)$, the value of P is equal to
 (A) 1 (B) 2
 (C) 4 (D) zero
- Q.12** $(\operatorname{cosec} \theta - \sin \theta)(\sec \theta - \cos \theta)(\tan \theta + \cot \theta)$ is equal to
 (A) zero (B) 1
 (C) -1 (D) none of these
- Q.13** If $\operatorname{cosec} \theta - \sin \theta = m$ and $\sec \theta - \cos \theta = n$, then
 (A) $(m^2 n)^{2/3} + (mn^2)^{2/3} = 1$
 (B) $(m^2 n^2)^{2/3} + (m^2 n^2)^{2/3} = 1$
 (C) $(mn)^{2/3} + (mn)^{1/3} = 1$
 (D) None of these
- Q.14** The expression

$$\sqrt{\sin^4 (37.5)^\circ + 4 \cos^2 (37.5)^\circ} + \sqrt{\cos^4 (37.5)^\circ + 4 \sin^2 (37.5)^\circ}$$
 simplifies to:
 (A) an irrational number
 (B) a prime number
 (C) a natural number which is not composite
 (D) a real number of the form $a + \sqrt{b}$
- Q.15** If $15 \sin^4 \alpha + 10 \cos^4 \alpha = 6$, then the value of $8 \operatorname{cosec}^4 \alpha + 27 \sec^6 \alpha$ is
 (A) 200 (B) 250
 (C) 220 (D) None of these
- Q.16** If $\sin \theta$ and $\cos \theta$ are the roots of the equation $ax^2 - bx + c = 0$, then
 (A) $a^2 - b^2 = 2ac$ (B) $a^2 + b^2 = 2ac$
 (C) $a^2 + b^2 + 2ac = 0$ (D) $b^2 - a^2 = 2ac$

- Q.17** If $0 < \theta < \pi$, $2\sin^2\theta + 5\sin\theta - 3 = 0$, then θ , in radians must be
 (A) $\frac{\pi}{12}$ (B) $\frac{\pi}{6}$ (C) $\frac{\pi}{3}$ (D) $\frac{5\pi}{6}$
- Q.18** Exact value of $\cos^2 73^\circ + \cos^2 47^\circ - \sin^2 43^\circ + \sin^2 107^\circ$ is equal to:
 (A) $\frac{1}{2}$ (B) $\frac{3}{4}$
 (C) 1 (D) None of these
- Q.19** If $\sin\theta$ and $\sec\theta$ ($0 < \theta < \pi/2$) are the roots of the equation $2x^2 + kx + 1 = 0$, then the value of 'k' is equal to
 (A) $-\frac{7\sqrt{2}}{5}$ (B) $\frac{7\sqrt{5}}{5}$
 (C) $\frac{7\sqrt{5}}{2}$ (D) $-\frac{7\sqrt{5}}{5}$
- Q.20** If $a = \frac{\cot\theta}{\cot\theta - \cot 3\theta}$ and $b = \frac{\tan\theta}{\tan\theta - \tan 3\theta}$, then $\sqrt{a+b}$ is equal to
 (A) ± 2 (B) -2
 (C) $+1$ (D) -1
- Q.21** If $a \cos\theta - b \sin\theta = C$ then $a \sin\theta + b \cos\theta =$
 (A) $\pm \sqrt{a^2 + b^2 + c^2}$
 (B) $\pm \sqrt{a^2 + b^2 - c^2}$
 (C) $\pm \sqrt{c^2 - a^2 - b^2}$
 (D) None of these
- Q.22** If $a \cos\theta + b \sin\theta = 4$ and $a \sin\theta - b \cos\theta = 3$ then $(a^2 + b^2)$ is equal to
 (A) 7 (B) 12
 (C) 25 (D) None of these
- Q.23** If $\sin\theta + \sin^2\theta + \sin^3\theta = 1$ the value of $\cos^6\theta - 4\cos^4\theta + 8\cos^2\theta = p$ the value of p is
 (A) 1 (B) 2 (C) 3 (D) 4
- Q.24** If $\cos(\theta + \phi) = m \cos(\theta - \phi)$ then $\tan\theta$ is equal to
 (A) $\left(\frac{1+m}{1-m}\right) \tan\phi$ (B) $\left(\frac{1-m}{1+m}\right) \tan\phi$
 (C) $\left(\frac{1-m}{1+m}\right) \cot\phi$ (D) $\left(\frac{1+m}{1-m}\right) \cot\phi$
- Q.25** If $\sin\theta - \cos\theta = 1$ then the value of $\sin^3\theta - \cos^3\theta$ is if ($\theta \in \mathbb{R}$)
 (A) zero (B) 1
 (C) $2/3$ (D) $3/2$
- Q.26** If $0^\circ \leq \theta \leq 90^\circ$ and $\sqrt{3} \tan\theta - \sec\theta = 1$ then θ has the value
 (A) 30° (B) 45° (C) 60° (D) 90°
- Q.27** If $a \cot\theta + b \operatorname{cosec}\theta = p$ and $b \cot\theta + a \operatorname{cosec}\theta = q$, then $p^2 - q^2$ is equal to:
 (A) $a^2 - b^2$ (B) $b^2 - a^2$
 (C) $a^2 + b^2$ (D) $b - a$
- Q.28** If $\sin^4\theta - \cos^4\theta = x$ then the value of x is
 (A) $2\sin^2\theta - 1$ (B) $1 - 2\sin^2\theta$
 (C) $\cos^2\theta - \sin^2\theta$ (D) $\sin^2\theta + \cos^2\theta$
- Q.29** If $\tan^2\theta + \cot^2\theta = 17/4$ then $(\tan\theta + \cot\theta)$ is equal to
 (A) $\frac{\sqrt{17}}{2}$ (B) $5/2$
 (C) $\frac{\sqrt{17}}{2} + \sqrt{2}$ (D) $\frac{\sqrt{17}}{2} - \sqrt{2}$
- Q.30** $\frac{1 + \sec\theta}{\sec\theta} =$
 (A) $\frac{\sin^2\theta}{1 - \cos\theta}$ (B) $\frac{\sin^2\theta}{1 - \sin\theta}$
 (C) $\frac{\cos^2\theta}{1 - \sin\theta}$ (D) $1 + \sin\theta$
- Q.31** if θ as an acute angle and $\tan\theta + \cot\theta = 2$, then:-
 (A) $\tan\theta = \frac{1}{2}$
 (B) $\tan\theta = 2$
 (C) $\tan^5\theta + \cot^5\theta = 32$
 (D) $\tan^7\theta + \cot^7\theta = 2$
- Q.32** The value of the expression $(\cos\theta - 1)(1 + \cos\theta)(1 + \cot^2\theta)$ is :
 (A) 0 (B) 1
 (C) $\sin^2\theta$ (D) -1
- Q.33** If $\frac{\sin x}{1 + \sec x} + \frac{\sin x}{\sec x - 1} = 2$, where $0^\circ < x < 90^\circ$ then $\operatorname{cosec} x$ has the value equal to :
 (A) 1 (B) 2
 (C) $\sqrt{2}$ (D) $\sqrt{3}$

Q.34 If $\cos\theta + \sin\theta = \sqrt{2} \cos\theta$, then $\cos\theta - \sin\theta$ is equal to :

- (A) $\sqrt{2} - 1$ (B) $\sqrt{2}$
 (C) $\sqrt{2} \sin\theta$ (D) $\sqrt{2} + \sin\theta$

Q.35 If $x = a \sec\theta + b \tan\theta$, $y = a \tan\theta + b \sec\theta$, then :

- (A) $x + y = a + b$
 (B) $x - y = a - b$
 (C) $x^2 + y^2 = a^2 + b^2$
 (D) $x^2 - y^2 = a^2 - b^2$

Q.36 If $x \sin^3\theta + y \cos^3\theta = \sin\theta \cos\theta$ and $x \sin\theta = y \cos\theta$ then :

- (A) $x^3 + y^3 = 1$
 (B) $x^2 - y^2 = 1$
 (C) $x^2 + y^2 = 1$
 (D) $x^3 - y^3 = 1$

Q.37 If $\sec\theta + \tan\theta = x$, then the value of $\sin\theta$ is :

- (A) $\frac{1-2x}{1+x^2}$ (B) $\frac{x^2-1}{x^2+1}$
 (C) $\frac{1+x^2}{2(1-x^2)}$ (D) $\frac{x^2+1}{x^2-1}$

Q.38 Let $x = r \cos\alpha \cdot \cos\beta$; $y = r \cos\alpha \sin\beta$ and $z = r \sin\alpha$ then $(x^2 + y^2 + z^2)$ is :-

- (A) independent of both α and β .
 (B) independent of α but dependent on β .
 (C) independent of β but dependent on α .
 (D) dependent on both α and β .

Q.39 Given $2y \cos\theta = \sin\theta$ and $2x \sec\theta - y \operatorname{cosec}\theta = 3$, then the value of $x^2 + 4y^2$ is equal to :

- (A) 1 (B) 2
 (C) 3 (D) 4

Q.40 Let $\alpha = \frac{\tan^2 A - \sin^2 A}{\tan^2 A \cdot \sin^2 A}$ and $\beta = \frac{\cot^2 A - \cos^2 A}{\cot^2 A \cdot \cos^2 A}$, (A is acute angle) are the roots of the quadratic equation whose discriminant is 'D', then the most appropriate choice is :-

- (A) $D > 0$ (B) $D \geq 0$
 (C) $D = 0$ (D) $D < 0$

Q.41 Which one of the following identities (wherever defined) is not correct ?

- (A) $\frac{\sin^4 x - \cos^4 x}{\sin^2 x - \cos^2 x} = 1$
 (B) $\frac{\cot x}{1 + \tan x} = \frac{\cot x - 1}{2 - \sec^2 x}$
 (C) $\operatorname{cosec}^2 x + \sec^2 x = \operatorname{cosec}^2 x \cdot \sec^2 x$
 (D) $(1 + \cot x - \operatorname{cosec} x)(1 + \tan x + \sec x) = 1$

Q.42 The expression, $2(1 + \cos x) - \sin^2 x$ is the same as :

- (A) $(1 - \cos x)^2$
 (B) $1 - \cos^2 x$
 (C) $(1 + \cos x)^2$
 (D) $1 + \cos^2 x$

Q.43 If $\sin x + \sin^2 x = 1$ then the value of $\cos^2 x + \cos^4 x$ is equal to :

- (A) 1 (B) $\frac{1}{2}$
 (C) $\frac{1}{3\sqrt{3}}$ (D) $\frac{3\sqrt{5}-5}{2}$

Q.44 If $\sin x + \cos x = \frac{1}{2}$ then $\sin^4 x + \cos^4 x$ as a rational number equal :

- (A) $\frac{3}{4}$ (B) $\frac{15}{32}$
 (C) $\frac{19}{32}$ (D) $\frac{23}{32}$

Q.45 The expression $1 + \frac{\tan^2 \theta}{1 + \sec \theta}$ when simplified, reduces to :

- (A) $\sin\theta$ (B) $\sec\theta$
 (C) $\operatorname{cosec}\theta$ (D) $\cot\theta$

MATCH THE COLUMN:

[A] [ONE TO MANY] :

Column-I and column-II contains four entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the same entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I

Q.46 Column I

- (a) The solution of equation $-\cos^2 \theta - \frac{1}{2} \sin \theta + 1 = 0$ lies in the interval
- (b) If $\sin \theta + \cos \theta > 1$ then θ lies in the interval
- (c) If $\sin \theta - \cos \theta < 0$ then θ lies in the interval
- (d) If $\cos \theta - \sin \theta < 0$ then θ lies in the interval

Column II

- (p) $0^\circ \leq \theta < 45^\circ$
- (q) $45^\circ < \theta \leq 90^\circ$
- (r) $\theta = 0^\circ$ or $\theta = 30^\circ$
- (s) $0 < \theta < 90^\circ$
- (A) (a)-(r), (b)-(s), (c)-(p), (d)-(q)
- (B) (a)-(q), (b)-(s), (c)-(r), (d)-(p)
- (C) (a)-(s), (b)-(p), (c)-(q), (d)-(r)
- (D) (a)-(r), (b)-(p), (c)-(s), (d)-(q)

Q.47 Column I

- (a) If $\tan^2 \theta + \cot^2 \theta = x$, then the value of x is
- (b) If $\sin^4 \theta - \cos^4 \theta = x$, then the value of x is
- (c) If $\sin^4 \theta \cdot \cos^4 \theta = x$, then the value of x is
- (d) If $\cos^4 \theta + \sin^4 \theta = x$, then the value of x is

Column II

- (p) $0 \leq x \leq 1/16$
- (q) $1/2 \leq x \leq 1$
- (r) $-1 \leq x \leq 1$
- (s) $x \geq 2$
- (A) (a)-(r), (b)-(s), (c)-(p), (d)-(q)
- (B) (a)-(q), (b)-(s), (c)-(r), (d)-(p)
- (C) (a)-(s), (b)-(r), (c)-(p), (d)-(r)
- (D) (a)-(r), (b)-(p), (c)-(s), (d)-(q)

ASSERTION & REASON TYPE QUESTIONS:

- (1) Both Assertion and Reason are correct and Reason is correct explanation for Assertion
- (2) Both Assertion and Reason are correct but Reason is not correct explanation for Assertion
- (3) Assertion is true but Reason is false
- (4) Assertion is false but Reason is true

Q.48 Assertion: the equation

$$\sec^2 \theta = \frac{4xy}{(x+y)^2} \text{ is only possible when } x = y.$$

Reason: $\sec^2 \theta \geq 1$ and therefore $(x-y)^2 \leq 0$

- (A) 1 (B) 2
(C) 3 (D) 4

Q.49 Assertion : if $\sec \theta + \tan \theta = x$,

$$\text{then the value of } \sin \theta = \frac{x^2 - 1}{x^2 + 1}$$

Reason: $x + \frac{1}{x} = 2 \tan \theta$ and

$$x - \frac{1}{x} = 2 \sec \theta$$

- (A) 1 (B) 2
(C) 3 (D) 4

Q.50 Assertion : In right triangle ABC and DEF ($\angle C = \angle F = 90^\circ$), $\angle B$ and $\angle E$ are acute angles such that $\sin B = \sin E$, then $\angle B = \angle E$.

Reason: $\triangle ABC$ and $\triangle DEF$ are similar triangles

- (A) 1 (B) 2
(C) 3 (D) 4

Q.51 Assertion : The value of each of the trigonometric ratios of an angle does not depend on the size of the triangle. It only depends on the angle.

Reason: In right $\triangle ABC$, $\angle B = 90^\circ$ and

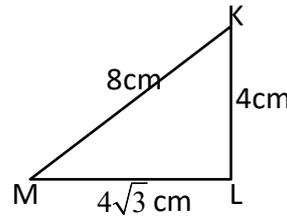
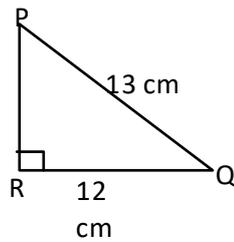
$$\angle A = \theta^\circ, \sin \theta = \frac{BC}{AC} < 1 \text{ and}$$

$\cos \theta = \frac{AB}{AC} < 1$ as hypotenuse is the longest side.

- (A) 1 (B) 2
(C) 3 (D) 4

CASE/SOURCE BASED TYPE QUESTIONS:

Q.52 Anita, a student of class 10th, has to made a project on 'Introduction to Trigonometry'. She decides to make a bird house which is triangular in shape. She uses cardboard to make the bird house as shown in the figure. Considering the front side of bird house as right-angled triangle PQR, right angled at R, answer the following questions.



- (i) If $\angle PQR = \theta$, then $\cos\theta =$
- (A) $\frac{12}{5}$ (B) $\frac{5}{12}$
- (C) $\frac{12}{13}$ (D) $\frac{13}{12}$
- (ii) The value of $\sec\theta$
- (A) $\frac{5}{12}$ (B) $\frac{12}{5}$
- (C) $\frac{13}{12}$ (D) $\frac{12}{13}$
- (iii) The value of $\frac{\tan \theta}{1 + \tan^2 \theta} =$
- (A) $\frac{5}{12}$ (B) $\frac{12}{5}$
- (C) $\frac{60}{169}$ (D) $\frac{169}{60}$
- (iv) The value of $\cot^2\theta - \operatorname{cosec}^2\theta =$
- (A) -1 (B) 0 (C) 1 (D) 2

Q.53 Sandwich making - Ritu's daughter is feeling so hungry so thought to eat something. She looked into a bread pieces. She decided to make a sandwich. She cut the piece of bread diagonally and found that it forms a right-angled triangle, with sides 4 cm, $4\sqrt{3}$ cm and 8 cm.

- On the basis of above information, answer the following questions.
- (i) The value of $\angle M =$
- (A) 30°
- (B) 60°
- (C) 45°
- (D) None of these
- (ii) The value of $\angle K =$
- (A) 45°
- (B) 30°
- (C) 60°
- (D) None of these
- (iii) $\sec^2 M - 1 =$
- (A) $\sqrt{3}$ (B) $\frac{1}{\sqrt{3}}$
- (C) 1 (D) None of these
- (iv) The value of $\frac{\tan^2 45^\circ - 1}{\tan^2 45^\circ + 1}$ is
- (A) 0 (B) 1
- (C) 3 (D) -2

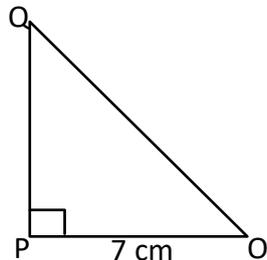
EXERCISE - III

Subjective Stuff



VERY SHORT ANSWER TYPE QUESTIONS:

Q.1 In ΔOPQ right angled at P, $OP = 7$ cm and $OQ - PQ = 1$ cm (see figure)



Determine the value of $\sin\theta$ and $\cos\theta$.

Q.2 Find $\sec 70^\circ \sin 20^\circ - \cos 20^\circ \operatorname{cosec} 70^\circ$.

Q.3 Find an acute angle θ , when

$$\frac{\cos \theta - \sin \theta}{\cos \theta + \sin \theta} = \frac{1 - \sqrt{3}}{1 + \sqrt{3}}$$

Q.4 If $\sin \theta + \sin^2 \theta = 1$, then find the value of $\cos^2 \theta + \cos^4 \theta$.

Q.5 If $(1 - \sin A)(1 - \sin B)(1 - \sin C) = (1 - \sin A)(1 + \sin B)(1 + \sin C)$, then prove that each side is equal to $\cos A \cos B \cos C$.

Q.6 Prove that

$$\sin^2 \left(\frac{\pi}{8} + \frac{A}{2} \right) - \sin^2 \left(\frac{\pi^2}{8} + \frac{A}{2} \right) = \frac{1}{\sqrt{2}} \sin A$$

SHORT ANSWER TYPE QUESTIONS:

Q.7 ABC is a right triangle, right angled at C. if $\angle A = 30^\circ$ and $AB = 40$ units, find the remaining two sides and $\angle B$ and ΔABC .

Q.8 If an acute triangle ABC, if $\tan (A + B - C) = 1$ and $\sec (B + C - A) = 2$, find the value of A, B and C.

Q.9 If $\sin \theta + \sin^2 \theta = 1$, find the value of $\cos^{12} \theta + 3 \cos^{10} \theta + 3 \cos^8 \theta + \cos^6 \theta + 2 \cos^4 \theta + 2 \cos^2 \theta - 2$

Q.10 Prove that

$$\frac{1}{(\operatorname{cosec} \theta - \cot \theta)} - \frac{1}{\sin \theta} = \frac{1}{\sin \theta} - \frac{1}{(\operatorname{cosec} \theta + \cot \theta)}$$

Q.11 Without using trigonometric tables, evaluate the following :

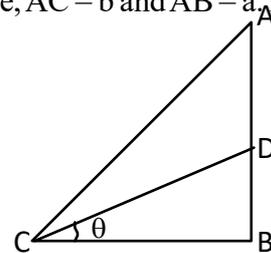
$$\left(\frac{\tan 20^\circ}{\operatorname{cosec} 70^\circ} \right)^2 + \left(\frac{\cot 20^\circ}{\sec 70^\circ} \right)^2 + 2 \tan 15^\circ \tan 37^\circ \tan 53^\circ \tan 60^\circ \tan 75^\circ$$

Q.12 If $\sin \theta = \frac{m}{n}$, find the value of $\frac{\tan \theta + 4}{4 \cot \theta + 1}$.

LONG ANSWER TYPE QUESTIONS:

Q.13 If $\sin \theta = \frac{a^2 - b^2}{a^2 + b^2}$, find the value of other trigonometric ratios.

Q.14 In the given figures, $AD = DB$ and $\angle B$ is a right angle, $AC = b$ and $AB = a$. Determine



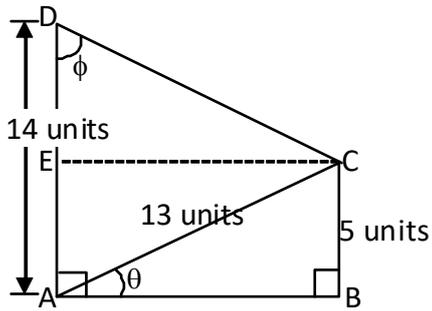
- (i) $\sin \theta$ (ii) $\cos \theta$ (iii) $\tan \theta$

Q.15 If $\sin \alpha + \sin \beta = a$ and $\cos \alpha + \cos \beta = b$, show that

(i) $\cos (\alpha + \beta) = \frac{b^2 - a^2}{b^2 + a^2}$

(ii) $\sin (\alpha + \beta) = \frac{2ab}{a^2 + b^2}$

Q.16 In the given figure, $\angle ABC = 90^\circ$, $\angle BAC = \theta$, $\angle ADC = \phi$, $BC = 5$ units, $AC = 13$ units and $AD = 14$ units. Also, $\angle BAD = 90^\circ$.



- (i) $\cos \theta$ (ii) $\tan \phi$ (iii) $\operatorname{cosec} \phi$

Q.17 Prove that :

$$\left(\frac{1}{\sec^2 q - \cos^2 q} + \frac{1}{\operatorname{cosec}^2 q - \sin^2 q} \right)$$

$$\times \sin^2 \theta \cdot \cos^2 \theta = \frac{1 - \sin^2 \theta \cos^2 \theta}{1 + \sin^2 \theta \cos^2 \theta}$$

EXERCISE-IV

Competitive Edge



- Q.1** If $x = a \sec\theta + b \tan\theta$ and $y = a \tan\theta + b \sec\theta$, then the value of $x^2 - y^2$ is :
[Raj. NTSE Stage-1 2005]
 (A) $a^2 b^2$ (B) $a^2 + b^2$
 (C) $a^2 - b^2$ (D) 1
- Q.2** If $\frac{\cos\theta}{1+\sin\theta} - \frac{1-\sin\theta}{\cos\theta} = 2k$ then the value of k is : **[Raj. NTSE Stage -1 2005]**
 (A) 0 (B) 1
 (C) $\frac{1}{2}$ (D) 2
- Q.3** If $a \cos\theta + b \sin\theta = 3$ and $a \sin\theta - b \cos\theta = 4$, then the value of $a^2 + b^2$ is :
[Raj. NTSE Stage -1 2006]
 (A) 9 (B) 16
 (C) 25 (D) None of these
- Q.4** If $\tan\theta + \sec\theta = 4$, then the value of $\sin\theta$ is : **[Raj. NTSE Stage -1 2007]**
 (A) $\frac{15}{28}$ (B) $\frac{8}{15}$
 (C) $\frac{15}{17}$ (D) $\frac{3}{5}$
- Q.5** If $\sin(A+B) = \frac{\sqrt{3}}{2}$, $\cos(A-B) = \frac{\sqrt{3}}{2}$ and $0 < A+B \leq 90^\circ$ If $A > B$ then the value of A and B are : **[Raj. NTSE Stage -1 2013]**
 (A) $A = 45^\circ, B = 15^\circ$
 (B) $A = 60^\circ, B = 30^\circ$
 (C) $A = 0^\circ, B = 30^\circ$
 (D) $A = 30^\circ, B = 0^\circ$
- Q.6** If $\cos A + \cos^2 A = 1$. then the value of $\sin^2 A + \sin^4 A$ is : **[Delhi NTSE Stage-1 2013]**
 (A) 1 (B) $\frac{1}{2}$
 (C) 2 (D) 3
- Q.7** In right triangle ABC, $BC = 7\text{cm}$, $AC - AB = 1\text{cm}$ and $\angle B = 90^\circ$. The value of $\cos A + \cos B + \cos C$ is : **[Delhi NTSE Stage-1 2013]**
 (A) $\frac{1}{7}$ (B) $\frac{32}{24}$
 (C) $\frac{31}{25}$ (D) $\frac{25}{31}$
- Q.8** If $\sin\phi$ and $\cos\phi$ are the roots of the equation $ax^2 + bx + c = 0$, then **[Haryana NTSE Stage-1 2013]**
 (A) $(a-c)^2 + c^2 = b^2$
 (B) $(a-c)^2 - c^2 = b^2$
 (C) $(a+c)^2 + c^2 = b^2$
 (D) $(a+c)^2 - c^2 = b^2$
- Q.9** If $\tan A + \sec A = 2$, $0^\circ < A < 90^\circ$, the value of $\cos A$ lies between : **[Haryana NTSE Stage-1 2013]**
 (A) 0.7 and 0.9
 (B) 0.7 and 0.8
 (C) 0.8 and 0.9
 (D) 0.5 and 0.7
- Q.10** If $\sin\theta + \cos\theta = 1$, then $\sin\theta \cos\theta$ is equal to : **[M.P. NTSE Stage-1 2013]**
 (A) 0 (B) $\frac{1}{\sqrt{3}-1}$
 (C) 1 (D) $\frac{1+\sqrt{2}}{\sqrt{3}-1}$
- Q.11** If $\sin\theta - \cos\theta = \sqrt{2} \sin(90^\circ - \theta)$, then $\tan\theta =$ **[Raj. NTSE Stage-1 2013]**
 (A) $\sqrt{2}-1$ (B) $\sqrt{2}$
 (C) $1-\sqrt{2}$ (D) $\sqrt{2}+1$
- Q.12** If $\sec^2\theta + \tan^2\theta = 2$, $0^\circ < \theta < 90^\circ$, then the value of $\operatorname{cosec}^2\theta + \cot^2\theta$ is - **[Haryana NTSE Stage-1 2013]**
 (A) 2 (B) 3
 (C) 4 (D) 5

Q.13 If $\tan \theta + 4 \cot \theta = 4$, then value of $\tan^3 \theta + \cot^2 \theta$ is : [Haryana NTSE Stage-1 2013]

- (A) $8\frac{1}{8}$ (B) 16
(C) $27\frac{1}{27}$ (D) $7\frac{9}{8}$

Q.14 The Maximum value of $\cos^6 \theta + \sin^6 \theta$ is : [West Bengal NTSE Stage-1 2014]

- (A) 1 (B) 0
(C) 4 (D) 2

Q.15 ϕ , is an acute angle such that $\tan \phi = 2/3$ then evaluate [NTSE Stage-2 2014]

- $\left(\frac{1 + \tan \phi}{\sin \phi + \cos \phi}\right) \cdot \left(\frac{1 + \cot \phi}{\sec \phi + \operatorname{cosec} \phi}\right)$
(A) $\frac{1}{5}$ (B) $-\frac{4}{\sqrt{13}}$
(C) $\frac{1}{5}$ (D) $\frac{4}{\sqrt{3}}$

Q.16 $\frac{\cos \theta}{1 - \tan \theta} - \frac{\sin \theta}{\cot \theta - 1}$ is equal to [Raj. NTSE Stage-1 2016]

- (A) $\sin \theta + \cos \theta$
(B) $\cos \theta - \sin \theta$
(C) $2 \sin \theta$
(D) $\frac{1}{\cos \theta - \sin \theta}$

Q.17 Value of $\tan 20^\circ \tan 40^\circ \tan 50^\circ \tan 70^\circ$ [Raj. NTSE Stage-1 2016]

- (A) 0 (B) $\frac{1}{\sqrt{3}}$
(C) $\sqrt{3}$ (D) 1

Q.18 If $\operatorname{cosec} x - \sin x = a$ and $\sec x - \cos x = b$, then [NTSE Stage-2 2016]

- (A) $(a^2 b)^{\frac{2}{3}} + (ab^2)^{\frac{2}{3}} = 1$
(B) $(ab^2)^{\frac{2}{3}} + (a^2 b^2)^{\frac{2}{3}} = 1$
(C) $a^2 + b^2 = 1$
(D) $b^2 - a^2 = 1$

Q.19 If $\sin \theta = p$ and $\cos \theta = q$ then the value of

$\frac{p - 2p^3}{2p^3 - q}$ [Raj. NTSE Stage-2 2017]

- (A) $\sec \theta$ (B) $\operatorname{cosec} \theta$
(C) $\cot \theta$ (D) $\tan \theta$

Q.20 Value of $\tan 25^\circ \tan 35^\circ \tan 45^\circ \tan 55^\circ \tan 65^\circ$ is : [Raj. NTSE Stage-2 2017]

- (A) 0 (B) 1
(C) $\sqrt{2}$ (D) $\sqrt{3}$

Q.21 If $m = \frac{\cos A}{\cos B}$ and $n = \frac{\cos A}{\cos B}$, then $(m^2 + n^2) \cos^2 B$ is equal to :

- [Raj. NTSE Stage-1 2018]
(A) m^2 (B) n^2
(C) $m^2 + n^2$ (D) $m + n$ Q.21

Q.22 What is the radian value of angle $60^\circ 30'$? [Raj. NTSE Stage-1 2018]

- (A) $\frac{\pi^c}{3}$ (B) $\frac{121}{360} \pi^c$
(C) $\frac{121\pi^c}{180}$ (D) $\frac{121}{540} \pi^c$

Q.23 If $\tan A = \sqrt{2} - 1$ where A is an acute angle then the value of $\sin A \cdot \cos A$ will be

- [Raj. NTSE Stage-1 2019]
(A) $2\sqrt{2}$ (B) $\sqrt{2}$
(C) $\frac{1}{2\sqrt{2}}$ (D) $\frac{3}{\sqrt{2}}$

Q.24 The value of $\cos x^\circ - \sin x^\circ$ ($0 \leq x < 45$) is [NTSE Stage-2 2019]

- (A) 0
(B) positive
(C) negative
(D) Sometimes negative and sometimes positive

Q.25 Value of $(\cos 0^\circ + \sin 45^\circ + \sin 30^\circ)(\sin 90^\circ - \cos 45^\circ + \cos 60^\circ)$

- [Raj. NTSE Stage-1 2019]
(A) $\frac{4}{7}$ (B) $\frac{7}{4}$
(C) $\frac{5}{7}$ (D) $\frac{3}{2}$

Q.26 If $\sin \theta = \frac{4}{5}$, then value of $\frac{4 \tan \theta - 5 \cos \theta}{\sec \theta + 4 \cot \theta}$
[Raj. NTSE Stage-1 2019]

(A) $\frac{2}{3}$ (B) $\frac{1}{3}$

(C) $\frac{3}{4}$ (D) $\frac{1}{2}$

Q.27 If $\operatorname{cosec} A = 2$, then the value of $\tan A + \frac{\cos A}{1 + \sin A}$ will be:

[Raj. NTSE Stage-1 2020-21]

(A) $\frac{1}{2\sqrt{3}}$ (B) $\frac{2}{\sqrt{3}}$

(C) $\frac{1}{\sqrt{3}}$ (D) $2\sqrt{3}$

Q.28 If $\tan 3P = \sin 45^\circ \cos 45^\circ + \sin 30^\circ$, then the value of P will be : ($P < 90$)

[Raj. NTSE Stage-1 2020-21]

(A) 15° and 45° (B) 15° and 60°
 (C) 15° and 75° (D) 45° and 60°

Q.29 The value of

$$\frac{(\sec \theta + \tan \theta)(1 - \sin \theta) \sec \theta}{(1 + \tan \theta + \sec \theta)(1 + \cot \theta - \operatorname{cosec} \theta)}$$
 lies

between

[Haryana NTSE Stage-1 2020-21]

(A) 0.2 and 0.4

(B) 0.4 and 0.6

(C) 0.6 and 0.8

(D) 0.8 and 1

Q.30 If $\tan 2A = \cot (A - 18^\circ)$, where $2A$ is an acute angle, then the value of A is :- **[STSE 2022]**

(A) 45° (B) 18°

(C) 36° (D) 20°

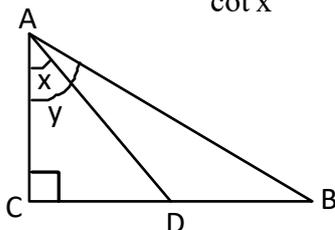
EXERCISE-V

Board Navigator



Q.1 If $\cos A = \frac{4}{5}$, then the value of $\tan A$ is
 [CBSE 2015]
 (A) $\frac{3}{5}$ (B) $\frac{3}{4}$
 (C) $\frac{4}{3}$ (D) $\frac{5}{3}$

Q.2 In the given figure, D is the mid-point of BC, then the value of $\frac{\cot y}{\cot x}$ is [CBSE 2015]



(A) 2 (B) $\frac{1}{2}$
 (C) $\frac{1}{3}$ (D) $\frac{1}{4}$

Q.3 If $\sin\theta - \cos\theta = 0$, then the value of $\sin^3\theta + \cot^3\theta$ is [CBSE 2015]
 (A) 30° (B) 45°
 (C) 90° (D) 0°

Q.4 If θ is an actual angle and $\tan\theta + \cot\theta = 2$, then the value of $\sin^3\theta + \cot^3\theta$ is [CBSE 2016]

(A) 1 (B) $\frac{1}{2}$
 (C) $\frac{\sqrt{2}}{2}$ (D) $\sqrt{2}$

Q.5 If $\tan\alpha + \cot\alpha = 2$, then $\tan^{20}\alpha$ is equal to [CBSE 2017]
 (A) 0 (B) 2
 (C) 20 (D) 2^{20}

Q.6 If $\tan\theta + \sin\theta = m$ and $\tan\theta - \sin\theta = n$, then $m^2 - n^2$ is equal to [CBSE 2018]
 (A) \sqrt{mn} (B) $\sqrt{\frac{m}{n}}$
 (C) $\sqrt{\frac{3}{2}}$ (D) 1

Q.7 If $\sin A = \frac{1}{2}$, then the value of $\cot A$ is [CBSE 2018]
 (A) $\sqrt{3}$ (B) $\frac{1}{\sqrt{3}}$
 (C) $\frac{\sqrt{3}}{2}$ (D) 1

Q.8 If $x\sin^3\theta + y\cos^3\theta = \sin\theta\cos\theta$ and $x\sin\theta = y\cos\theta$, then $x^2 + y^2$ is equal to [CBSE 2018]
 (A) 0 (B) $\frac{1}{2}$
 (C) 1 (D) $\frac{3}{2}$

Q.9 If $\sin\theta = \frac{a}{b}$, then $\cos\theta$ is equal to [CBSE 2019]
 (A) $\frac{b}{\sqrt{b^2 - a^2}}$ (B) $\frac{b}{a}$
 (C) $\frac{\sqrt{b^2 - a^2}}{b}$ (D) $\frac{a}{\sqrt{b^2 - a^2}}$

Q.10 If $\sec\theta \tan\theta = p$, then $\tan\theta$ is [CBSE 2020]
 (A) $\frac{p^2 + 1}{2p}$ (B) $\frac{p^2 - 1}{2p}$
 (C) $\frac{p^2 - 1}{p^2 + 1}$ (D) $\frac{p^2 + 1}{p^2 - 1}$

Q.11 If $\tan A = \frac{3}{4}$, find the value of $\frac{1}{\sin A} + \frac{1}{\cos A}$. [CBSE 2020]

Q.12 Given that, $\sin\alpha = \frac{1}{2}$, $\cos\beta = \frac{1}{2}$, what is the value of $(\alpha + \beta)$? [CBSE 2021]

Q.13 If $7\tan\theta = 4$ then find the value of $\frac{7\sin\theta - 3\cos\theta}{7\sin\theta + 3\cos\theta}$ [CBSE 2022]

Q.14 If $4x = \operatorname{cosec}\theta$ and $\frac{4}{x} = \cot\theta$, then the value of $4\left[x^2 - \frac{1}{x^2}\right]$ [CBSE 2022]

ANSWER KEY

EXERCISE-II

MULTIPLE CHOICE QUESTIONS:

Q.1	D	Q.2	B	Q.3	A	Q.4	A	Q.5	A	Q.6	B	Q.7	C
Q.8	A	Q.9	C	Q.10	B	Q.11	B	Q.12	B	Q.13	A	Q.14	C
Q.15	B	Q.16	D	Q.17	B	Q.18	C	Q.19	D	Q.20	C	Q.21	B
Q.22	C	Q.23	D	Q.24	C	Q.25	B	Q.26	C	Q.27	B	Q.28	A
Q.29	B	Q.30	A	Q.31	D	Q.32	D	Q.33	C	Q.34	C	Q.35	D
Q.36	C	Q.37	B	Q.38	A	Q.39	D	Q.40	C	Q.41	D	Q.42	C
Q.43	A	Q.44	D	Q.45	B								

MATCH THE COLUMN :

Q.46 (A) Q.47 (C)

ASSERTION & REASON TYPE QUESTIONS:

Q.48 A Q.49 C Q.50 A Q.51 B

CASE/ SOURCE BASED :

Q.52 (i) C (ii) C (iii) C (iv) A

Q.53 (i) A (ii) C (iii) C (iv) A

EXERCISE-III

VERY SHORT ANSWER TYPE :

Q.1 $\sin \theta = \frac{7}{25}$ & $\cos \theta = \frac{24}{25}$ Q.2 0 Q.3 60° Q.4 1

SHORT ANSWER TYPE :

Q.7 $AC = 20\sqrt{3}$ units & $BC = 20$ units and $\angle B = 60^\circ$

Q.8 $A = 60^\circ$, $B = 52\frac{1}{2}^\circ$ and $C = 67\frac{1}{2}^\circ$

Q.9 1 Q.11 $(1 + 2\sqrt{3})$ Q.12 $\frac{m}{\sqrt{n^2 - m^2}}$

LONG ANSWER TYPE :

$$\text{Q.13 } \cos \theta = \frac{2ab}{a^2 + b^2}, \quad \tan \theta = \frac{a^2 - b^2}{2ab},$$

$$\operatorname{cosec} \theta = \frac{a^2 + b^2}{a^2 - b^2}, \sec \theta = \frac{a^2 + b^2}{2ab} \text{ and } \operatorname{Cot} \theta = \frac{2ab}{a^2 - b^2}$$

$$\text{Q.14 (i) } \frac{a}{\sqrt{4b^2 - 3a^2}} \quad \text{(ii) } \frac{2\sqrt{b^2 - a^2}}{\sqrt{4b^2 - 3a^2}} \quad \text{(iii) } \frac{a}{\sqrt{b^2 - a^2}}$$

$$\text{Q.16 (i) } \frac{12}{13} \quad \text{(ii) } \frac{4}{3} \quad \text{(iii) } \frac{5}{4}$$

EXERCISE-IV

Q.1	C	Q.2	A	Q.3	C	Q.4	C	Q.5	A	Q.6	A	Q.7	C
Q.8	D	Q.9	A	Q.10	A	Q.11	D	Q.12	D	Q.13	A	Q.14	A
Q.15	A	Q.16	A	Q.17	D	Q.18	A	Q.19	D	Q.20	B	Q.21	B
Q.22	B	Q.23	C	Q.24	B	Q.25	B	Q.26	D	Q.27	B	Q.28	C
Q.29	B	Q.30	C										

EXERCISE-V

Q.1	B	Q.2	B	Q.3	B	Q.4	C	Q.5	B	Q.6	C	Q.7	A
Q.8	C	Q.9	C	Q.10	B	Q.11	$\frac{35}{12}$	Q.12	90°	Q.13	$\frac{1}{7}$	Q.14	$\frac{1}{4}$

- Shortage of water as compared to its demand is known as **Water Scarcity**.
- The availability of water resources varies over space and time, mainly due to the variations in seasonal and annual precipitation, but water scarcity in most cases is caused by over- exploitation, excessive use and unequal access to water among different social groups.

4. CAUSES OF WATER SCARCITY

- Water scarcity is the result of depletion of limited availability of fresh water and it may occur in regions having ample water resources, but suffer from unequal access.

I. Large Population :

- Water scarcity may be an outcome of large and growing population and consequent greater demands for water, and unequal access to it.

II. Industrialisation :



Industrialisation

- The ever increasing number of industries has made matters worse by exerting pressure on existing freshwater resources.
- Industries, apart from being heavy users of water, also require power to run them. Much of this energy comes from hydroelectric power.
- Today, in India hydroelectric power contributes approximately 22% of the total electricity produced.

III. Urbanisation :

- The multiplying urban centres with large and dense populations and urban lifestyles have not only added to water and energy requirements but have further aggravated the problem.

IV. Water Pollution :



- Water may be polluted by domestic and industrial wastes, chemicals, pesticides and fertilisers used in agriculture, thus, making it hazardous for human use.

5. MULTI-PURPOSE RIVER PROJECTS AND INTEGRATED WATER RESOURCES MANAGEMENT

- Archaeological and historical records show that from ancient times we have been constructing sophisticated hydraulic structures like dams built of stone rubble, reservoirs or lakes, embankments and canals for irrigation.

➤ Hydraulic Structures in Ancient India

- In the first century B.C., Sringaverapura near Allahabad had sophisticated water harvesting system channelling the flood water of the river Ganga.
- During the time of Chandragupta Maurya, dams, lakes and irrigation systems were extensively built.
- Evidences of sophisticated irrigation works have also been found in Kalinga, (Orissa), Nagarjunakonda (Andhra Pradesh), Bennur (Karnataka), Kolhapur (Maharashtra), etc.
- In the 11th Century, Bhopal Lake, one of the largest artificial lakes of its time was built.
- In the 14th Century, the tank in Hauz Khas, Delhi was constructed by Iltutmish for supplying water to Siri Fort area.
- Dams were traditionally built to impound rivers and rainwater that could be used later to irrigate agricultural fields.
- Today, dams are built not just for irrigation but for electricity generation, water supply for domestic and industrial uses, flood control, recreation, inland navigation and fish breeding. Hence, dams are now referred to as multi-purpose projects where the many uses of the impounded water are integrated with one another. For example, in the Sutluj-Beas river basin, the Bhakra-Nangal project water is being used both for hydel power production and irrigation. Similarly, the Hirakud project in the Mahanadi basin integrates conservation of water with flood control.



Hirakud Dam

I. Multi-Purpose Projects :

- Multi-purpose projects, launched after Independence with their integrated water resources management approach, were thought of as the vehicle that would lead the nation to development and progress, overcoming the handicap of its colonial past.
- **Jawaharlal Nehru** proudly proclaimed the dams as the ‘**temples of modern India**’; the reason being that it would integrate development of agriculture and the village economy with rapid industrialisation and growth of the urban economy.



Major Rivers and Dams

II. Adverse effect of Multi-Purpose Projects :

River Projects	Rivers
Salal Project	Chenab
Bhakra Nangal	Sutlej
Tehri	Bhagirathi (Ganga)
Naraura	Ganga
Rana Pratap Sagar	Chambal
Gandhi Sagar	Chambal
Kota Barrage	Chambal
Sardar Sarovar	Narmada
Pravara	Pravara (Godavari)
Koyna	Krishna
Nagarjuna Sagar	Krishna
Tungabhadra	Tungabhadra (Krishna)
Mettur	Kaveri
Krishna Raj Sagar	Kaveri
Periyar	Periyar
Hirakud	Mahanadi
Tilaya, Konar, Maithon and Panchet	Damodar (DVC)

- Regulating and damming of rivers affect their natural flow causing poor sediment flow and excessive sedimentation at the bottom of the reservoir, resulting in rockier stream beds and poorer habitats for the rivers' aquatic life.

- Dams also fragment rivers making it difficult for aquatic fauna to migrate, especially for spawning.
- The reservoirs that are created on the floodplains also submerge the existing vegetation and soil leading to its decomposition over a period of time.
- Multi-purpose projects and large dams have also been the cause of many new social movements like the ‘Narmada Bachao Andolan’ and the ‘Tehri Dam Andolan’ etc.
- Resistance to these projects has primarily been due to the large-scale displacement of local communities. Local people often had to give up their land, livelihood and their meagre access and control over resources for the greater good of the nation.
- Irrigation has also changed the cropping pattern of many regions with farmers shifting to water intensive and commercial crops. This has great ecological consequences like salinisation of the soil.
- It has transformed the social landscape i.e. increasing the social gap between the richer landowners and the landless poor.
- Sometimes, the dams did create conflicts between people wanting different uses and benefits from the same water resources. In Gujarat, the Sabarmati-basin farmers were agitated and almost caused a riot over the higher priority given to water supply in urban areas, particularly during droughts.
- Inter-state water disputes are also becoming common with regard to sharing the costs and benefits of the multi-purpose project.
- The dams that were constructed to control floods have triggered floods due to sedimentation in the reservoir.
- The big dams have mostly been unsuccessful in controlling floods at the time of excessive rainfall. For example, the release of water from dams during heavy rains aggravated the flood situation in **Maharashtra** and **Gujarat** in 2006. The floods have not only devastated life and property but also caused extensive soil erosion.
- **Sedimentation** also meant that the flood plains were deprived of silt, a natural fertiliser, further adding on to the problem of land degradation. It was also observed that the multi-purpose projects induced earthquakes, caused waterborne diseases and pests and pollution resulting from excessive use of water.



HANGING BY A THREAD

Lift-off An IAF helicopter rescues a woman and her child from the Durgagaon village of Maharashtra's Hingoli district. In all, 11 choppers were pressed into rescue operations across the state. (Related reports on p7)



FLOODS

Basic Safety Precautions To Be Taken :

- Listen to radio/TV for the latest weather bulletin and flood warnings. Pass on the information to others.
- Make a family emergency kit which should include: a portable radio/translator, torch, spare batteries, a first aid box along with essential medicines, CDS, dry food items, drinking water, matchboxes, candles and other essential items.
- Keep spare lamp, ropes, rubber tubes, umbrellas and bamboo stick in your house. These could be useful.
- Keep your cash, jewellery, valuables, important documents etc. in a safe place.
- If there is a flood, move along with your family members and cattle to safe areas like relief camps, evacuation centres, elevated grounds where you can take shelter.
- Turn off power and gas connections before leaving your house.

During floods

- Don't enter into flood waters; it could be dangerous.
- Don't allow children to play in or near flood waters.
- Stay away from overhanging trees, gutters, drains, culverts etc.
- Be careful of snakes; snakes bite are common during floods.
- Stay away from electric poles and fallen power-lines to avoid electrocution.
- Don't use wet electrical appliances - get them checked before use.
- Eat freshly cooked and dry food. Always keep your food covered.
- Use boiled and filtered drinking water.
- Keep all dishes, gutters near your house clean.
- Stagnation of water can breed vector-borne diseases . In case of sickness, use bleaching powder and lime to disinfect the surroundings.



THE RIDE OF HIS LIFE

UP, UP & AWAY! An IAF helicopter rescues a worker who was trapped in the floodwaters of the Tawi river in Jammu on Thursday

Rain havoc in Maha, Gujarat

Dead, Over 25000 Evacuated; Army leads Rescue Operations



Heavy rain drowns Kolkata

Durga Puja Preparations Go Awry As Met Predicts Downpour For Next 2 Days



Washed Ashore A fisherman watches tidal waves crash into wall temporarily erected by the local people to protect their houses and cattle at Meerakara near Kochi on Saturday



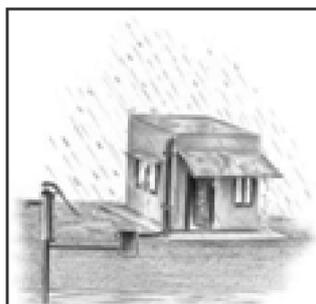
Flood Prone Areas

6. RAINWATER HARVESTING

- Rainwater harvesting is the accumulation and storage of rainwater for reuse before it runs-off. Uses include water for the garden, water for livestock, water for irrigation etc.
- Due to increasing problems resulting from the multi purpose projects, water harvesting system was a viable alternative, both socioeconomically and environmentally.
- In ancient India, along with the sophisticated hydraulic structures, there existed an extraordinary tradition of water-harvesting system.
- People had in-depth knowledge of rainfall regimes and soil types and developed wide ranging techniques to harvest rainwater, groundwater, river water and flood water in keeping with the local ecological conditions and their water needs.

I. Rainwater Harvesting Methods in India

- (A) **Khadins and Johads** : In arid and semi-arid regions, agricultural fields were converted into rain fed storage structures that allowed the water to stand and moisten the soil like the ‘**khadins**’ in Jaisalmer and ‘**Johads**’ in other parts of Rajasthan.

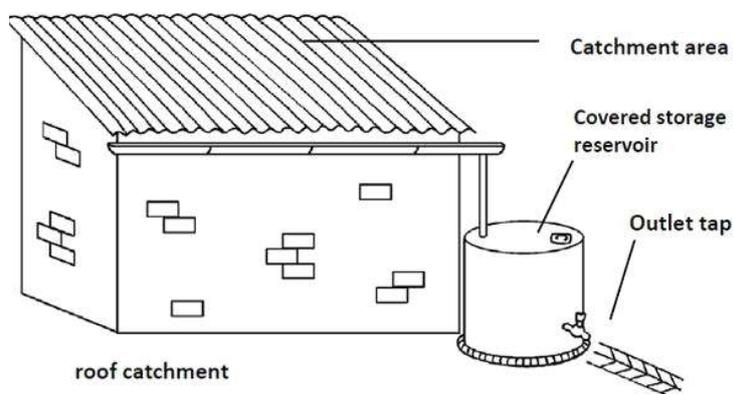


Recharge through Hand Pump



Recharge through Abandoned Dugwell

- (B) **Tankas or Tanks** : In the semi-arid and arid regions of Rajasthan, particularly in **Bikaner**, **Phalodi** and **Barmer**, almost all the houses traditionally had underground tanks or tankas for storing drinking water. The tankas were part of the well-developed rooftop rainwater harvesting system and were built inside the main house or the courtyard. They were connected to the sloping roofs of the houses through a pipe. Rain falling on the rooftops would travel down the pipe and was stored in these underground ‘**tankas**’.



Rooftop harvesting in Thar

- (C) **Rooftop rainwater harvesting** : People living in arid regions of Rajasthan and Gujarat, where rainfall is scanty, have used rooftop rainwater harvesting systems since many years to store drinking water. Process of rooftop rainwater harvesting is given below :

- (a) Roof top rain water is collected using a PVC pipe
- (b) Filtered using sand and bricks
- (c) Underground pipe takes water to sump for immediate usage
- (d) Excess water from the sump is taken to the well
- (e) Water from the well recharges the underground
- (f) Take water from the well (later)

- (D) **Inundation channels :** In the flood plains of Bengal, people developed inundation channels to irrigate their fields.
- (E) **Guls or Kuls :** In hilly and mountain regions, people built diversion channels to collect rainwater, spring water and store circular tanks like the ‘guls’ or ‘kuls’. For example, Western Himalayan i.e. Himachal Pradesh for agriculture.



Traditional method of rainwater harvesting

- (F) **Bamboo Drip Irrigation System:**

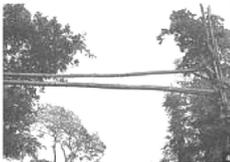
BAMBOO DRIP IRRIGATION SYSTEM

In Meghalaya, a 200-year-old system of tapping stream and spring water by using bamboo pipes, is prevalent. About 18-20 litres of water enters the bamboo pipe system, gets transported over hundreds of metres, and finally reduces to 20-80 drops per minute at the site of the plant.

Picture 1: Bamboo pipes are used to divert perennial springs on the hilltops to the lower reaches by gravity.




Picture 2 and 3: The channel sections, made of bamboo, divert water to the plant site where it is distributed into branches, again made and laid out with different forms of bamboo pipes. The flow of water into the pipes is controlled by manipulating the pipe positions.



Picture 4: If the pipes pass a road, they are taken high above the land.



Picture 5 and 6: Reduced channel sections and diversion units are used at the last stage of water application. The last channel section enables water to be dropped near the roots of the plant.

Bamboo Drip Irrigation System

➤ **Rainwater Harvesting in Shillong**

Rooftop rainwater harvesting is the most common practice in Shillong, Meghalaya. It is interesting because Cherapunjee and Mawsynram situated at a distance of 55 km. from Shillong receive the highest rainfall in the world, yet the state capital Shillong faces acute shortage of water. Nearly every household in the city has a roof top rain water harvesting structure. Nearly 15-25% of the total water requirement of the household comes from roof top water harvesting.

II. Case study of Gendathur :

- In many parts of rural and urban India, rooftop rainwater harvesting is being successfully adapted to store and conserve water.
- In Gendathur, a remote backward village in Mysore, Karnataka, villagers have installed, in their household's rooftop, rainwater harvesting system to meet their water needs.
- Nearly 200 households have installed this system and the village has earned the rare distinction of being rich in rainwater.
- Gendathur receives an annual precipitation of 1,000 mm, and with 80% of collection efficiency and of about 10 fillings, every house can collect and use about 50,000 litres of water annually. From the 20 houses, the net amount of rainwater harvested annually amounts to 1,00,000 litres.

➤ **KNOWLEDGE BASED QUESTIONS ON HYDRAULIC STRUCTURES IN ANCIENT INDIA**

- In the first century B.C., Sringerapur near Allahabad had sophisticated water harvesting system channelling the flood water of the river Ganga.
 - During the time of Chandragupta Maurya, dams, lakes and irrigation systems were extensively built.
 - Evidences of sophisticated irrigation works have also been found in Kalinga, (Orissa), Nagarjunakonda (Andhra Pradesh), Bennur (Karnataka), Kolhapur (Maharashtra), etc.
 - In the 11th Century, Bhopal Lake, one of the largest artificial lakes of its time was built.
 - In the 14th Century, the tank in Hauz Khas, Delhi was constructed by Iltutmish for supplying water to Siri Fort area.
- i. The water body whose water is almost unfit for domestic and industrial purposes
(A) Pond (B) Lake (C) Sea (D) Tank
 - ii. India climatically falls in the category of.
(A) Monsoon country (B) Arid zone (C) Temperate zone (D) Equatorial country
 - iii. The main source of surface water.
(A) Pond (B) Lake (C) River (D) Tank
 - iv. Most of the Himalayan rivers are of this nature.
(A) Perennial (B) Seasonal (C) Occasional (D) None of the above
 - v. Rivers of this region are generally rain fed.
(A) Himalayan (B) Peninsular (C) North East (D) South East
 - vi. Moving Masses of ice found generally in mountains
(A) Ice caps (B) Ice sheet (C) Glaciers (D) Snow cover
 - vii. What is major use of water resources available in India.
(A) Drinking Water (B) Industrial uses (C) Irrigation (D) Power generation
 - viii. In which city of Rajasthan water resources are being used for generating power.
(A) Bikaner (B) Kota (C) Jaipur (D) Udaipur
 - ix. Which state of India is having largest area under irrigation.
(A) Mizoram (B) Assam (C) Punjab (D) Rajasthan
 - x. Which canal has been constructed to provide irrigation to areas of the desert.
(A) Indira Gandhi canal (B) Ganga Canal
(C) Chambal Canal (D) Upper Yamuna Canal

EXERCISE-I

NCERT Solutions



Q.1 Multiple choice questions.

(i) Based on the information given below classify each of the situations as 'suffering from water scarcity' or 'not suffering from water scarcity'.

- (a) A region with high annual rainfall.
- (b) A region having high annual rainfall and large population.
- (c) A region having high annual rainfall but water is highly polluted.
- (d) A region having low rainfall and low population.

Sol. (a) A region with high annual rainfall - Not suffering from water scarcity
 (b) A region having high annual rainfall and large population - Suffering from water scarcity
 (c) A region having high annual rainfall but water is highly polluted - Suffering from water scarcity
 (d) A region having low rainfall and low population- Not suffering from water scarcity

(ii) Which one of the following statements is not an argument in favour of multipurpose river projects?

- (a) Multi-purpose projects bring water to those areas which suffer from water scarcity.
- (b) Multi-purpose projects by regulating water flow help to control floods.
- (c) Multi-purpose projects lead to large scale displacements and loss of livelihood.
- (d) Multi-purpose projects generate electricity for our industries and our homes.

Sol. (c) Multi-purpose projects lead to large scale displacements and loss of livelihood
 (iii) Here are some false statements. Identify the mistakes and rewrite them correctly.

(a) Multiplying urban centres with large and dense populations and urban lifestyles have helped in proper utilisation of water resources.

(b) Regulating and damming of rivers does not affect the river's natural flow and its sediment flow.

(c) In Gujarat, the Sabarmati basin farmers were not agitated when higher priority was given to water supply in urban areas, particularly during droughts.

(d) Today in Rajasthan, the practice of rooftop rainwater water harvesting has gained popularity despite high water availability due to the Indira Gandhi Canal.

Sol. (a) Multiplying urban centres with large and dense populations and urban lifestyles have resulted in improper utilisation of water resources.

(b) Regulating and damming of rivers does affect the river's natural flow and its sediment flow.

(c) In Gujarat, the Sabarmati basin farmers were agitated when higher priority was given to water supply in urban areas, particularly during droughts.

(d) Today in Rajasthan, the practice of rooftop rainwater water harvesting popularity has declined due to high water availability from Indira Gandhi Canal.

Q.2 Answer the following questions in about 30 words.

(i) Explain how water becomes a renewable resource.

Sol. Water can be considered as a renewable resource since there will be rains and surface water and groundwater will get recharged continuously due to the 3 process involved in the hydrological cycle.

The 3 processes of the hydrological cycle are

1. Evaporations
2. Condensation
3. Precipitation

(ii) What is water scarcity and what are its main causes?

Sol. Many of our cities are such examples. Thus, water scarcity may be an outcome of large and growing population and consequent greater demands for water, and unequal access to it. A large population requires more water not only for domestic use but also to produce more food. Hence, to facilitate higher food-grain production, water resources are being over-exploited to expand irrigated areas for dry-season agriculture. Irrigated agriculture is the largest consumer of water. Most farmers have their own wells and tube-wells in their farms for irrigation to increase their productivity. This has adversely affected water availability and food security of the people.

(iii) Compare the advantages and disadvantages of multi-purpose river projects.

Sol. Advantages:

1. Irrigation
2. Electricity generation
3. Flood control
4. Water supply for industrial and domestic purposes
5. Tourist attraction
6. Inland navigation

• **Disadvantages:**

1. The natural flow of water is affected
2. Aquatic life gets affected
3. Submergence of land in the surrounding areas
4. Ecological consequences
5. Large scale displacement of local people

Q.3 Answer the following questions in about 120 words.

(i) Discuss how rainwater harvesting in semi-arid regions of Rajasthan is carried out.

Sol. In the semi-arid and arid regions of Rajasthan, particularly in Bikaner, Phalodi and Barmer, almost all the houses traditionally had underground tanks or tankas for storing drinking water. The tanks could be as large as a big room; one household in Phalodi had a tank that was 6.1 metres deep, 4.27 metres long and 2.44 metres wide.

The tankas were part of the well-developed rooftop rainwater harvesting system and were built inside the main house or the courtyard. They were connected to the sloping roofs of the houses through a pipe. Rain falling on the rooftops would travel down the pipe and be stored in these underground 'tankas'. The first spell of rain was usually not collected as this would clean the roofs and the pipes. The rainwater from the subsequent showers was then collected. The rainwater can be stored in the tankas till the next rainfall, making it an extremely reliable source of drinking water when all other sources are dried up, particularly in the summers. Rainwater, or 'palar pani', as commonly referred to in these parts, is considered the purest form of natural water.

(ii) Describe how modern adaptations of traditional rainwater harvesting methods are being carried out to conserve and store water.

Sol. Water harvesting system is a viable alternative, both socio-economically and environmentally. In ancient India, along with the sophisticated hydraulic structures, there existed an extraordinary tradition of water-harvesting system. People had in-depth knowledge of rainfall regimes and soil types and developed wide-ranging techniques to harvest rainwater, groundwater, river water and floodwater in keeping with the local ecological conditions and their water needs. In hill and mountainous regions, people built diversion channels like the 'guls' or 'kuls' of

the Western Himalayas for agriculture. 'Rooftop rainwater harvesting' was commonly practised to store drinking water, particularly in Rajasthan. In the flood plains of Bengal, people developed inundation channels to irrigate their fields. In arid and semi-arid regions, agricultural fields were converted into rain-fed storage structures that allowed the water to stand and moisten the soil like the 'khadins' in Jaisalmer and 'Johads' in other parts of Rajasthan. In Gendathur, a remote backward village in Mysuru, Karnataka, villagers have installed, in their household's rooftop, rainwater harvesting system to meet their water needs. Nearly 200 households have installed this system and the village has earned the rare

distinction of being rich in rainwater. Rooftop rainwater harvesting is the most common practice in Shillong, Meghalaya. It is interesting because Cherapunjee and Mawsynram situated at a distance of 55 km. from Shillong receive the highest rainfall in the world. Yet, the state capital Shillong faces an acute shortage of water. Nearly every household in the city has a rooftop rainwater harvesting structure. Nearly 15-25 per cent of the total water requirement of the household comes from rooftop water harvesting. Tamil Nadu is the first state in India which has made rooftop rainwater harvesting structure compulsory for all the houses across the state.

EXERCISE-II

Knowledge Vault



MCQ BASED QUESTIONS:

- Q.1** The minimum demand for water is for
(A) Industries (B) Animal husbandry
(C) Household Needs (D) Irrigation
- Q.2** Canal irrigation is most common in
(A) Northern Plains
(B) Peninsular regions
(C) Eastern coastal plains
(D) Western coastal plains
- Q.3** Rajasthan is the beneficiary of
(A) Narmada Valley project
(B) Hirakud project
(C) Nagarjunsagar project
(D) Tehri project
- Q.4** Who claimed multipurpose river valley projects 'new temples of modern India'.
(A) Mahatma Gandhi
(B) Sardar Patel
(C) Jawaharlal Nehru
(D) Indira Gandhi
- Q.5** Sunderlal Bahuguna is associated with
(A) Narmada Bachao Andolan
(B) Tehri Dam Andolan
(C) Caveri Water dispute
(D) Linking of Rivers
- Q.6** The first multi-purpose project of India was
(A) Sivasamudram (B) Damodar Valley
(C) Hirakud (D) Rajasthan Canal
- Q.7** Hirakud dam is located in which one of the following states?
(A) Andhra Pradesh (B) West Bengal
(C) Orissa (D) Tamil Nadu
- Q.8** What percentage of the global precipitation is received in India?
(A) 2 percent (B) 5 percent
(C) 4 percent (D) 10 percent
- Q.9** The total renewable water resources of India is estimated to be
(A) 1900 sq.km/annum
(B) 2895 sq.km/annum
(C) 2000 sq.km/annum
(D) 1897 sq.km/annum
- Q.10** Water scarcity is a serious problem in recent years mainly in
(A) Cities
(B) Rural areas
(C) Deserts
(D) Mountains
- Q.11** Which of the following states has made roof top harvesting compulsory?
(A) Karnataka (B) Kerala
(C) Tamil Nadu (D) Maharashtra
- Q.12** Which of the following Indian rivers are the most polluted?
(A) Ganga and Yamuna
(B) Ganga and Indus
(C) Godavari and Krishna
(D) Kosi and Damodar
- Q.13** Which one of the following statements is incorrect as regards to opposition against multipurpose projects.
(A) Regulating and damming of rivers affected the natural flow
(B) It has caused interstate river water disputes
(C) It has increased the social gap between the rich land owners and the landless poor
(D) They are successful in meeting many objectives.
- Q.14** On which of the following rivers is the Salal Project located?
(A) Luni (B) Satluj
(C) Jhelum (D) Chenab

FILL IN THE BLANKS :

- Q.15** The primary source of water on the earth is _____ that comes in the form of rain and snowfall.
- Q.16** _____ are the main source of surface water.
- Q.17** India receives 75% to 90% of its rainfall from the _____ monsoon.
- Q.18** Nearly 70% of the _____ occurs as icesheets and glaciers in Antarctica, Greenland and the Mountain regions of the world.
- Q.19** On the basis of _____ rivers are divided into himalayan and peninsular rivers.
- Q.20** Areawise before 1951 only _____ million hectares of land was under irrigation.
- Q.21** 1 metre of water standing on a hectare of levelled land is called _____ .
- Q.22** The state with heighest area under irrigation is _____ .
- Q.23** _____ is known as river of sorrow.
- Q.24** A 200 year old system of tapping stream and spring water prevalent in Meghalaya is known as _____
- Q.25** _____ project in Orissa in an example of multi-purpose project.
- Q.26** In flood plains of West Bengal people developed _____ to irrigate their fields.
- Q.27** Narmada Bachao Andolan is a movement created against _____.

MATCH THE COLUMN:

[A] [ONE TO ONE] :

Column-I and **column-II** contains **four** entries each. Entries of **column-I** are to be matched with some entries of **column-II**. Only One entries of **column-I** may have the matching with the same entries of **column-II** and one entry of **column-II** Only one matching with entries of **column-I**

Q.28 Column I

- (a) Heavy Rainfall
 (b) Moderate Rainfall
 (c) Low Rainfall
 (d) Scanty Rainfall

Column II

- (p) Runn of Kutch
 (q) Ganga Delta
 (e) Eastern Rajasthan
 (s) Bihar
 (A) (a)-(r), (b)-(s), (c)-(p), (d)-(q)
 (B) (a)-(q), (b)-(s), (c)-(r), (d)-(p)
 (C) (a)-(s), (b)-(p), (c)-(q), (d)-(r)
 (D) (a)-(r), (b)-(p), (c)-(s), (d)-(q)

Q.29 Column I

- (a) Nagarjun sagar project
 (b) Bhakra Nangal project
 (c) Gandhi Sagar project
 (d) Sardar Sarovar project

Column II

- (p) River Satluj
 (q) Narmada
 (r) River Krishna
 (s) River Chambal
 (A) (q)-(r), (b)-(s), (c)-(p), (d)-(a)
 (B) (a)-(q), (b)-(s), (c)-(r), (d)-(p)
 (C) (a)-(s), (b)-(p), (c)-(q), (d)-(r)
 (D) (a)-(r), (b)-(p), (c)-(s), (d)-(q)

EXERCISE - III**Subjective Stuff****VERY SHORT TYPE QUESTIONS:**

- Q.1** How is freshwater obtained ?
- Q.2** What is meant by hydrological cycle ?
- Q.3** What purpose does the Bhakra Nangal project water serve?
- Q.4** Why did Jawaharlal Nehru call multi-purpose projects the 'temples of modern India' ?
- Q.5** Name two social movements which have been launched against the multi-purpose projects.
- Q.6** Mention two techniques of rooftop rainwater harvesting.
- Q.7** Who are benefited from the multi-purpose projects?
- Q.8** What is the traditional system of rainwater harvesting used in Rajasthan ?
- Q.9** Which is the first state to make it mandatory for all house holders to harvest rooftop rainwater?
- Q.10** What are 'Guls' or 'Kuls' ?

SHORT TYPE QUESTIONS:

- Q.11** On what different bases are dams classified?
- Q.12** What are the major causes of deterioration of water quality or water pollution in India?
- Q.13** What can be the effects of over-exploitation and excessive use of water resources?
- Q.14** What is the need of rainwater harvesting?
- Q.15** Why are dams now referred to as multi-purpose projects?
- Q.16** Why did Jawaharlal Nehru proclaim the dams as the 'temples of modern India'?
- Q.17** Write a short note Narmada Bachao Andolan or Save Narmada Movement.
- Q.18** Mention some major causes of water scarcity.

- Q.19** Why is the construction of multi-purpose projects and large dams opposed by many people?
- Q.20** 'Three-fourths of the earth's surface is covered with water but there is still scarcity of water across the globe.' Explain giving three reasons.
- Q.21** Mention a negative effect of irrigation. How can irrigation transform the social landscape?
- Q.22** Describe any three hydraulic structures of ancient India.

LONG TYPE QUESTIONS:

- Q.23** Write the features of the 'tankas' built in the houses of Bikaner, Phalodi and Barmer. **(CBSE 2022)**
- Q.24** What is the need for conservation of water resources? Suggest three measures to conserve water resources. **(CBSE 2018)**
- Q.25** Is it possible that an area or region may have ample water resources but is still facing water scarcity? Explain with the help of three relevant examples. **(CBSE 2014)**
- Q.26** Analyse three major causes of water scarcity in India. **(CBSE 2016)**
- OR
- Explain any four reasons responsible for water scarcity in India. **(CBSE 2010)**
- Q.27** 'Water is a very important and critical resources in India.' Support the statement by explaining any three points. **(CBSE 2007, 2013)**
- Q.28** Describe any three hydraulic structures of ancient India. **(CBSE 2012)**
- Q.30** Examine the ill effects of industrialization and urbanization on water resources. **(CBSE 2014)**

EXERCISE-IV

Competitive Edge



- Q.1** The dominant type of irrigation in Peninsular India is by :-
[Punjab_NTSE_Stage-1_2013]
 (A) Canals (B) Tanks
 (C) Wells (D) Sprinklers
- Q.2** Column - A is the list of Hydro Electric Power Projects and Column - B is the list of states where located.
Column - A **Column - B**
 A. Sileru i. Gujarat
 B. Dhuvaran ii. Karnataka
 C. Shabarigiri iii. Andhra Pradesh
 D. Chakra iv. Kerala
 Which one of the following correctly matched set ? **[Karnataka_NTSE_Stage-1_2013]**
 (A) A-ii, B-iii, C-i, D-iv
 (B) A-iii, B-i, C-iv, D-ii
 (C) A-iv, B-i, C-ii, D-iii
 (D) A-i, -ii C-iii, D-iv
- Q.3** "Renigaon" is famous for
[M.P. NTSE Stage-1-2013-14]
 (A) Water Conservation
 (B) Organic Agriculture
 (C) Environment Conservation
 (D) Chipko Movement
- Q.4** When the word "Acid Rain" was first used -
[M.P. NTSE Stage-1_2013-14]
 (A) 1953 year (B) 1983 year
 (C) 1973 year (D) 1873 year
- Q.5** The rocks, through which the water seeps very fast, are called as :-
[Punjab NTSE Stage-1 2013]
 (A) Mushroom Rocks
 (B) Hard Rocks
 (C) Igneous Rocks
 (D) Permeable Rocks
- Q.6** Hirakud Dam is situated on the river
[Rajasthan_NTSE Stage-1- 2014-15]
 (A) Godavari (B) Tapi
 (C) Mahanadi (D) Yamuna
- Q.7** One which river is the Hirakud dam constructed
(Uttar Pradesh/NTSE Stage I/2014)
 (A) Narmada (B) Godavari
 (C) Mahanadi (D) Kaveri
- Q.8** Damodar is tributary of river -
(Uttar Pradesh/NTSE Stage I/2014)
 (A) Ganga (B) Hugli
 (C) Suvamrekha (D) Yamuna
- Q.9** Water availability per person in India is :
(Chhattisgarh/NTSE Stage I/2014)
 (A) Decreasing (B) Increasing
 (C) Stagnant (D) None of the above
- Q.10** Which state of India has made roof top rain water harvesting compulsory to all houses :
(Delhi/NTSE Stage I/2014)
 (A) Andhra Pradesh (B) Tamil Nadu
 (C) Kerala (D) Karnataka
- Q.11** Which of the following factor is responsible for gully crosion of soil ?
(Chandigragh/NTSE Stage I/2014)
 (A) Wind (B) Rainfall
 (C) Snowfall (D) Wheat

Q.12 From which river 'Indira Canal' started for irrigation of desert area of north Rajasthan ?

(Gujarat/NTSE Stage I/2016)

- (A) Ravi river (B) Chinab river
(C) Biyas river (D) Satluj river

Q.13 With reference to water availability per person per year India's rank in the world is

[Rajasthan_NTSE Stage-1_2018]

- (A) 131st (B) 133rd
(C) 137th (D) 157th

Q.14 Roof water harvesting system is a compulsory structure in which state ?

[Rajasthan_NTSE Stage-1_2020]

- (A) Bihar (B) Meghalaya
(C) Tamil Nadu (D) Karnataka

Q.15 On which river is Sardar Sarovar Dam built?

[Delhi_NTSE Stage-1_2018]

- (A) Tapi (B) Narmada
(C) Krishna (D) Kaveri

EXERCISE-V**Board Navigator**

- Q.1** Write the features of the 'tankas' built in the houses of Bikaner, Phalodi and Barmer. **(CBSE 2022)**
- Q.2** What is the need for conservation of water resources? Suggest three measures to conserve water resources. **(CBSE 2018)**
- Q.3** Is it possible that an area or region may have ample water resources but is still facing water scarcity? Explain with the help of three relevant examples. **(CBSE 2014)**
- Q.4** Analyse three major causes of water scarcity in India. **(CBSE 2016)**
- OR
- Explain any four reasons responsible for water scarcity in India. **(CBSE 2010)**
- Q.5** 'Water is a very important and critical resources in India.' Support the statement by explaining any three points. **(CBSE 2007, 2013)**
- Q.6** Describe any three hydraulic structures of ancient India. **(CBSE 2012)**
- Q.7** Examine the ill effects of industrialization and urbanization on water resources. **(CBSE 2014)**

ANSWER KEY

KNOWLEDGE BASE QUESTIONS :

Q.1 C **Q.2** A **Q.3** C **Q.4** A **Q.5** B **Q.6** C **Q.7** C
Q.8 B **Q.9** C **Q.10** A

EXERCISE-II

MULTIPLE CHOICE QUESTIONS :

Q.1 D **Q.2** A **Q.3** A **Q.4** C **Q.5** B **Q.6** B **Q.7** C
Q.8 C **Q.9** D **Q.10** A **Q.11** C **Q.12** A **Q.13** D **Q.14** B

FILL IN THE BLANKS :

Q.15 Precipitation **Q.16** Rivers **Q.17** Advancing southwest
Q.18 Freshwater **Q.19** hydrology **Q.20** 22
Q.21 hectare metre **Q.22** Punjab **Q.23** Damodar
Q.24 Bamboo drip irrigation **Q.25** Kerala **Q.26** Inundation channels
Q.27 Sardar Sarovar Dam

MATCH THE COLUMN :

Q.28 B **Q.29** D

EXERCISE-IV

Q.1 B **Q.2** C **Q.3** B **Q.4** C **Q.5** A **Q.6** A **Q.7** A
Q.8 B **Q.9** C **Q.10** D **Q.11** D **Q.12** D **Q.13** B **Q.14** A
Q.15 B

21. Sitting Arrangement

➤ **Different Types of Sitting Arrangement**

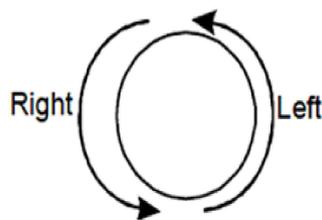
There are two types of questions which are asked in various competitions

Type 1: Arrangement around a Closed Path

In such questions, we are giving some clues regarding arrangement. We have apply these clues on a circle and using these information, we have to find the solutions of questions associated with them. In this arrangement, we also deal square/pentagon/ hexagon, questions. Before solving type 1 questions, following facts are necessary to know.

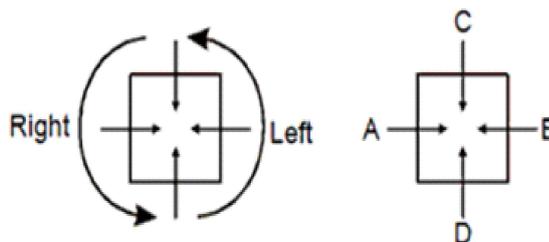
➤ **For Circular Arrangement**

In this arrangement some persons are sitting around a circle and they facing the centre.



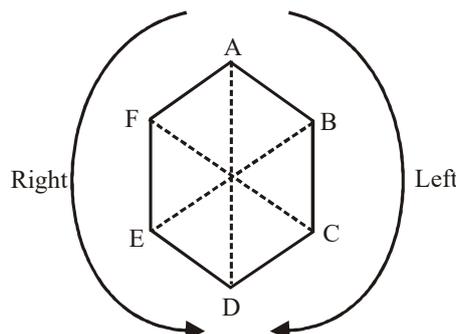
1. Left movement is also called clockwise rotation.
2. Right movement is also called anticlockwise rotation.

➤ **For Rectangular Arrangement**



- A ↔ B (Front with each other)
 C ↔ D (Front with each other)

➤ **For Hexagonal Arrangement**



$A \leftrightarrow D$ (Front with each other)

$B \leftrightarrow E$ (Front with each other)

$C \leftrightarrow F$ (Front with each other)

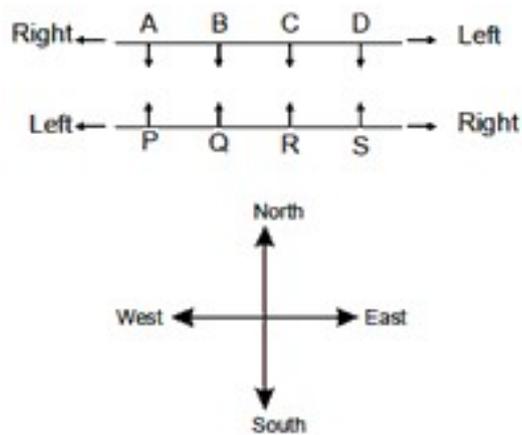
Six persons M, N, O, P, Q and R are playing cards sitting in a circle facing the centre. R is sitting between M and N and Q is sitting between O and P. P is sitting immediate right of M.

Type 2: Arrangement in a Line or Others

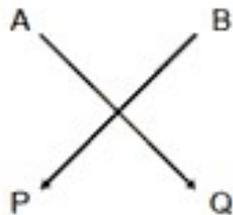
Sometime, we deal with questions where arrangement is required to be done in a line or others.

Before solving type 2 questions, following facts are necessary to know.

When A, B, C, D facing South direction and P, Q, R, S facing North direction in a line, then their position of Right and Left will be



When A, B in one line and P, Q in other line. then their diagonally opposite direction will be



A is diagonally opposite to Q. B is diagonally opposite to P.

EXERCISE-I**Analytical Questions**

Direction : (Q.1 to 5) : Seven persons, Anil, Bharat, Chand, Dinesh, Eshwar, Fazal, Ganesh, who have gathered at a picnic spot, are sitting in a row facing a photographer.

- (1) Chand and Dinesh are sitting next to each other.
- (2) There are exactly four persons between Bharat and Ganesh.
- (3) Dinesh is sitting to the immediate right of Bharat.

Q.1 If Anil and Eshwar are separated exactly by two persons, then who is sitting to the left of Ganesh?

- (1) Anil
- (2) Eshwar
- (3) Fazal
- (4) Chand

Q.2 If Bharat is sitting at one end, then who is sitting at the other end of the row?

- (1) Anil
- (2) Eshwar
- (3) Ganesh
- (4) Cannot be determined

Q.3 If Bharat is not sitting at either end of the row, then who among the following has as many persons on his left as on his right?

- (1) Chand
- (2) Fazal
- (3) Eshwar
- (4) Ganesh

Q.4 If Eshwar is sitting to the right of Bharat and Anil is separated from Eshwar by exactly three persons, then who is sitting to the immediate left of Ganesh?

- (1) Fazal
- (2) Anil
- (3) Eshwar
- (4) Chand

Q.5 In how many different ways can the seven persons sit in a row, without violating the given conditions?

- (1) 3
- (2) 10
- (3) 2
- (4) 12

Direction (Q.6 to 10) : Seven girls, Ramya, Simran, Vinutha, Mandakini, Urmila, Preethi, and Kinnera, are sitting in a row. Simran is sitting to the immediate left of Vinutha and third to the right of Ramya, whereas Mandakini, who is sitting at the extreme left, is sitting next to Kinnera.

Q.6 Who is sitting to the immediate left of Ramya?

- (1) Mandakini
- (2) Urmila
- (3) Kinnera
- (4) Preethi

Q.7 If Vinutha and Kinnera mutually exchange their places without any change in the arrangement of other positions, who will be sitting to the immediate left of Ramya?

- (1) Kinnera
- (2) Preethi
- (3) Urmila
- (4) Vinutha

Q.8 If only Simran is sitting between Preethi and Vinutha, who is sitting exactly at the centre?

- (1) Preethi
- (2) Urmila
- (3) Vinutha
- (4) Ramya

Q.9 If Ramya exchanges her place with Mandakini and Vinutha exchanges her place with Urmila, then how many girls will be there between Urmila and Ramya?

- (1) Two
- (2) Three
- (3) Four
- (4) Five

Q.10 In addition to the above statements, which of the following statements cannot specify the seating position of every girl?

- (1) Ramya and Simran have two girls sitting between them.
- (2) Vinutha and Urmila have two girls between them.
- (3) Mandakini and Preethi have two girls between them.
- (4) There are two girls sitting between Preethi and Kinnera.

Direction (Q11 to 15) : Six persons, A, B, C, D, E, and F are sitting in two rows, three in each, facing each other.

- (1) E is not at the end of any row.
- (2) D is second to the left of F.
- (3) C, the neighbour of E, is sitting diagonally opposite to D.
- (4) B is the neighbour of F.

Q.11 Who is facing B?

- (1) C
- (2) A
- (3) D
- (4) E

Q.12 Who among the following are in one of the two rows?

- (1) C, E, B (2) D, B, F
(3) A, B, F (4) A, E, F

Q.13 Who among the following are sitting diagonally opposite to each other?

- (1) A and C (2) F and C
(3) A and F (4) A and B

Q.14 Who among the following are sitting in the same row?

- (1) A and B (2) C and F
(3) C and B (4) A and E

Q.15 If D and E exchange their seats who will be the neighbours of D in the new seating arrangement?

- (1) Only C (2) Only B
(3) A and C (4) Only A

Direction : (Q16 to 19) : A, B, C, D and E, sit around a circular table and play 'Rummy'. A is sitting one seat away to the left of C, and B is sitting one seat away to the right of C.

Q.16 If D sits between B and C, who sits to the immediate right of A?

- (1) E (2) D
(3) B (4) C

Q.17 Which of the following cannot be the correct seating arrangement of these persons either in clockwise or anticlockwise direction?

- (1) ABCDE (2) A DC E B
(3) ABDCE (4) A ECDB

Q.18 If D is not sitting next to B, who is sitting between Band D ?

- (1) C (2) A
(3) E
(4) Cannot be determined

Q.19 If another person F joins the game, but does not sit next to C, whereas the others sit in their earlier positions, then which of the following statements is correct ?

- (1) F sits to the immediate right of D.
(2) F sits to the immediate left of A.
(3) F sits to the immediate left of E.
(4) Either (1) or (2).

Directions : (Q.20 & 21) Are based on the information given below :

A group of seven singers, facing the audience, are standing in a line on the stage as follows :

- (i) D is to the immediate right of C.
(ii) F is to the immediate neighbours of G.
(iii) B is to the immediate left of F.
(iv) E is to the immediate left of A.
(v) C and B have one singer between them.
(vi) A and D have one singer between them.

Q.20 Which of the following pairs of singer are sitting at the extreme ends ?

- (1) D,G (2) F,A
(3) E,G (4) E,F

Q.21 Immediately between which of the following pairs of singer is D sitting ?

- (1) A,B (2) F,A
(3) B,C (4) E,F

EXERCISE-II

Competitive Edge



Directions : (Q.1 to 3) Six Persons P, Q, R, S, T and U are sitting in a circle facing one another front to front. P is sitting in front of Q, Q is sitting to the immediate right of T and immediate left of R, P is to the left of U and right of S.

Q.1 Who is sitting opposite to R ?

- (1) P (2) Q
(3) S (4) U

Q.2 Who is sitting opposite to S ?

- (1) U (2) T
(3) R (4) Q

Q.3 Who is sitting between P and R ?

- (1) S (2) T
(3) U (4) Q

Directions : (Q.4 to 8) Read the following information carefully and answer the questions given below it.

- (I) Eight persons E, F, G, H, I, J, K and L are seated around a square table- two on each side.
(II) There are three lady members and they are not seated next to each other.
(III) J is to the immediate neighbours of L and F.
(IV) G is between I and F.
(V) H, a lady member, is second to the left of J
(VI) L, a male member, is seated opposite of E, a lady member,
(VII) There is a lady member between F and I.

Q.4 Who among the following is to the immediate neighbours of E and H ?

- (1) F (2) I
(3) J (4) None of these

Q.5 How many persons are seated between K and F ?

- (1) One (2) Two
(3) Three
(4) Cannot be determined

Q.6 Who among the following are the three lady members ?

- (1) E, G and J (2) E, H and G
(3) G, H and J
(4) Cannot be determined

Q.7 Who among the following is to the immediate left of F?

- (1) G (2) I (3) J
(4) Cannot be determined

Q.8 Which of the following is true about J ?

- (1) J is a male member
(2) J is a female member
(3) Sex of J cannot be determined
(4) Position of J cannot be determined

Directions : (Q.9 to 13) Read the following information carefully and answer the questions :

- (i) Six flats on a floor in two rows, facing east and west are allotted to Q, R, S, T, U and V.
(ii) R gets east side facing and not next to T.
(iii) T and V get diagonally opposite flats.
(iv) S next to V gets a west facing flat.
(v) U gets a east facing flat.

(NTSE Stage-II, 2008/2009)

Q.9 Which of the following combination gets west facing flats ?

- (1) SQR (2) RTS
(3) STU (4) QSV

Q.10 Whose flat is between R and T ?

- (1) Q (2) S
(3) U (4) V

Q.11 If the flats of U and Q are interchanged then whose flat will be opposite to the flat of U ?

- (1) V (2) Q
(3) T (4) S

Q.12 The flats of which pair other than T and V are diagonally opposite to each other ?

- (1) TQ (2) US
(3) TU (4) RQ

Q.13 Whose flat is between Q and V ?

- (1) R (2) T
(3) U (4) S

Q.14 Six friends L, M, N, O, P and Q are seated in a circle facing the centre. Q is between L and O. N is between P and M. P is not between O and N. O is second to the left of N.

Who is between L and N ?

(NTSE Stage-II, 2009)

- (1) M (2) P
(3) O (4) N

Q.15 Six students are sitting in a row. A is sitting between B and C. B is sitting next to E. E is sitting next to O who is sitting on the extreme left and D is sitting next to C. Who two are sitting adjacent to B ?

(NTSE Stage-2_ 2009)

- (1) EA (2) BA
(3) AD (4) ED

Directions : (Q.16 to 18) Study the information carefully and then choose the correct alternative to answer the questions.

Five friends A, B, C, D and E are sitting on a bench.

- (1) A is sitting next to B.
(2) C is sitting next to D.
(3) D is not sitting with E.
(4) E is on the left end of the bench.
(5) C is on second position from the right.
(6) A is on the right side of B and to the right side of E.
(7) A and C are sitting together.

(NTSE Stage-II, 2010)

Q.16 Where is A sitting ?

- (1) Between B and D
(2) Between D and C
(3) Between C and E
(4) Between B and C

Q.17 C is sitting between

- (1) B and D (2) A and E
(3) D and E (4) A and D

Q.18 What is the position of D ?

- (1) Extreme left (2) Extreme right
(3) Third from left (4) Second from left

Directions : (Q.19 & 20) Read the following information carefully and answer the questions based on it by selecting the correct option from the given alternatives.

- (i) S, T, U, V, W, X and Y are sitting along a wall facing North direction
(ii) U is on the immediate right of V
(iii) T is at an extreme end and has W as his neighbour.
(iv) Y is between W and X.
(v) V is sitting third from the other end.

(NTSE Stage-II, 2011)

Q.19 Who is sitting on the left of X ?

- (1) T (2) Y
(3) W (4) U

Q.20 Where is S sitting ?

- (1) Extreme East
(2) Extreme West
(3) In the middle
(4) Second from the East end

Q.21 Six persons P, Q, R, S, T and U are sitting in two rows, three in each as per following information. T is not at the end of any row. S is second of the left of U. R the neighbour of T is sitting diagonally opposite to S. Q is the neighbour of U

Which of the following are sitting diagonally opposite to each other.

(NTSE Stage-II, 2011)

- (1) P and R (2) S and P
(3) P and U (4) None of these

Q.22 X, Y, Z and P are sitting around a circular table and discussing their trades .

- (i) X, sits opposite to cook
(ii) Y, sits right to the barber
(iii) The washerman is on the left of the tailor
(iv) P, sits opposite Z

What are the trades of X and Y ?

(NTSE Stage-I/ Raj./ 2013)

- (1) Tailor and Barber
(2) Barber and Cook
(3) Tailor and Cook
(4) Tailor and washerman

Q.23 Six persons A, B, C, D, E and F are standing in a circle. B is between F and C, A is between E and D, F is to the left of D. Who is between A and F ?

(NTSE Stage-I/ Raj./ 2013)

- (1) B (2) C
(3) D (4) E

Q.24 Six students are sitting in a row. K is sitting between V and R. V is sitting next to M. M is sitting next to B who is sitting on the extreme left and Q is sitting next to R.

Who are sitting adjacent to V ?

(NTSE Stage-I/ Raj./ 2013)

- (1) R and Q (2) B and M
(3) K and R (4) M and K

Directions (Q.25 to 29) : These questions are based on the following information:

$\alpha, \beta, \gamma, \delta, \epsilon, \phi, \psi, \eta$ are sitting on a merry-go-round facing at the centre. δ is second to the left on η who is third to the left of α . β is fourth to the right of γ who is immediate neighbour of η . ψ is not a neighbour of β or γ . ϕ is not a neighbour of β .

(NTSE Stage-II, 2011)

- Q.25** Who is third to the left of β .
 (1) α (2) γ
 (3) ϕ (4) ψ
- Q.26** In which of the following pairs is the first person sitting to the immediate right of the second person?
 (1) δ, ψ (2) β, ϵ
 (3) η, β (4) ψ, η
- Q.27** What is ϕ 's position with respect to ψ ?
 (1) Third towards right
 (2) Third towards left
 (3) Second towards right
 (4) Second towards left
- Q.28** Who is sitting between α and β ?
 (1) Both ϵ and η (2) Both ϕ and γ
 (3) Only ϵ (4) Only ϕ
- Q.29** How many of them are sitting between γ and β ?
 (1) 0 or 6 (2) 1 or 5
 (3) 2 or 4 (4) 3
- Q.30** A, B, C, D and E are sitting on a bench. A is sitting next to B, C is sitting next to D, D is not sitting next to E, who is sitting on the left end of the bench. C is on the second position from the right. A is to the right of B and E. Counting from the left in which position is A sitting?
 (1) 2 (2) 3
 (3) 5
 (4) Cannot be determined from the given conditions.

Directions (31-35): Answer the questions based on the information given below. Eight persons- S, T, U, V, W, X, Y, and Z are standing on the circular table facing the center. All the information is not necessarily in the same order.

S stands second to the left of X. W stands adjacent to neither S nor X. Y stands to the immediate right of W. Z stands second to the left of V. V and W are not immediate neighbors.

The number of persons stands between X and V is the same as the number of persons stands between V and T. U stands adjacent to neither W nor Z. [Punjab/NTSE/ 2019-20]

- Q.31** What is the position of S with respect to V?
 (1) Immediate left
 (2) Immediate right
 (3) Third to the left
 (4) Third to the right
 (5) Second to the left
- Q.32** Who among the following person stands between T and S when counted to the right of S?
I. The one who stands immediate left of X
II. The one who stands opposite to Z
III. The one who stands second to the right of U
IV. W
 (1) Only II and IV
 (2) Only I and III
 (3) Only III and IV
 (4) Only I and II
 (5) None of these
- Q.33** Four of the five among the following are similar in such a way to form a group, who among the following doesn't belong to the group?
 (1) UV (2) WZ
 (3) TS (4) YX
 (5) WV
- Q.34** If all the persons are arranged in alphabetical order from S in an anti-clockwise then how many persons remain unchanged in their position (excluding S)?
 (1) Three (2) Two
 (3) Four (4) One
 (5) No one
- Q.35** Who among the following person stands third to the left of Y?
 (1) Z
 (2) The one who stands immediate left of W
 (3) The one who stands immediate right of X
 (4) S

Directions (36-40): Study the following information carefully and answer the below questions. Ten people- I, J, K, L, M, N, O, P, Q and R are sitting around the circular table and facing towards the table but not necessarily in the same order. I faces the one who sits third to the right of Q. J sits fourth to the left of K. Neither I nor Q sits adjacent to both J and K. Only two persons sit between J and R who sits second to the left of N. As many persons sit between N and J is the same as between I and P. The one who sits second from P is sits second to the right of L. M sits third to the right of O.

[Rajasthan/NTSE/ 2020-21]

Q.36 _____ sits fourth to the right of M.

- (1) L (2) K
(3) Q (4) I
(5) None of these

Q.37 Who sits third to the left of the person who faces O?

- (1) Person sits second to the right of Q
(2) Person sits third to the left of L
(3) Person sits fourth to the right of P
(4) Person sits second to the left of R
(5) None of these

Q.38 Which of the following statement is/are true?

- I. N faces the one who sits just left of P
II. Q sits exactly between K and M
III. Only three persons sit between R and Q
(1) Only I (2) Only III
(3) Both I and II
(4) All I, II and III
(5) None of these

Q.39 Four of the following five are alike in a certain way and hence from the group. Which is the one that does not belong to the group?

- (1) LJ (2) MN
(3) IO (4) PK
(5) RO

Q.40 In which of the following statement the third person faces the one who sits exactly between the first and the second person in the following arrangement?

- I. RLJ II. MIK
III. RQP
(1) Only I (2) Only II
(3) Only I and II (4) All I, II and III
(5) None of these

Directions (41-45): Study the following information carefully and answer the below questions Six persons- I, J, K, L, M, and N are sitting on the circular table facing the center. They are using different types of bags- Birkin, Kelly, Clutch, Saddle, Duffel, and Hobo but not necessarily in the same order. L sits second to the left of the one who uses Hobo bags. The one who uses Hobo bags and the one who uses Clutch bags are immediate neighbors. J sits opposite to the one who sits immediate right of I. J neither uses Hobo nor Clutch. The one who uses Birkin sits second to the left of I. The one who uses Saddle sits immediate left of the one who uses Duffel. L neither uses Duffel nor Kelly. Either J or M uses Kelly. N does not use Clutch.

[Rajasthan/NTSE/ 2020][SSO/2022]

Q.41 Who among of the following person sits immediate right of I?

- (1) The one who uses Birkin
(2) The one who sits second right of K
(3) The one who sits immediate left of L
(4) The one who uses Hobo E. K

Q.42 Which of the following bag does K use?

- (1) Clutch (2) Hobo
(3) Duffel (4) Kelly
(5) Saddle

Q.43 Which of the following combination is true?

- (1) N- Clutch (2) K- Kelly
(3) J- Birkin (4) M- Saddle
(5) I- Hobo

Q.44 Which of the following statement is true?

- (I) M sits second to the left of the one who uses Saddle
(II) K sits immediate right of I
(III) I uses Duffel
(1) Only II
(2) Only I and III
(3) Only III
(4) All I, II, and III
(5) None of these

Q.45 Who among the following person uses Hobo bag?

- (1) The one who sits immediate left of L
(2) The one who sits second to the right of M
(3) K
(4) The one who sits third to the right of I
(5) N

ANSWER KEY

EXERCISE-I

Q.1	3	Q.2	4	Q.3	1	Q.4	1	Q.5	4	Q.6	3	Q.7	4
Q.8	2	Q.9	4	Q.10	1	Q.11	4	Q.12	2	Q.13	3	Q.14	D
Q.15	C	Q.16	1	Q.17	1	Q.18	2	Q.19	2	Q.20	3	Q.21	3

EXERCISE-II

Q.1	4	Q.2	2	Q.3	1	Q.4	4	Q.5	3	Q.6	2	Q.7	3
Q.8	1	Q.9	4	Q.10	3	Q.11	3	Q.12	4	Q.13	4	Q.14	2
Q.15	1	Q.16	4	Q.17	4	Q.18	2	Q.19	2	Q.20	1	Q.21	3
Q.22	3	Q.23	3	Q.24	4	Q.25	3	Q.26	2	Q.27	1	Q.28	3
Q.29	4	Q.30	2	Q.31	3	Q.32	2	Q.33	5	Q.34	2	Q.35	3
Q.36	4	Q.37	4	Q.38	3	Q.39	5	Q.40	3	Q.41	4	Q.42	1
Q.43	3	Q.44	2	Q.45	5								