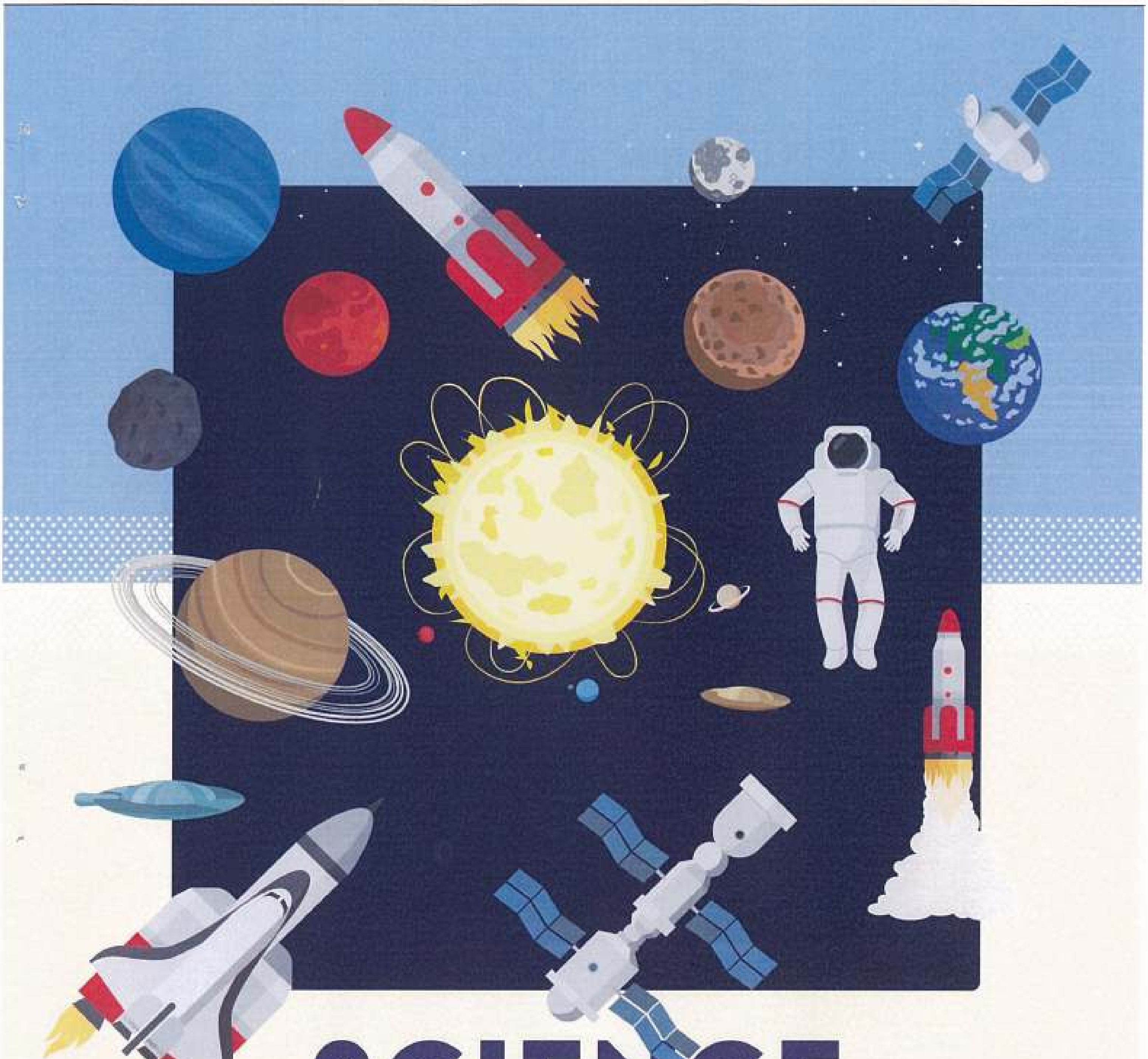

SCIENCE OLYMPIAD

Official Guide

International Olympiad Foundation

GRADE 10

GRADE X

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1. Light

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Light

It is a form of radiant energy which produces sensation in eyes and makes us able to see the object around us. Whenever light falls on an object, it gets reflected by the object and received by our eyes, therefore enable us to see that object.

Dual Property of Light

Light exhibits two properties, known as dual property. These are:

Wave Nature: Light is electromagnetic waves which do not require any medium to travel.

Particle Nature: Light travels in a straight line and cannot pass through the opaque object or any other barrier. Reflection and refraction also shows the particle nature of light.

Reflection of Light

Whenever a light falls on a polished surface such as mirror, it gets reflected back in the same plane from where it is incidented. This **bouncing back of light, after striking a polished surface, is called reflection of light.**

An object placed in the dark cannot be seen as there is no light incident on the object that gets reflected back to our eyes to make it visible.

Silver is considered as one of the best reflector of light as it reflects most of the light falling on it.

Types of Reflection

In reflection, path of light rays changes without any change in the medium.

Regular reflection

When the reflecting surface is smooth and well polished, the parallel incident rays falling on it are reflected back in the same medium with all the reflected rays parallel to each other. This is called regular reflection.

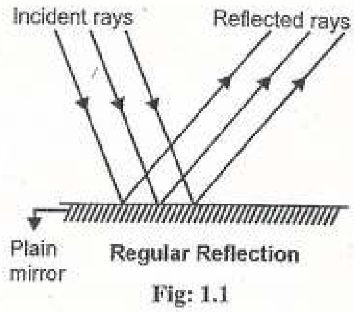


Fig: 1.1

Irregular reflection

When the reflecting surface is rough, the parallel rays falling on it gets reflected in different directions, such a reflection is called diffuse reflection or irregular reflection and sometimes called scattering of light.

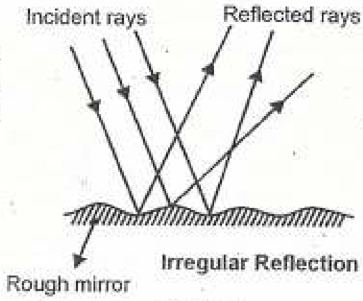


Fig: 1.2

Key Note: Any object in a room can be seen from all parts of the room. This is because surface of the object is rough and it scatters or reflects light in all the directions.

Laws of Reflection of Light

First law

According to the first law of reflection, the incident ray, the reflected ray and the normal (at the point of incidence), all lie in the same plane.

PP′ – Plane mirror

AO – Incident ray

OB – Reflected ray

ON – Normal to the mirror at O.

AO, OB and ON lie in the plane of the paper

$\angle AON = \angle i =$ Angle of incidence

$\angle NOB = \angle r =$ Angle of reflection

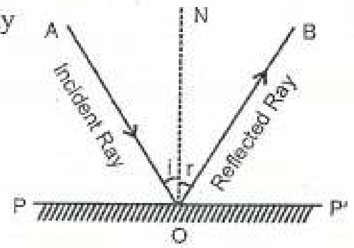


Fig: 1.3

Second law

According to the second law of reflection, the angle of incidence (i) is always equal to angle of reflection (r).

Note: When a ray of light is falling perpendicularly (normally) on a mirror, $\angle i = 0^\circ$. It means, the reflected ray would also go along the normal itself. Thus, $\angle i = \angle r = 0^\circ$. It means that a ray of light incident normally on the mirror, retraces its path on reflection.

Types of Mirrors

- Plane Mirror
- Spherial Mirror

Plane Mirrors

- When a ray of light emerging from a point A, after reflection from a mirror, **meet actually at another point B,** then the point B is called *real image* of the point A.
- When rays of light starting from a point A, after reflection from the mirror, **appear to come from another point B,** then the point B is called *virtual image* of the point A.
- In a plane mirror, the image of a real object is always:
  - Virtual
  - Erect
  - Of same size as the object
  - As far behind the mirror as the object in the front of the mirror
  - Laterally inverted.

Spherical Mirrors

A spherical mirrors is that mirror whose reflecting surface is a part of a hollow sphere of glass. One side of the mirror is well polished and reflecting; and other side of the mirror is opaque (often pointed red). There are two types of spherical mirrors.

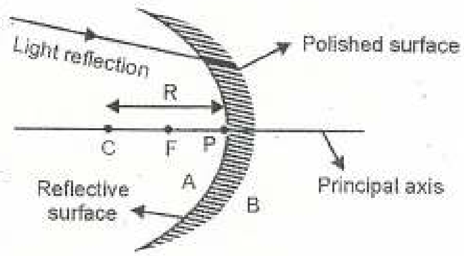


Fig: 1.4

Concave mirror

It is the mirror which is curved inwards. In this mirror, **reflecting surface is towards the centre of the sphere,** i.e. reflection of light occurs from concave surface or the **bent in surface A.** Surface B is opaque. It converges the ray of light falling on its surface at a point on the surface.

C is the centre of curvature and CP is the radius of curvature (R). F is the focal points, mid way between the centre of curvature and pole of the mirror.

$$FP = F, CP = 2F = R$$

Concave mirror is converging: The principal focus of a concave mirror is a point on the principle axis of the mirror, at which rays of light incident on the mirror in a direction parallel to the principle axis, actually meet after reflection from the mirror. The principal focus F of a concave mirror is a *real point.* It always lies in front of the concave mirror.

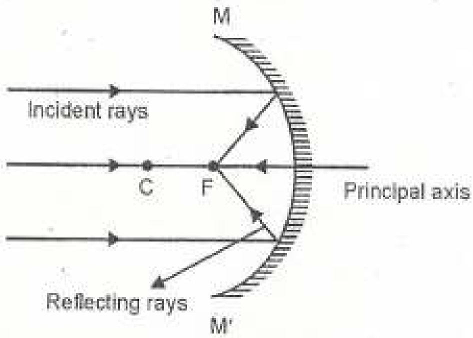


Fig: 1.5

Convex mirror

It is curved outward and the reflecting surface is away from the centre of the sphere *i.e.*, reflection of light occurs at bulging out surface 'A' and the inner surface 'B' is opaque. This mirror is also known as diverging mirror. The centre of curvature does not lay on the mirror, it lies infront of the concave mirror and behind the convex mirror. Pole P is defined as the centre of the mirror. The centre of curvature C, focal point F and pole P lies on the imaginary line passing through the mirror which is principle axis.

$$PF = \text{focal length } F$$

$$PC = \text{radius } R = 2F$$

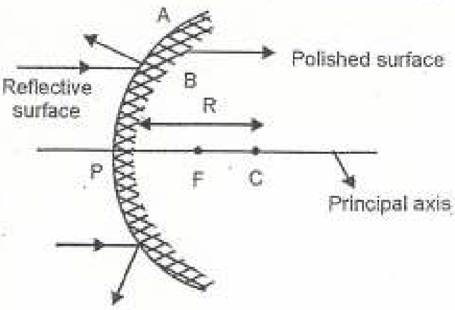


Fig: 1.6

Convex mirror is diverging: The principal focus of a convex mirror is a point on the principal axis of the mirror, from which rays of light incident on the mirror in a direction parallel to the principal axis, appear to diverge, after reflecting from the mirror. When the diverging reflected rays are produced back by dotted lines, the y appear to meet at F. The principal focus of a convex mirror is a *virtual point.*

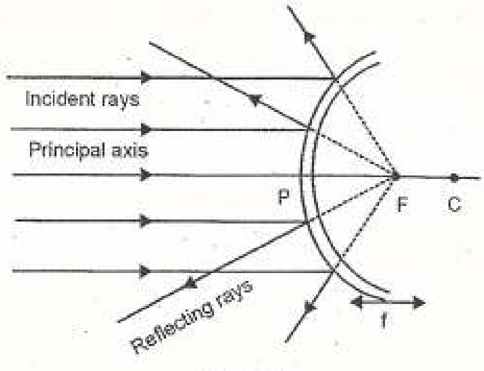


Fig: 1.7

Key Note: **(i)** The reflected rays appear to diverge from F. Thus it is called diverging mirror. It can be assumed as the outer surface of spoon.

(ii) As a concave mirror converges the parallel beam of light falling on it, therefore it is called a converging mirror. The inner surface of a silver spoon can be assumed as a converging mirror.

Rules for Tracing Image Formed by Concave Mirrors

Rule 1: A ray of light falling on a concave mirror in a direction parallel to the principal axis of the mirror, passes actually through the principal focus of the mirror after reflection.

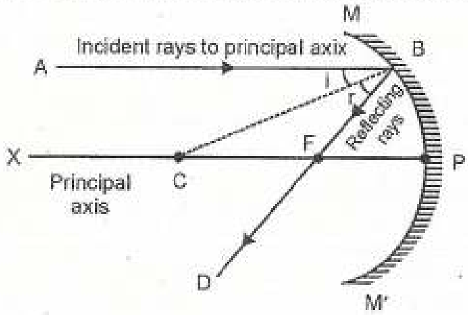


Fig: 1.8

A ray of light AB falls on the concave mirror MM', having principal axis XP and focal point F, in a direction parallel to XP. After reflection, it passes through F. Thus BFD is the reflected ray.

Rule 2: A ray of light incident on a concave mirror on passing through the centre of curvature of the mirror is reflected back along the same path *i.e.*, such a ray retraces its path in reverse direction.

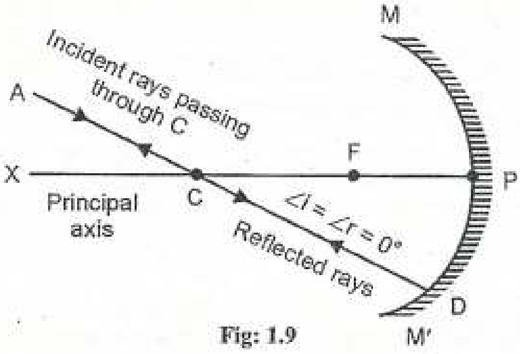


Fig: 1.9

A ray of light AD passing through C strikes the mirror MM' at D, normally and perpendicularly. It is reflected by the mirror along the same path i.e., DCA.

Rule 3: A ray of light incident on a concave mirror on passing through of focus of the mirror becomes parallel to the principal axis of the mirror after reflection.

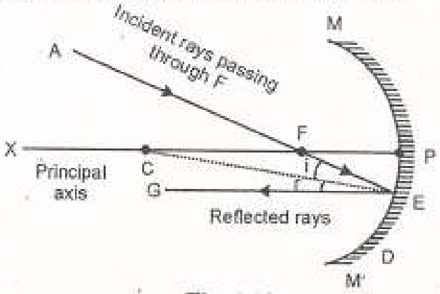


Fig: 1.10

AE is a ray, passing through the focus F of the concave mirror MM' and striking the mirror at E, reflect along EG in a direction parallel to principal axis XP.

Rule 4: A ray of light incident obliquely towards the pole P of concave mirror is reflected obliquely as per the laws of reflection such that angle of incidence equals angle of reflection.

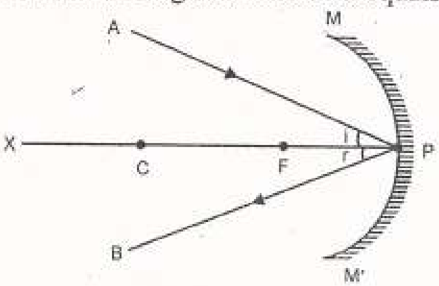


Fig: 1.11

A ray of light AP is incident obliquely on the concave mirror at $\angle APX = i$. *This ray is reflected along PB at* $\angle XPB = r$ *such that* $\angle i = \angle r$.

Image Formation by a Concave Mirrors

The type of image formed by a concave mirror depends chiefly on the position of the object in front of the mirror. The position of image is obtained by intersection of atleast two of the reflected rays.

Case 1: When the object is at infinity: When an object is at a very large distance from a concave mirror, it is said to be at infinity.

In this figure, AB is an object placed very far off from the mirror. Two rays AD and AP from the top of the object A are parallel to one another and inclined to the principal axis. These rays are reflected at points D and P on the mirror and intersect at a point A', which is the real image of the top A of the object. Therefore, A'B' is the inverted image of an object AB at infinity. **This image is formed at the principal focus F; is real and inverted; and is much smaller in size than the actual object.**

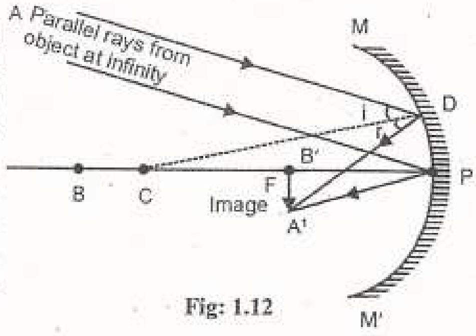


Fig: 1.12

Case 2: When the object is beyond the centre of curvature: The figure shows two rays starting from the top end A of the object AB placed beyond the centre of curvature C of the mirror on the principal axis. One ray AD incident at point D, parallel to the principal axis, reflects at focus F of the mirror MM′. The second ray AE passes through the centre of curvature C of the mirror, falling normally on it, retraces its path of reflection. The two reflected rays intersect at A′ which is the real image of A. To get the complete image, we draw A′B′. **The image is real and inverted; smaller in size than the object; and is lying between the focus F and centre of curvature C of the mirror.**

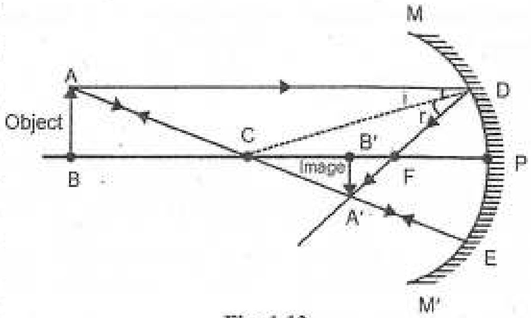


Fig: 1.13

Case 3: When the object is at the centre of curvature: The object AB is held at the centre of curvature C of concave mirror MM′. **The image formed by intersection of two reflected rays is real and inverted; at the centre of curvature of the mirror; and of the same size as the object; at the centre of curvature of the mirror; and of the same size as the object (AB = A′B′).**

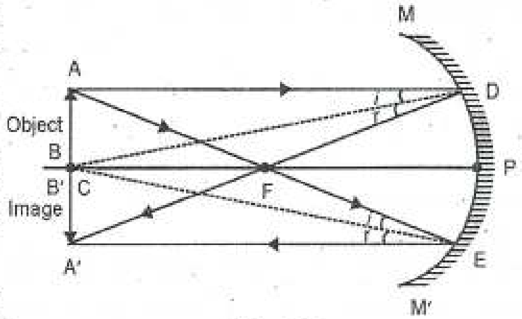


Fig: 1.14

Case 4: When the object lies between centre of curvature and focus of mirror : In the figure, object AB is held between focus F and centre of curvature C of concave mirror MM′, in direction perpendicular to the principal axis of the mirror.

We find that when an object is placed between C and F of concave mirror, **the image formed is real and inverted; larger in size than the object; and situated beyond C.**

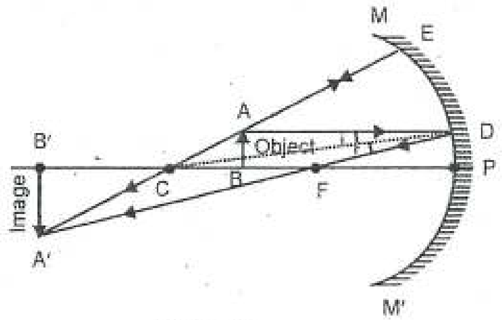


Fig: 1.15

Case 5: When the object is at the focus of concave mirror: Object AB is positioned at point B on the principal axis perpendicular to it. A ray of light AD falling on the mirror in the direction parallel to the principal axis is reflected at D and passes through the focus F of the mirror. Another ray of light starting from A is incident on the mirror along AE and passes through the centre of curvature C of the mirror. As their rays falls normally on the mirror, it retraces its path on reflection at E. The two reflected rays DBG and EACH are parallel to each other and would meet at very far off point, say infinity. **The image formed is at infinity is; real and inverted; and is highly enlarged.**

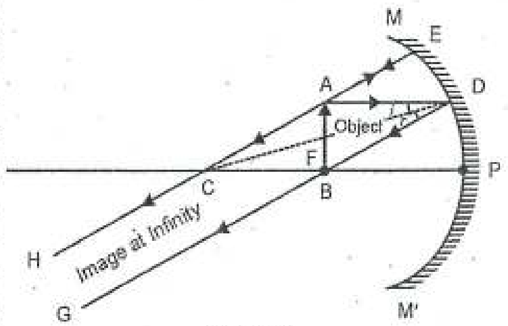


Fig: 1.16

Case 6: When the object is held between focus of pole of the mirror: In the figure is shown two reflected rays DF and EAC diverge and cannot meet in reality. However, when these two reflected rays are produced back, they appear to come from point A′. Therefore, A′ is the virtual image of A. To get complete image, draw A′B′ perpendicular to the principal axis. **The image formed is virtual and erect; is larger than the size of the object; and is behind the mirror.**

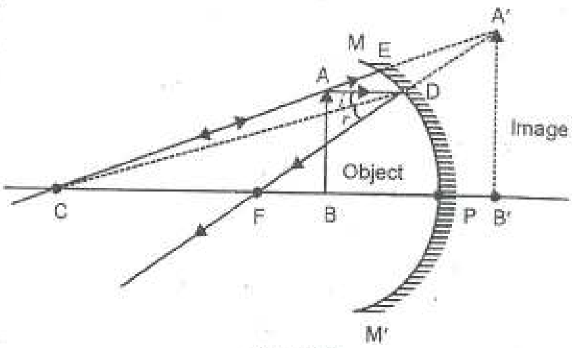


Fig: 1.17

Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At F	Highly diminished	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between F and P	Behind the mirror	Enlarged	Virtual and erect

Uses of Concave Mirror

- A concave mirror is used as a reflector in search light, torches, head lights of motor vehicles etc.
- A concave mirror is used a doctor's head mirror to focus light on body parts like eyes, nose, throat to be examined.
- A concave mirror is also used us a shaving mirror, as it can form an erect and magnified image of the face. It is also used as makeup mirror.
- Large concave mirrors are used in solar cookers and in reflecting type telescopes.
- The dentists use concave mirrors to observe large images of the teeth of patients.

Rules for Tracing Images Formed by a Convex Mirror

Rule 1: A ray of light falling on the convex mirror in a direction **parallel to the principal axis** of the mirror **appears to be coming from its focus after reflection from the mirror.**

Rule 2: A ray of light falling on a convex mirror **on passing through the centre of curvature** of the mirror is **reflected back along the same path** *i.e.*, retraces its path on reflection.

Rule 3: A ray of light falling on convex mirror **on passing through the focus** of the mirror becomes **parallel to the principle axis** after reflection.

Rule 4: A ray of light **incident obliquely towards the pole P** of a convex mirror is reflected obliquely such that the incident and reflected rays make equal angles $\angle i = \angle r$ **with the principal axis.** We can observe these four rules in the image formation process for a convex mirror.

Image Formation by a Convex Mirror

Case 1: When the object is placed at infinity: An object is placed at infinity, *i.e.*, at far distance in front of the mirror, **the image formed is highly diminished, pointed virtual and erect.**

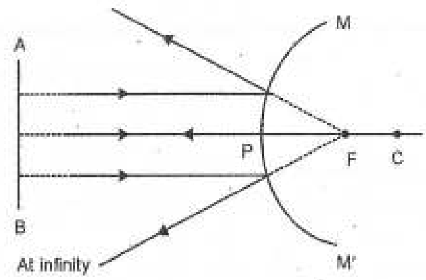


Fig: 1.18

Case 2: When the object is at finite distance from the mirror: AB is an object kept in front of the convex mirror at some distance. A parallel ray AD reflected along. DE on producing back appears to emerge from F. An incident ray AG, tending to pass through C, retraces its path on reflection at G. The two reflected ray DE and GA when produced back appears to intersect at A′ between P and F. Therefore, A′ is the virtual image of point A. **The image formed is diminished virtual and erect.**

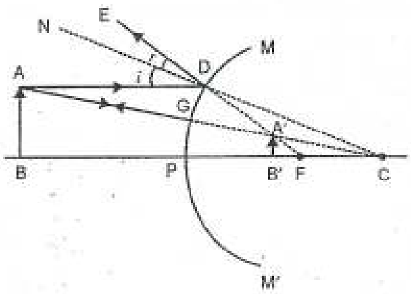


Fig: 1.19

Uses of a Convex Mirror

- It is used as a reflector in street lamps. Light from the lamp diverges over a large area.
- It is used in cars, buses and trucks as a rear view mirror. These mirrors are fitted on the sides of the vehicle enabling the driver to see traffic behind for safe driving.

Mirror Formula

The formula which gives us a relation between the object distance (u) image distance (v) and focal length (f) is called the mirror formula.

This formula can be written as

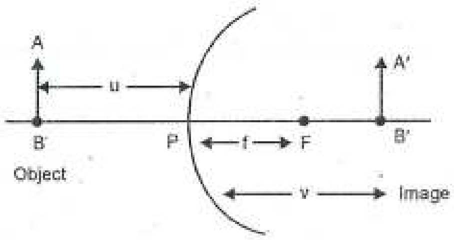


Fig: 1.20

$$\frac{1}{\textbf{Object distance}} + \frac{1}{\textbf{image distance}} = \frac{1}{\textbf{Focal lenght}}$$

i.e., $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

All these distances are measured from the centre of the mirror at pole P on the principal axis.

If R is the radius of curvature of the spherical mirror, then

$$f = \frac{R}{2}$$

$$\therefore \quad \frac{1}{u} + \frac{1}{v} = \frac{2}{R}$$

This formula is valid in all situation for all types of spherical mirror for all positions of the object. Always remember the New Cartesian Sign conventions which says all distances to the left of the mirror are negative and to the right of the mirror are positive. Distances above the principal axis are positive and below the axis are negative.

***Example* 1:** An object 4 cm in size is placed at a distance of 25 cm from a concave mirror of focal length 15 cm. Find the nature and position of the image.

***Solution*:**

$$u = -25 \text{ cm}$$
$$f = -15 \text{ cm}$$
$$\frac{1}{u}+\frac{1}{v} = \frac{1}{f}$$
$$\Rightarrow \quad \frac{1}{v} = \frac{1}{f}-\frac{1}{u} = \frac{1}{(-15)}-\frac{1}{(-25)} = \frac{-5+3}{75} = \frac{-2}{75}$$
$$\therefore \quad v = \frac{75}{-2} = -37.5 \text{ cm.}$$

Thus image is formed at distance 37.5 cm from the mirror, in front of the mirror as v is negative. Image formed is real and inverted.

Linear Magnification Produced by a Spherical Mirror

Magnification can be defined as the extent to which an image can be enlarged, or diminished by a mirror. The linear magnification produced by a spherical mirror is defined as 'the ratio of height of the image (h_2) to the height of the object (h_1), represented by m.'

$$\text{Linear magnification (m)} = \frac{\text{height of image } (h_2)}{\text{height of image} (h_1)}$$

$$m = \frac{h_2}{h_1}$$

Case 1: When the image is magnified or enlarged, size of image is greater than the size of the object *i.e.*, $h_2 > h_1$ or $m > 1$.

Case 2: When image is of the same size as that the object *i.e.*, $h_2 = h_1$ or $m = 1$.

Case 3: When image is smaller than the object *i.e.*, $h_2 < h_1$ or $m < 1$.

Sign of linear magnification

Case 1: When the image is real, it is inverted *i.e.*, the image lies below the principal axis *i.e.*, h_2 is negative. Height of the object is always positive. Therefore, $m = \frac{h_2}{h_1}$ is negative. Thus, we can say **when linear magnification is negative, the image formed by spherical mirror must be real and inverted.**

Case 2: When the image is virtual, it is erect *i.e.*, the image lies above the principal axis and h_2 is positive. Therefore, $m = \frac{h_2}{h_1}$ is also positive. Thus we can say that **When linear magnification is positive, the image formed by spherical mirror is virtual and erect.**

Linear magnification is also related to the object distance (u) and the image distance (v) as

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

***Example* 2:** A converging mirror forms a real image of height 4 cm of an object of height 1 cm placed 20 cm away from the mirror. Calculate the image distance and the focal length of the mirror.

***Solution*:** $h_2 = -4$ cm (image is real *i.e.*, inverted below axis)

$$h_1 = +1 \text{ cm}, u = -20 \text{ cm}$$

$$m = \frac{h_2}{h_1} = -\frac{v}{u}$$

$$\Rightarrow \frac{-4}{1} = \frac{-v}{-20} \Rightarrow v = -80 \text{ cm}$$

Negative sign of the v indicates that the image is on the side of the object and must be real and inverted.

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \Rightarrow \frac{1}{f} = \frac{1}{-20} + \frac{1}{-80} = \frac{-4-1}{80} = \frac{-5}{80} = \frac{-1}{16}$$

$$f = -16 \text{ m.}$$

Negative sign of f indicates that the mirror is concave.

***Example* 3:** The image formed by a convex mirror of focal length 20 cm is a quarter of the object. What is the distance of the object from the mirror ?

***Solution*:** $f = 20$ cm, $m = \frac{h_2}{h_1} = \frac{-v}{u} = \frac{1}{4}\left[h_2 = \left(\frac{1}{4}\right)h_1 \text{ given}\right]$

Or $\quad v = \frac{-u}{4} \Rightarrow \frac{1}{v} = \frac{-4}{u}$

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{u} + \left(\frac{-4}{u}\right) = \frac{-3}{u}$$

$$\Rightarrow \quad \frac{1}{20} = \frac{-3}{u} \Rightarrow u = -60 \text{ cm.}$$

Refraction of Light

The change in the direction of light in going from one transparent medium to another is called refrection of light. This phenomenon of refraction occurs right at the boundary of the two mediums. Thus, when light travels from air to glass, glass to water, water to air, etc. each time the ray undergoes refraction. This we can show with the help of a glass slab placed in the air.

The diagram shows a glass slab ABCD placed on a table. A light ray EF has entered from a rarer medium (air) to denser medium (glass) at point O at an angle of incidence i_1 to the normal NN′. At O the light ray has bent towards the normal making an angle of refraction r_1.

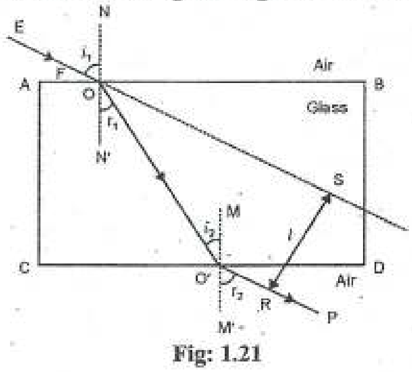


Fig: 1.21

This refracted ray now passes from denser medium (glass) to the rare medium (air) at O′ at an angle i_2 and refracted away from the normal MM′ at angle r_2.

EO is the incident ray, OO′ is the refracted ray, and O′P is the emergent ray. You may observe that emergent ray is parallel to the incident ray. The extent of bending of the light ray at the opposite parallel faces AB and CD of a rectangular glass slab is equal and opposite. In case of refraction, $\angle i$ is never equal to $\angle r$.

Why does Refraction Happens?

Refraction is due to **change in speed of light** as it enters from one transparent medium to another. This change in speed is due to the difference in the density of the two medium. The medium in which the speed of light is more is called the **rarer medium** and the medium in which the speed of light is less is called the **denser medium.**

Lateral displacement

When the light goes from rarer to denser medium, it bends towards the normal; and when it goes from denser to the rarer medium, it bends away from the normal. **The distance between the emergent ray and the original direction of ray of light (RS as shown in Fig. 1.21) is called the lateral displacement.**

Laws of Refraction of Light

Law 1: The incident ray, the refracted ray and normal all lie in the same plane.

Law 2: The ratio of sine of angle of incidence to the sine of angle of refraction is always a constant for the two given medium, in which refraction takes place.

$\frac{\text{Sin i}}{\text{Sin r}} = \text{constant} = \mu$; Refractive index can also be represented as n_2

This constant is called the **refractive index.** This law is known as the **Snell's Law.**

- When light goes from one medium to another, the value of refractive index is called the **relative refractive index.**
- If the light is going from vacuum to another medium, the value of refractive index in called **absolute refractive index.**
- An object with greater refractive index is **optically denser** than another object having smaller refractive index.

Law 3: Whenever light goes from one medium to another, the frequency of light does not change. However, the velocity of light and the wavelength of light change.

Velocity of light and refractive index

The refractive index can be linked to the relative speed of propagation of light in different media. Light travels fastest in vacuum with speed of 3 × 108 ms–1. Speed of light in water is 2.25 × 108 ms–1. Speed of light in glass is 2 × 108 ms–1. Therefore, air is optically a rarer medium compared to both water and glass. Glass is optically denser than air and water.

Absolute refractive index of a medium is defined as the ratio of speed of light in vaccum to the speed of light in the medium, represented by n.

$$n = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}} = \frac{C}{v}$$

$$n = \frac{C}{v}$$

$$n_{\text{glass}} = \frac{C}{v_{\text{glass}}} = \frac{3 \times 10^8\ \text{ms}^{-1}}{2 \times 10^8\ \text{ms}^{-1}} = 1.5$$

$$n_{water} = \frac{C}{v_{water}} = \frac{3\times10^8\ ms^{-1}}{2.25\times10^8\ ms^{-1}} = \frac{4}{3} = 1.33$$

A medium with higher value of n is said to be optically denser compared to a medium with lower value of n.

$$n = \frac{C}{v} \Rightarrow \quad \boxed{v = \frac{C}{n}}$$

Larger the value of n, small is the value of v. It means in a denser medium, speed of light is lower than in a rare medium.

Key Note: Refractive index is a characteristics property of the medium, whose value depends only on nature of material of the medium and the colour or wavelength of light.

Relative refractive index

When light passes from one medium (say 1) to another medium 2, the refractive index of medium 2 w.r.t. medium 1 is written as ${}^1n_2$ or n_{21} and is called relative refractive index; where

$${}^1n_2 = n_{21} = \frac{n_2}{n_1} = \frac{C/v_2}{C/v_1} = \frac{v_1}{v_2}$$

$${}^1n_2 = \frac{v_1}{v_2} \quad {}^1n_2 \times {}^2n_1 = 1$$

$${}^2n_1 = \frac{v_2}{v_1} \quad {}^1n_2 = \frac{1}{{}^2n_1}$$

Therefore, relative refractive index of medium 2 w.r.t. medium 1 is equal to the ratio of speeds of air in medium 1 and medium 2.

Refractive index of medium 2 w.r.t. medium 1 is the reciprocal of refractive index of medium 1 w.r.t. medium 2.

Key Notes: Refractive index represents the extent of the change in direction that takes place in a given pair of mediums. **No refraction occurs** when light is incident normally on a boundary of two media or when refractive indices of the two media in contact are equal.

Experiences due to refraction of light

- A word written on a paper appears to be raised, when viewed through a glass slab
- A glass slab appears to be less thick than it actually is. This is because bottom of the glass slab appears to be raised.
- Twinkling of stars and shape of sun at sunrise and sunset
- A coin placed at bottom of a container appears to be raised when the container is filled slowly with water.

$${}^{air}n_{water} = \frac{\text{real depth}}{\text{apparent depth}} = \frac{4}{3}$$

$$\text{apparent depth} = \frac{3}{4}\ \text{real depth.}$$

***Example* 4:** Light travels from a rarer medium 1 to denser medium 2. The angle of incidence and refraction are respectively 45° and 30°. Calculate the refractive index of second medium w.r.t. first medium, and also the refractive index of first medium w.r.t. second medium.

***Solution*:** Angle of incidence, $i = 45°$

Angle of refraction, r = 30°;

According to Snell's Law $^1n_2 = \frac{\text{Sin i}}{\text{Sin r}}$

Therefore, $^1n_2 = \frac{\text{Sin }45°}{\text{Sin }30°} = \frac{1/\sqrt{2}}{1/2} = \frac{1}{\sqrt{2}} \times \frac{(\sqrt{2} \times \sqrt{2})}{1} = \sqrt{2}$

$^1n_2 = 1.414 \Rightarrow {}^2n_1 = \frac{1}{^1n_2} = \frac{1}{1.41} = 0.707$

***Example* 5:** A pond of depth 16 cm is filled with water of refractive index $\frac{4}{3}$. Calculate the apparent depth of the tank when viewed normally.

***Solution*:** Real depth = 16 cm, $^an_w = \frac{4}{3}$

$^an_w = \frac{\text{real depth}}{\text{apparent depth}} \Rightarrow \text{apparent depth} = \frac{\text{real depth}}{^an_w}$

Thus, apparent depth = $\frac{16}{4/3} = 12$ cm.

***Example* 6:** How much time will light take to cross 2 mm thick glass pane if refractive index of glass is 3/2 ?

***Solution*:** $n = \frac{C}{v} \Rightarrow v = \frac{C}{n} = \frac{3 \times 10^8}{3/2}\text{ m/s} = 2 \times 10^8$ m/s

Distance travelled, x = 2 mm = 2×10^{-3} m

Speed in glass, v = 2×10^8 m/s

Therefore, time taken to cover x with speed v is

$$t = \frac{x}{v} = \frac{2 \times 10^{-3}}{2 \times 10^8} = 10^{-11} \text{ s.}$$

Absolute refractive index of some material media

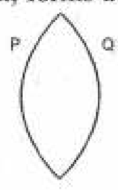
Material medium	Refractive index
Air	1.0003
Ice	1.31
Water	1.33
Alcohol	1.36
Benzene	1.50
Crown glass	1.52
Diamond	2.42

Spherical Lenses

Lens

A transparent material bound by two surfaces, of which one or both the surface are spherical, forms a lens. On passing through a lens, light is refracted twice at the two surfaces of the lens.

Lenses are of two types:

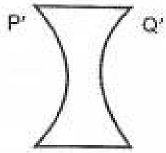


Convex lens

A lens having two spherical surface **bulging outwards** is called convex lens. Such a lens is

thick at the centre and thin at the edges. The two surfaces P and Q binding the lens are convex (*i.e.*, bulging out) A convex lens is called **converging lens** as it converges the rays of light falling on it.

Concave lens

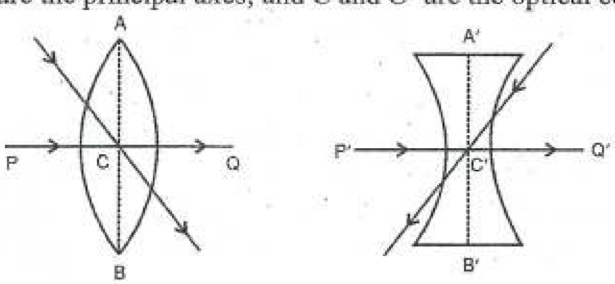


A lens having the spherical surfaces **bulging inwards** is called concave lens. Such a lens is **thick at the edges and thin at the centre.** The two surfaces P′ and Q′ binding the lens are concave (*i.e.*, curved inwards). A concave lens is also called **diverging lens** because it diverges the rays of light falling on it.

Key Note: Both surfaces of the two lenses have their own centres of curvature and radii of curvature. The radii of curvature of two surfaces of both the lenses may be equal or unequal.

Optical centre of the lens

The optical centre of a lens is a point on the principal axis of the lens such that ray of light passing through it goes undeviated (without any refraction). In the figure we can see that AB and A′B′. are the apertures; PQ and P′Q′ are the principal axes; and C and C′ are the optical centres of both the lenses.

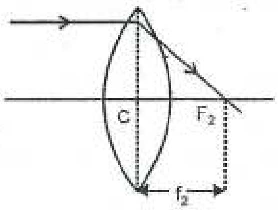


Two rays of light have been shown, passing through the centres of both the lenses, undeviated but straight.

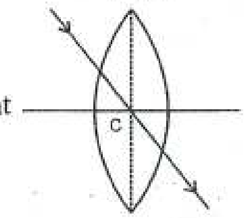
Image formation by a convex lens

There are three rules which shows the refraction of light rays incident on the convex lens.

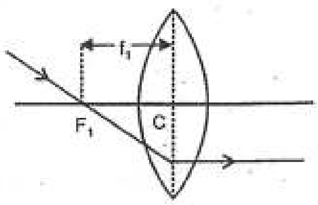
Rule 1: Ray incident on the lens in a direction parallel to the principal axis, on refraction passes through second principal focus (F_2) of the lens located on the other side of the lens $CF_2 = f_2$.



Rule 2: Ray passing through optical centre C of convex lens passes straight (undeviated) after refraction through the lens.



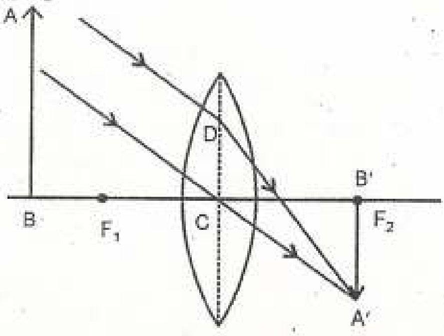
Rule 3: Ray passing through first principal focus f_1 of convex lens, incident on the lens becomes parallel to the principal axis of the lens, after refraction through the lens.



The image is formed at a point where any two of the refracted rays actually meet (for real image) or appear to meet (for virtual image).

Note: The position, size and nature of the image depend upon the position of the object in front of the lens. Following six cases arise.

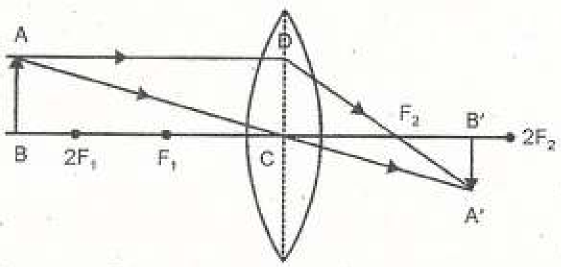
Case 1: When the object is at infinity : Suppose the object is placed far off from the lens consisting of an arrow AB pointing upwards.



Two rays coming from infinity appears parallel. The ray AC passing through C goes underviated. The ray AD converges on refraction through the convex lens. The two refracted rays actually meet at A′ which would be the real image of the top point A, of the object. Draw A′B′ perpendicular to the principal axis of the lens.

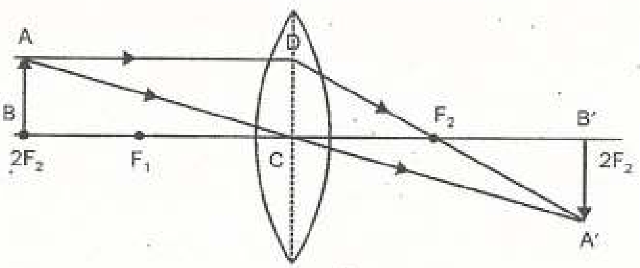
The image formed is at second principal focus; is real and inverted; and highly diminished (much smaller in size than the object).

Case 2: When the object is held beyond $2F_1$: The distance of the object is more than the focal length ($2F_1$) of the lens.

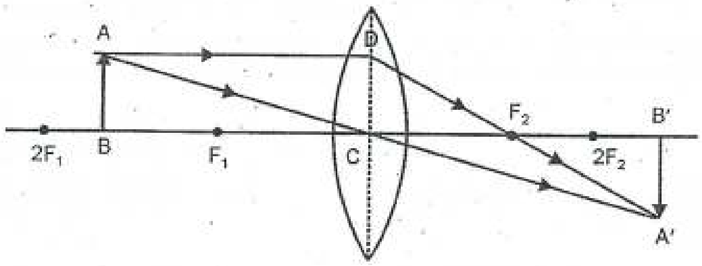


The image is formed between F_2 and 2 F_2 on the other side of the lens; is real and inverted; and is smaller in size than the actual object.

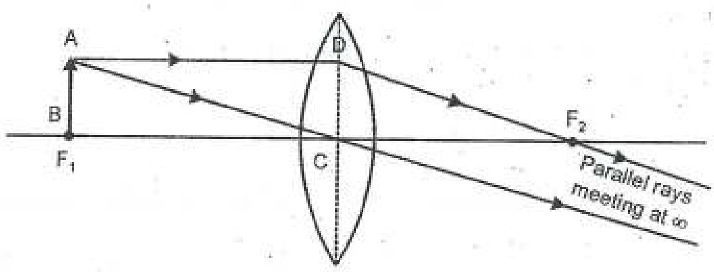
Case 3: When the object is held at 2 F_1 : The distance of the object from the convex lens is equal to twice the focal length of the lens. **The image is formed on the other side of the lens of $2F_2$; is real and inverted; and of the same size of the object.**



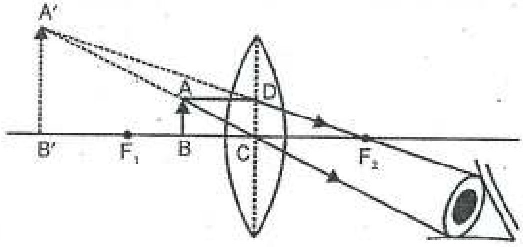
Case 4: **When the object is held between F_1 and 2 F_1 :** Here, the distance of the object from the convex lens is more than the focal length of the lens, but less than thrice the focal length of the lens. The two refracted rays meet actually at point A′ which is the real image of the point A, of the object. **The image is formed beyond 2 F_2 on the other side of the convex lens; is real and inverted; and is large in size than the object.**



Case 5: **When the object is at F_1:** Here, the distance of the object from the lens is equal to focal length of the lens. The two refracted rays emerge from the lens in a direction parallel to each other. These rays would meet at very large distance from the lens, say at infinity. **The image is formed at infinity on the other side of the lens; is real and inverted; and is highly magnified *i.e.*, much larger in size than the object.**



Case 6: **When the object is between F_1 and C:** Here, the distance of the object from the lens is less than the focal length of the lens. The two refracted rays from the lens are diverging and not parallel and would not meet on the right side of the lens. However, when we produce the two refracted rays in the backward direction, they appear to come from the point A′. Therefore, point A′ is the virtual iamge of the point A of the object. The image formed is beyond F_1 on the same side of the lens as the object is; virtual and erect; and magnified.

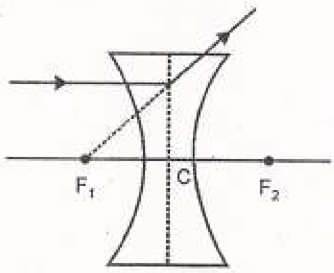


Summary table of images formed by a convex lens

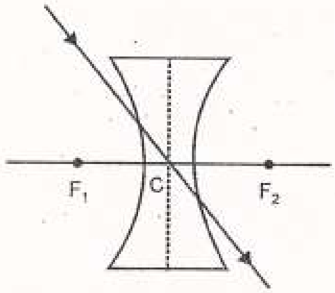
S. No.	Position of the object	Position of image	Size of image	Nature of image
1.	At infinity	At F_2	Highly reduced	Real and inverted
2.	Beyond 2 F_1	Between $F_2 \times 2$ F_2	Diminished	Real and inverted
3.	At 2 F_1	At 2 F_2	Equal in size	Real and inverted
4.	Between F_1 and 2 F_1	Beyond 2 F_2	Enlarged	Real and inverted
5.	At F_1	At infinity	Highly magnified	Real and inverted
6.	Between F_1 and C	Beyond F_1 on the same side of the object	Enlarged	Virtual and erect

Rules for Refraction in a Concave Lens

1. **A ray incident on the concave lens in a direction parallel to the principal axis, on refraction,** it appears to come from the first principal focus F_1 of concave lens.



2. **A ray passing through optical centre C of concave lens,** passes straight without any deviation after refraction through the lens.



3. **A ray of light appearing to meet at the second principal focus F_2 of a concave lens,** after refraction will emerge parallel to the principal axis of the lens.

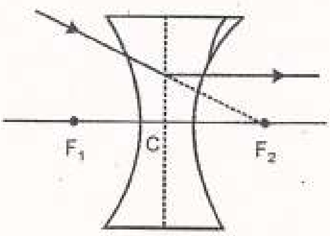
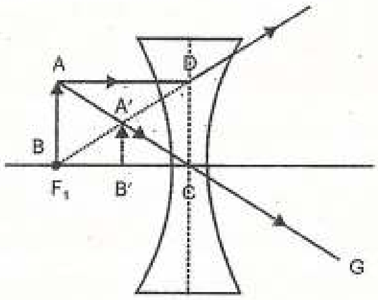


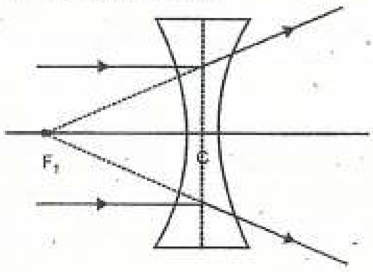
Image Formation by Concave Lens

Case 1: When the object lies between optical centre C and infinity: A ray of light, AD, starting from the top point A of the object placed between infinity and C, is falling on the concave lens in a direction parallel to principal axis of the lens. This ray diverges along DE, and on producing back, it appears to come from F_1. Another ray of light AC, starting from A, on passing through C goes undeviated along ACG. The two refracted rays intersect at A′.

Therefore A′ is the virtual image of point A on the object. **The image formed is between C and F_1, is on the same side of the lens as the object, is virtual, erect and highly diminished to almost point size (show as A′B′).**



Case 2: When the object is at infinity: As the object is moved away from the concave lens, the image A′B′ becomes still smaller in size and moves towards F_1. **The image is formed at F_1, is much smaller than the object; virtual and erect.**



Lens Formula

An equation which shows the relation between object distance (u), image distance (v) and focal length (f) of a lens is callèd lens formula. It can be written as

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

This formula is valid for any spherical lens, whenever the object may be placed. A convex lens may form a real or virtual image depending on the position of the object. A concave lens forms a virtual image, whenever the object may be.

***Example* 7:** A concave lens has focal length of 15 cm. At what distance should an object be placed from the lens so that it forms an image at 10 cm from the lens.

Solution: A concave lens always form a virtual and erect image i.e., on the same side of the object.

Image distance v = – 10 cm

Focal length f = – 15 cm

$$\frac{1}{v}-\frac{1}{u} = \frac{1}{f}, \frac{1}{u}=\frac{1}{v}-\frac{1}{f}=\frac{1}{(-10)}-\frac{1}{(-15)}=\frac{-1}{10}+\frac{1}{15}$$

$$\frac{1}{u} = \frac{-3+2}{30}=\frac{-1}{30}$$

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

Linear magnification produced by lenses

The linear magnification produced by lens in defined as the ratio of the size of the mage (I) as formed by refraction through the lens to the size of the object (O). It is represented by m.

$$m = \frac{I}{O} = \frac{\text{Size of image}}{\text{Size of object}}$$

If we take size of object as h_1 and size of image as h_2, then

$$m = \frac{h_2}{h_1}$$

For concave lens, image formed is always smaller, thus linear magnification, m is always less than one ($h_2 < h_1$).

For convex lens, image formed can be

(i) Equal in size of the object ($h_2 = h_1$), then $m = 1$

(ii) Bigger in size to the object ($h_2 > h_1$), then $m > 1$

(iii) Smaller in size of the object ($h_2 < h_1$), then $m < 1$

Key Note: (i) Linear magnification produced by any type of lens is equal to the ratio of image distance (v) to the object distance (u), *i.e.*,

$$M = \frac{h_2}{h_1} = \frac{v}{u}$$

(ii) For concave lens both h_1 and h_2 are positive. Therefore, m is always positive.

(iii) For concave lens, m is positive when image is virtual; and m is negative when the image is real.

***Example* 8:** 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 its magnificance.

***Solution*:** Here size of object, $h_1 = 2$ cm, $f = 10$ cm

$u = -15$ cm

$$\frac{1}{v} - \frac{1}{u} = \Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} + \left(\frac{1}{-15}\right) = \frac{1}{30}$$

$v = 30$ cm. As v is positive, the image formed is on the right side of the lens and is real and inverted.

Linear magnification, $m = \frac{h_2}{h_1} = \frac{v}{u}$

$$\frac{h_2}{2} = \frac{30}{-15} \Rightarrow h_2 = -4 \text{ cm.}$$

Negative sign of m and h_2 shows that image is inverted. Thus image formed is enlarged two times.

Power of a lens

Power of a lens can be defined as the ability of the lens to converge the rays of light falling on a convex lens or to diverge the rays of light falling on the concave lens. Power of a convex lens is positive and of a concave lens is said to be negative.

If the point of convergence lies close to the optical centre of convex lens its power is more. If the point of convergence of rays lies away from the optical centre, its power is less. **The degree of convergence or divergence of light rays is a measure of power of lens.**

Hence, power of a lens is the reciprocal of focal length of the lens.

$$P = \frac{1}{f}$$

P = power of lens

f = focal length of the lens

smaller the focal length, greater is its power and vice-versa.

For a convex lens, f is positive. Therefore P is positive

For a concave lens, f is negative. Therefore P is negative

S.I. unit of power of lens is **dioptre** represented by symbol D.

When f = 1 m, P = 1 dioptre. Thus, one dioptre is the power of a lens whose focal length is one metre. This power can be measured using an instrument called dioptremeter, used often by opticians to measure the power of spectacles. In general, power of a lens in dioptres is called the **number of the lens.**

Note : $P = \frac{100}{f}$ when f is in centimetres.

***Example* 9:** A convex lens has a focal length 50 cm. Calculate its number.

***Solution*:** f = 50 cm = 0.5 m

Power, $P = \frac{1}{0.5} = 2$ dioptre = 2D

Thus, its number is said to be + 2.

Power of a combination of lenses

When a number of thin lenses are place in contact with each other, the power of the combination is equal the sum of the powers of all individual lenses used. These are used in cameras, microscopes and telescopes.

It increases the sharpness and clarity of images.

$$P = P_1 + P_2 + P_3 + \dots\dots\dots \Rightarrow \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \dots$$

Note that all the individual powers have to be taken with proper signs, positive for a convex lens and negative for concave lens, while adding them.

***Example* 10:** A concave lens of focal length 25 cm and a convex lens of focal length 20 cm are placed in contact with each other. What is the power of this combination and its focal length ?

***Solution*:** $f_1 = 25$ cm (concave lens)

$f_2 = +20$ cm (convex lens)

$$P_1 = \frac{100}{-25} = -4\text{ D}, P_2 = \frac{100}{+20} = +5\text{ D}$$

$$P = P_1 + P_2 = -4\text{ D} + 5\text{ D} = 1\text{ D}$$

$$F = \frac{100}{P} = \frac{100}{1} = 100\text{ cm} = 1\text{m}$$

Positive sign of P and F indicates that the combination is behaving like a convex lens.

Key Points

- ✓ The two laws of refraction are:
  - The incident ray, the reflected ray and the normal (at the point of the incidence), all lie in the same plane.
  - The angle of reflection (r) is always equal to the angle of incidence (i) *i.e.*, $\angle r = \angle i$
- ✓ For a normal incidence, $\angle i = \angle r = 0°$
- ✓ In plane mirror, the image of real object is always
  - Virtual and erect
  - Laterally inverted
  - Of the same size as of the object
  - As far behind the mirror as the object is in front of the mirror.
- ✓ In concave mirror, reflecting surface is towards the centre of the sphere of which the mirror is a part.
- ✓ Convex mirror has the reflecting surface away from the centre of the sphere of which the mirror is a part.
- ✓ In a spherical mirror, focal length (f) is half the radius of curvature (R) of the mirror *i.e.*, $f = R / 2$.
- ✓ The image formed by a concave mirror may be real, inverted and smaller / equal / larger in size than the object, depending on position of the object. Only when the object is between pole P and focus F of concave mirror, the image formal is virtual, erect and magnified.
- ✓ The image formed by a convex mirror is virtual, erect and smaller than the object, whatever be the position of the object.
- ✓ If u is the object distance, v is the image distance and f is focal length of as spherical mirror, then $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$.
- ✓ Linear magnification produced by a spherical mirror, m is given by
  $M = \frac{h_2}{h_1} = \frac{-v}{u}$
- ✓ For convex mirror, m is positive and less than one, as the image formed is virtual, erect and shorter than the object.
- ✓ For a concave mirror, m can be positive or negative.
- ✓ Absolute refractive index (n) of a medium is the ratio of speed of light in vacuum or air (C) to the speed of light in the medium (v) *i.e.*, $n = \frac{C}{v}$. It is simply called refractive index of medium.
- ✓ When speed of light in a medium is smaller, its refractive index is larger. The medium is said to be optically denser. When v is larger, n is smaller; the medium is said to be optically rarer.
- ✓ When light passed from one medium 1 to another medium 2, the refractive index medium 2 w.r.t medium 1 is called relative refractive index, represented by ${}^1n_2$
  ${}^1n_2 = \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{1}{{}^2n_1}$.
- ✓ Refraction of light is the phenomenon of change in the path of the light in going from one medium to another. The basic cause of refraction is the change in the speed of light in going from one medium to another.

- ✓ According to Snell's law of refraction, when light travels from one medium to another, the ratio of sine of $\angle i$ and sine of $\angle r$ is equal to the ratio of refractive index of medium 2 w.r.t. medium 1

  $$\frac{\text{Sin } i}{\text{Sin } r} = \frac{n_2}{n_1} = {}^1n_2$$

- ✓ No refraction occurs when light is incident normally on a boundary of two media, or in case refractive indices of the two media in contact are equal.
- ✓ In a convex lens, F_1 and F_2 are real points. In a concave lens, F_1 and F_2 are virtual points. When medium on either side of the lens is the same, $f_1 = f_2$.
- ✓ The lens formula is $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$
- ✓ The linear magnification produced by a lens is given as

  $$m = \frac{I}{O} = \frac{h_2}{h_1} = \frac{v}{u}$$

- ✓ Power of a lens is reciprocal of focal length *i.e.*, $P = \frac{1}{f}$. It is positive for a convex a convex lens and negative for a concave lens.
- ✓ SI unit of power of a lens is dioptre (D), $P = \frac{100}{f(\text{cm})}$ D

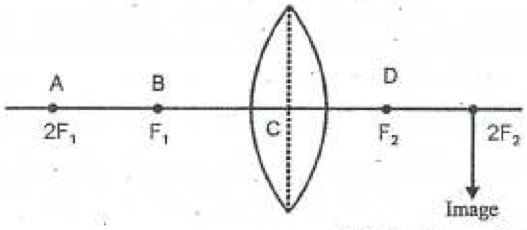
Multiple Choice Questions

1. The image formed by a concave mirror is found to be virtual, erect and enlarged. Where should the object be placed?
   (a) At the centre of curvature, C
   (b) Between P and F
   (c) Between F and C
   (d) Beyond C
2. 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 F_1
   (b) At F_2
   (c) At 2 F_1
   (d) At 2 F_2
3. A ray of light falls on a plane mirror making an angle of 30° with the mirror. On reflection, the ray deviates through an angle of
   (a) 60°
   (b) 30°
   (c) 90°
   (d) 120°
4. A child runs towards a plane mirror with a velocity of 5 m/s with what speed will his image move towards him?
   (a) 5 m/s
   (b) 10 m/s
   (c) Zero
   (d) 15 m/s
5. The linear magnification produced by concave mirror is always positive. This is because
   (a) Convex mirror is a small mirror
   (b) Image formed by a convex mirror is always smaller in size than the object
   (c) Image formed by a convex mirror is real
   (d) Image formed by a convex mirror is always virtual and erect
6. The focal length of a concave mirror that produces four times larger real image of an object held at 5 cm from the mirror is
   (a) – 4 cm
   (b) – 20 cm
   (c) 20 cm
   (d) 5 cm
7. When two or more than two rays starting from a point on the object, after refraction through a lens, do not actually meet but appear to diverge from point, the image formed is
   (a) Virtual
   (b) Real
   (c) Inverted
   (d) None of these
8. A ray of light falling normally on a plane mirror on reflection
   (a) Retraces its path
   (b) Deviate through 90°
   (c) Reflect parallel to the mirror
   (d) Do not reflect at all
9. A concave mirror produces an image of 20 cm height which is five times magnified. The height of the object is
   (a) 10 cm
   (b) 2 cm
   (c) 4 cm
   (d) 5 cm
10. If an object is placed at a distance of 10 cm in front of a plane mirror, how far would it be from its image
    (a) 10 cm
    (b) 20 cm
    (c) 40 cm
    (d) 5 cm

11. The linear magnification of a convex mirror of focal length 15 cm is $\frac{1}{3}$. The distance of the object from the mirror is

(a) + 15 cm
(b) – 15 cm
(c) + 30 cm
(d) – 30 cm

12. If you want to get an image of the object in inverted position at 2 F_2, the object should be placed at

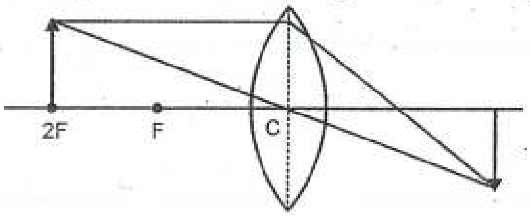


(a) Between A × C
(b) Between B × C
(c) At A
(d) At B

13. The power of a convex lens P_1 is equal to 4 D, which is placed in close contact with a concave lens having power P_2 equal to – 10 D. What will be the power of the combination of the two lenses?

(a) – 6 D
(b) 6 D
(c) 40 D
(d) – 40 D

Direction: See the given below diagram and answer the questions from Q. 14 to 16.



14. If the height of the object is 1 cm, what will be the size of the image if the object is placed at a distance of 2 F?

(a) 2 cm
(b) 4 cm
(c) 1 cm
(d) 8 cm

15. The above lens is a

(a) Concave lens
(b) Convex lens
(c) Concave convex lens
(d) Convex concave lens

16. The ray of light parallel to the principal axis of a convex lens will pass after refraction

(a) Through F
(b) Through 2 F
(c) Between F and 2 F
(d) Between C and F

17. The image of a small electric bulb fixed on the wall of a room is to be obtained, on the opposite wall 3 m away by means of a large convex lens. What is the maximum possible focal length of the lens required for the purpose ?

(a) 0.25 m
(b) 0.50 m
(c) 1 m
(d) 0.75 m

18. A concave lens is kept in contact with a convex lens of focal length 20 cm. The combination works as converging lens of the focal length 100 cm. The power of concave lens is

(a) – D
(b) – 2 D
(c) – 4 D
(d) 4 D

19. The linear magnification of a convex is – 1 when object in front of the lens is

(a) At infinity
(b) At focus
(c) At 2 F_1
(d) Between F_1 and 2 F_1

20. An object is held at 40 cm from a concave lens of focal length 60 cm. The distance of the image from the lens is

(a) – 24 cm
(b) 24 cm
(c) – 60 cm
(d) + 60 cm

21. If a glass is placed in a liquid of refractive index that is equal to glass, it will

(a) Enlarge
(b) Disappear
(c) Shine
(d) Become tiny

22. The focal length of a combination of convex lens of power 1 D and concave lens of power – 1.5 D is

(a) – 0.5 m
(b) – 1.5 m
(c) – 2 m
(d) 2.5 m

23. A concave mirror produces three times magnified real image of an object placed at 10 cm in front of it. The image is located at

(a) 30 cm in front of the mirror
(b) 30 cm behind the mirror
(c) 60 cm in front of the mirror
(d) 60 cm behind the mirror

24. One dioptre is the power of lens of focal length

(a) 100 metre
(b) 1 metre
(c) 10 metre
(d) 1 centimetre

25. The power of a concave lens of focal length 2 m is

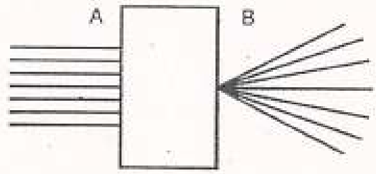
(a) – 0.5 D
(b) 0.5 D
(c) 2 D
(d) – 2 D

26. Which of the following can make a parallel beam of light when light from a point source incident on it ?

(a) Convex mirror as well as concave lens
(b) Concave mirror as well as convex lens
(c) Both concave and convex mirror
(d) Both concave and convex lens

27. A beam of light is incident through the holes on side A and emerge out of the holes on the side B of the box as shown in the figure ? Which of the following could be inside the box ?

(a) Concave lens
(b) Rectangular glass slab
(c) Convex lens
(d) Prism



28. Which of the following statement is true?
   (a) A convex lens has – 4 dioptre power having a focal length 0.25 m
   (b) A concave lens has 4 dioptre power having a focal length 0.50 m
   (c) A concave lens has – 4 dioptre power having a focal length 0.25 m
   (d) A convex lens has 4 dioptre power having a focal length 0.25 m

29. Magnification produced by a rear view mirror fitted in which lens is
   (a) Less than one
   (b) More than one
   (c) Equal to one
   (d) Can be more or less than one depending upon the position of the object in front of it.

40. A full length image of a distant tall building can definitely be seen by using
   (a) A concave mirror
   (b) A convex mirror
   (c) A plane mirror
   (d) Both concave as well as plane mirror

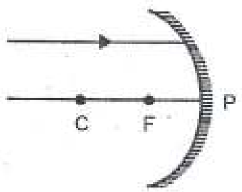
31. In torches, search lights and headlights of vehicles, the bulb is placed
   (a) Very near to the focus of the reflector
   (b) Between the pole and the focus of the reflector
   (c) At the centre of curvature of the reflector
   (d) Between the focus and centre of curvature of the reflector

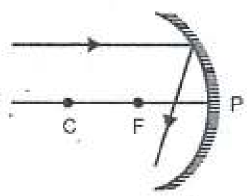
32. When a ray of light is incident (coming out) from a glass slab into the air, then the reflected ray will be
   (a) Near to the normal
   (b) Away from the normal
   (c) On the same path of the normal
   (d) Reflected back in the glass slab

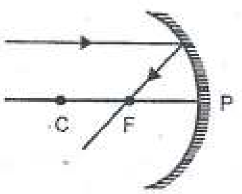
33. Which of the following has a very high refractive index ?
   (a) Water
   (b) Ice
   (c) Diamond
   (d) Crown glass

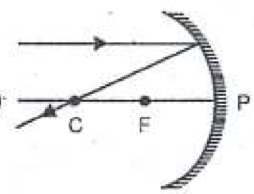
34. You are given water, mustard, oil glycerine and kerosene. In which of these media a ray of light incident obliquely at same angle would bend the most?
   (a) Kerosene
   (b) Water
   (c) Mustard oil
   (d) Glycerine

35. Which of the following ray diagrams is correct for the ray of light incident on a concave mirror ?

(a)


(b)


(c)


(d)


36. A child is standing in front of magic mirror. He finds the image of his head bigger, the middle portion of his body of the same size and that of legs smaller. The following is the order of combinations for the magic mirror from the top.

(a) Concave, plane and convex
(b) Plane, convex and concave
(c) Convex, plane and concave
(d) Convex, concave and place

37. In which mirror will the image of an object placed at infinity be highly diminished and point sized.

(a) Concave mirror only
(b) Convex mirror only
(c) Convex lens only
(d) In all lenses and mirrors

38. You have caught your left ear but it appears that you have caught your right ear, it means you are standing in front of a

(a) Concave mirror
(b) Plane mirror
(c) Convex mirror
(d) Transparent glass

39. If an object is placed at infinity in front of a convex lens, the image of the object formed will be

(a) Real, at focus and equal to the object
(b) Virtual, at focus and equal to the object
(c) Real, inverted at focus and highly diminished
(d) Real, inverted at focus and larger than the object

40. The linear magnification of a convex lens

(a) Is always positive
(b) Is always negative
(c) May be positive or negative
(d) Cannot say

41. The image formed by a convex lens is virtual and erect only when object is held

(a) At F
(b) At 2 F
(c) Between F and C
(d) Cannot say

42. You are provided with a convex lens of focal length 20 cm. To obtain a real inverted and magnified image of an object, distance of object from lens must be

(a) 20 cm
(b) 40 cm
(c) 30 cm
(d) 60 cm

43. A virtual, erect and magnified image is formed by a convex lens of focal length 10 cm. The distance of object from the lens is

(a) 10 cm
(b) 5 cm
(c) 20 cm
(d) 30 cm

44. You are provided with a convex lens of F = 50 cm. To obtain a smaller inverted image, the distance of the object from the lens should be

(a) 50 cm
(b) 75 cm
(c) 100 cm
(d) 120 cm

45. A student performs the experiment on tracing the path of ray of a light passing through a rectangular glass slab for different angles of incidence. He measures the angle of incidence $\angle i$, angle of refraction $\angle r$ and angle of emergence $\angle e$ for all his observations. He would find in all cases

(a) $\angle i$ is more than $\angle r$ but nearly equal to $\angle e$
(b) $\angle i$ is less than $\angle r$ but nearly equal to $\angle e$
(c) $\angle i$ is more than $\angle e$ but nearly equal to $\angle r$
(d) $\angle i$ is less than $\angle e$ but nearly equal to $\angle r$

Answer Key

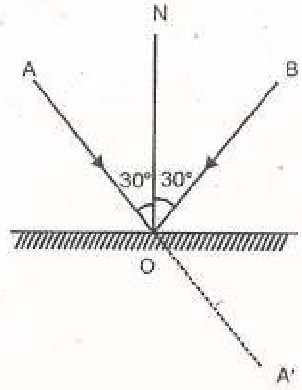
1. (b)	2. (c)	3. (d)	4. (b)	5. (d)	6. (a)	7. (a)	8. (a)	9. (c)	10. (b)
11. (d)	12. (c)	13. (a)	14. (c)	15. (b)	16. (a)	17. (d)	18. (c)	19. (c)	20. (a)
21. (b)	22. (c)	23. (a)	24. (b)	25. (a)	26. (b)	27. (c)	28. (d)	29. (a)	30. (b)
31. (a)	32. (b)	33. (c)	34. (d)	35. (c)	36. (a)	37. (d)	38. (b)	39. (c)	40. (c)
41. (c)	42. (c)	43. (b)	44. (d)	45. (a)					

Hints and Solutions

3. (d)

$\angle AON = i = 30° = r = \angle NOB$

Ray AA′ deviates such that angle of



Deviation $\angle A'OB = 180° - 30° - 30° = 120°$

4. (b)

As image is far behind the mirror an the object is in front of the mirror, therefore the image will move towards him with double the speed *i.e.*, $2 \times 5 = 10$ m/s

5. (d)

$m = \frac{-v}{u}$. For a convex mirror, v is –ive, thus m becomes positive.

6. (a)

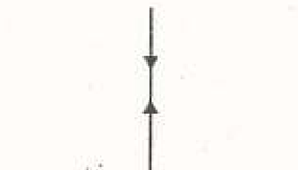
$u = -5$ cm, $m = -4$ [when the image is real, it is inverted, m is negative]

As $m = \frac{-v}{u} \Rightarrow v = -mu = -(-4)(-5) = -20$ cm

Now, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{-20} + \frac{1}{-5} = \frac{-1-4}{20} = \frac{-1}{4}$

$f = -4$ cm

8. (a)



For the ray falling normally,

$\angle i = 0° = \angle r$

Therefore reflected ray retraces its path

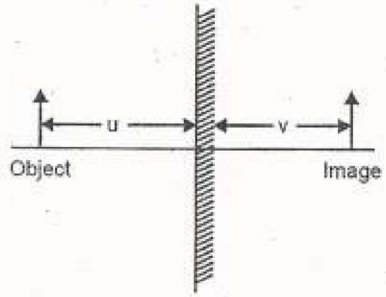
9. (c)

$m = \frac{h_2}{h_1} = \frac{I}{O}$, $m = 5$, $h_2 = 20$ cm

$\therefore h_1 = \frac{h}{m}\ \frac{20}{5} = 4$ cm

10. (b)

The image formed in a plane mirror is as far behind the mirror as the object is in front of the mirror



$u = v = 10$

Therefore, distance between object and image $u + v = 2u = 2 \times 10 = 20$ cm

11. (d)

$m = \frac{1}{3}$, $f = 15$ cm

$m = -\frac{v}{u} = \frac{1}{3} \Rightarrow v = \frac{u}{3}$

For mirror, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{-3}{u} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{-2}{u} + \frac{1}{f}$

$u = -2f$

$= -2 \times 15$

$= -30$ cm

12. (c)

When the object is hold at $2F_1$ of convex lens, the image is formed on the other side the lens of $2F_2$ and is real and inverted.

13. (a)

$P = P_1 + P_2 = 4\,D + (-10\,D) = -6\,D$

14. (c)

In case of a convex lens, an object placed at 2 F from the lens forms an inverted image of the equal size at the other side of the lens at 2 F distance.

15. (b)

The case is of convex lens

16. (a)

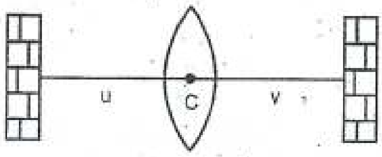
The parallel ray after refraction pass through focus on the other side of the convex lens.

17. (d)

u + v = 3 m (given)

As maximum distance between an object and image in case of a convex lens = 4 f

$4\,f = 3\,m \Rightarrow f = \frac{3}{4}\,m = 0.75\,m$



18. (c)

f_1 of convex lens = 20 cm, $P_1 = \frac{100}{f_1} = 5\,D$

combined focal length F = 100 cm, combined power of $P = \frac{100}{F.} = \frac{100}{100} = 1\,D$

$P = P_1 + P_2 \Rightarrow P_2$ (of concave lens) $= P - P_1 = D - 5\,D = -4\,D$

19. (c)

In a convex lens, when object is in front of the lens at 2 F_1, an inverted image of size of object ($h_2 = h_1$) is formed at $2F_2$. Therefore, m = – 1.

20. (a)

u = – 40 cm, f = – 60 cm

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{-60} + \frac{1}{-40} = \frac{-5}{120}$

$v = -\frac{120}{-5} = -24$ cm

22. (c)

$P = P_1 + P_2 = 1\,D + (-1.5\,D) = -0.5\,D$

$P = \frac{100}{F} = -0.5 \Rightarrow F = -\frac{100}{0.5} = -200\text{ cm} = -2\text{m}$

23. (a)

A concave mirror producing real image is always inverted *i.e.*, h_2 is negative, then m is also negative.

m = – 3; u = – 10 cm;

$m = \frac{-v}{u} \Rightarrow v = -mu = -(-3)(-10\text{ cm})$

= – 30 cm

Since v is also negative, image is formed in front of the mirror.

25. (a)

f = – 2 m = – 200 cm

$F = \frac{100}{f\text{ (cm)}} = \frac{100}{-200}\ -0.5\,D$

26. (b)

When a point source is held at focus of a concave mirror or a convex lens, we get a parallel beam of light.

27. (c)

A convex lens alone can deviate the rays as shown in the figure.

28. (d)

$P = \frac{1}{f} \Rightarrow f = \frac{1}{P} = \frac{1}{4} = 0.25$ cm

29. (a)

A rear view mirror used in vehicles is a convex mirror whose magnification is always less than one.

30. (b)

A full length image of a tall object can definitely be seen using a convex mirror.

34. (d)

A ray of light incident obliquely at some angle would bend the most in the liquid whose refractive index is maximum.

35. (c)

The ray of light incident on a concave mirror in a direction parallel to principal axis must pass through focus F on reflection from the mirror.

36. (a)

As image of head is bigger, the top portion of magic mirror must be concave. The middle portion appears to be of same size, therefore, middle portion of magic mirror must be plane. As image of his legs appear smaller, the bottom of magic mirror must be convex.

43. (b)

For a virtual, erect and magnified image, object lie between F and C. If F = 10 cm, r = $\frac{F}{2}$ = 5 cm which is OC.

44. (d)

For a smaller inverted image, object has to be beyond 2 F *i.e.*, greater than 100 cm in this case.

2. Human Eye and colourful World

Learning Objectives

* The Human Eye and its Working
* Power of Accommodation of Human Eye
* Defects of Vision
    * Myopia
    * Hypermetropia
    * Presbyopia
    * Astigmatism
* Refraction of Light Through a Prism
* Dispersion of White Light by a Glass Prism
* Atmospheric Refraction
    * Twinkling of stars
    * Blue colour of clear sky
    * Redness of sun at sunrise and sunset
    * Scattering of light
    * Tyndall effect

The Human Eye

Human eye is considered as one of the most sensitive and most important sense organ. It uses light and enables us to see. It works on the refraction of light through eye lens inside the eye ball.

Parts of Human Eye

Cornea

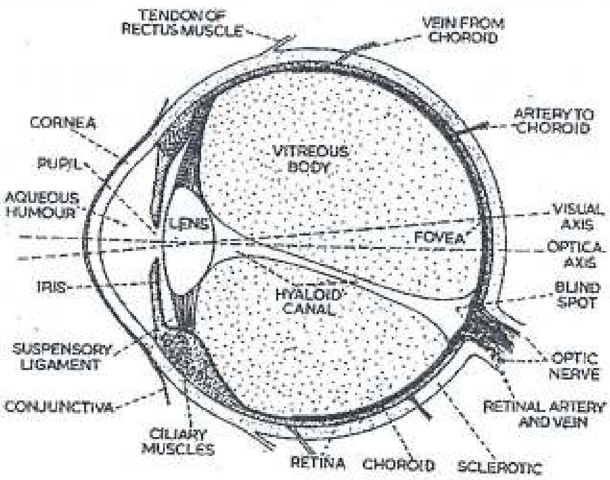
It is the front transparent part of the eye which is bulged outwards. Cornea serves as the window of the eye. Light from objects to be seen enters the eye through the cornea.

Iris

Behind the cornea, is a circular diaphragm called iris. The iris has muscles and coloured pigment which decides the colour of the eye.

Pupil

The hole in the centre of cornea is called pupil.



Human Eye
Fig. 2.1

Key Note: The function of iris is to control and regulate the amount of light entering the eye by adjusting the size of the pupil.

- **Eye lens**

Behind the pupil is a double convex lens, called the eye lens. This lens is made up of fibrous, jelly like matter, and is held in position by the ciliary muscles on both sides. The focal length and hence converging power of eye lens is not fixed. It is adjustable, because its curvature can be modified to some extent by the ciliary muscles.

Retina

Behind the eye lens and at the back part of the eye ball is a screen called retina on which image of the object is formed. The retina contains numerous light sensitive cells in the form of *rods* and *cones*.

Eye lid

An eye lid in front of human eye acts like shutter in a camera.

Blind spot

The least sensitive spot on the retina is called the blind spot. The blind spot, is where the optic nerve enters the eye ball.

Optic nerve

Rod type cells respond to intensity of light and cone type cells respond to the colour of light. These cells get activated upon illumination and generate electric signals or nerve impulses which are sent to the brain via optic nerve.

Aqueous humour

The space between cornea and eye lens is filled with a viscous liquid called aqueous humour.

Vitreous humour

The space between eye lens and retina contains a transparent jelly called vitreous humour.

Working of the Human Eye

Light rays coming from the object AB enter the eye through cornea and fall on the eye lens through the pupil of the eye. The eye lens being convex, forms a real, inverted and smaller image of the object on the retina. The rod and cone type cells of retina get activated by the light falling on the retina and generate electrical signals or nerve impulses, which are sent to the brain via optic nerve. The brain processes this information and we perceive object as they are *i.e.*, without inversion.

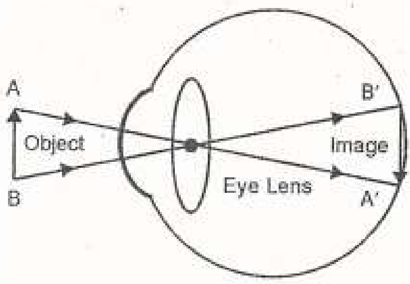


Fig. 2.2

Colour blindness

It is said to occur when a person cannot distinguish between different colours, through his vision may otherwise be normal. This is because retina of eye such as a person does not possess some specific cone cells. For example, a person who is blind to green colour may be deficient in cone cells having green pigment in the retina of his eyes.

Power of Accommodation of Human Eye

The ability of the eye to observe distinctly the objects situated at widely different distances from the eye is called accommodation or power of accommodation of the eye. This is due to the **action of ciliary muscles** holding the eye lens.

- For observing distance objects (say at infinity), the ciliary muscles are released. The eye lens is thin, and it has maximum focal length and minimum covering power. The image of the distance object is formed on the retina. This, **for observing distant objects, eye is in relaxed state. It is said to be unaccommodated.**

- The most distant point at which an object can be seen clearly is called **Far point (F)** of the eye. For a normal eye, far point lies at infinity.
- The point at closet distance at which an object can be seen clearly by the eye is called **Near Point (N)** of the eye. The distance of the near point of a normal eye is called the least distance of distinct vision, represented by d.
- For a normal eye, value of least distance of distinct vision is d = 25 cm. This distance increases with age, because of weak ciliary muscles and loss of flexibility of the eye lens.
- The distance between the near point N and far point F of the eye is called **Range of Vision.**
- The maximum power of accommodation of the eye for a person having normal vision (d = 25 cm) is $P = \frac{100}{f} = \frac{100}{25} = 4$ dioptre.

Defects of Vision

Sometimes, the eye may lose its power of accommodation, the vision becomes blurred due to the refractive defects of eyes. In such conditions, a man cannot see the object clearly and comfortably. There may be different reasons for different defect of vision.

Myopia or short sightedness

It is that defect of human eye by virtue of which it can see clearly the objects lying at short distances from it but the far off objects cannot be seen clearly. **Myopia is a common name for impaired vision.** In a myopic eye *image is formed in front of retina.*

Causes: This defect arises because the power of the eye is too large due to the decrease in focal length of the crystalline lens. This may arise due to either (i) excessive curvature of the cornea or (ii) elongation of the eyeball.

Correction: This defect can be **corrected using a concave lens.** A concave lens of appropriate power or focal length is able to bring the image of the object back on the retina itself and not in front of the retina.

Key Note: Focal length of concave lens used for correcting the myopic eye is equal to the distance of far point (F) of the myopic eye.

Hypermetropia or long sightedness

It is that defect of human eye, by virtue of which it can see clearly the objects lying at large distances from it. But the nearby objects cannot be seen clearly by the hypermetropic eye. **Hypermetropia is the common name for defect in vision.** In this case, *the image is formed behind the retina.*

Causes: This defect arises because either (i) the focal length of the eye lens is too great, or (ii) the eyeball becomes too short, so that light rays from the nearby object, say at point N, cannot be brought to focus on the retina to give a distinct image.

Correction: This defect can be corrected by using a convex lens of appropriate focal length. When the object is at N′, the eye exerts its maximum power of accommodation. Eyeglass with converging lenses supply the additional focusing power required for forming the image on the retina.

Key Note: When a person suffers from both Myopia as well as Hypermetropia his spectacles for correction have bifocal lenses. The upper half is a concave lens for distant vision and lower half is convex lens for reading.

Presbyopia or old sight

It is a progressive from of for sightedness, in which an old person cannot read and write comfortably. It affects most people by the age of early 60s. That is why it is also called old sight. Most people find that the near point gradually decreases.

Causes: Old sigh arrises due to gradual weakening of the ciliary muscles and domininshing flexibility of the crystalline lens.

Correction: Simple reading eyeglass with convex lenses correct most cases of presbyopia.

Astigmatism
It is a defect in the outer curvature on the surface of the eye that causes distorted vision. A person suffering from astigmatism cannot simultaneously focus on both horizontal and vertical lines.

Causes: This defect is usually due to the cornea that is not perfectly spherical

Correction: This defect can be corrected by using eyeglasses with cylindrical lenses oriented to compensate for the irregularities in the cornea.

Refraction of Light Through a Prism

When the light passes through the glass prism it bends towards the base of the prism. When the light ray is incidented on glass prism, it undergoes refraction while passing through the glass prism. The angle between the incident ray and emergent ray is called the angle of deviation.

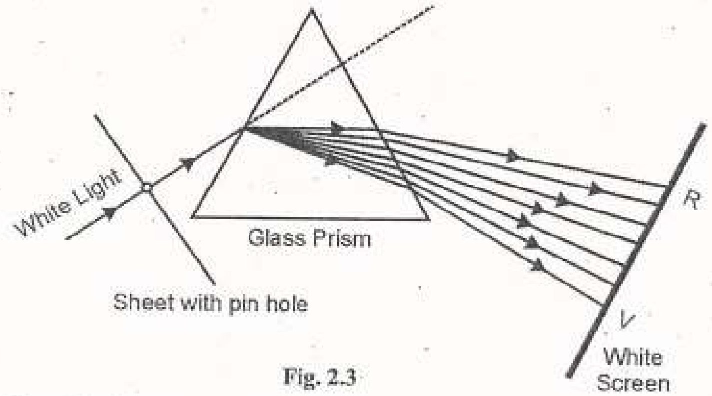


Fig. 2.3

Dispersion of White Light by a Glass Prism

When the white light is allowed to pass through the prism, it spilts up into its constituent colours, called **spectrum.** Spectrum is the band of seven colours popularly known as **VIBGYOR**. This splitting of white light into seven colours is called **the dispersion of light.** Each constituent colours has different angle of refraction. The red colour undergoes least deviation and the violet colour undergoes maximum deviation.

Rainbow: One of the most beautiful example of **dispersion of light** is the formation of rainbow, soon after rainfall in the sky. It is also called the **natural spectrum.** Soon after rainfall when the sun comes out, the sunlight falls on the tiny droplets of water hanging in the atmosphere and undergoes dispersion into its constituent colours and appears as band of seven colours in the sky, in the form of rainbow. The raindrops acts as prism in the atmosphere.

Atmospheric Refraction

Our atmosphere is made of different layers having different optical density. When the light passes through these different layers, it undergoes refraction, which is called the **atmospheric refraction.** Light coming from stars after entering earth's atmosphere passes from rarer to denser layers. Therefore, it suffers multiple refractions before reaching the surface of the earth. Some of the phenomena based on atmospheric refraction and total internal reflection of light are discussed below.

Twinkling of stars

We know that stars have the light of their own and their light passes through different densities of the atmosphere causing refraction. When atmosphere refracts more light towards us, it appears to be bright. When it refracts less light, it appears to be dim. This effect is called twinkling of stars.

Blue colour of clear sky

The sunlight is made up of seven colours and when this mixture of seven colours passes through the atmosphere, most of the longer wavelength lights do not get scattered much by air particles and passes straight through the atmosphere.

However, the shorter wavelength blue colour light gets scattered all around the sky by air molecules in the atmosphere and our eyes receives only this blue colour and hence sky appears blue to us. It there would have been no atmosphere, the sky would have appeared black to us, as it appears in the outer space at night.

Reddishness of sun at sunrise and sunset

At the time of sunrise and sun set, the sun is near the horizon and the sunlight has to travel the long distance through the atmosphere, before reaching our eyes. During the journey most of the shorter wavelength of the sunlight gets scattered away in the atmosphere and only the longer wavelength of light i.e., red light reaches our eyes. Hence, the sun appears reddish during sunrise and sunset.

Scattering of light

Scattering of light is the phenomenon of change in the direction of light on striking an obstacle like an atom, a molecule, dust particle, water droplet, etc. The scattering involves bouncing off electromagnetic radiation by atoms / molecules of the medium through which they are travelling.

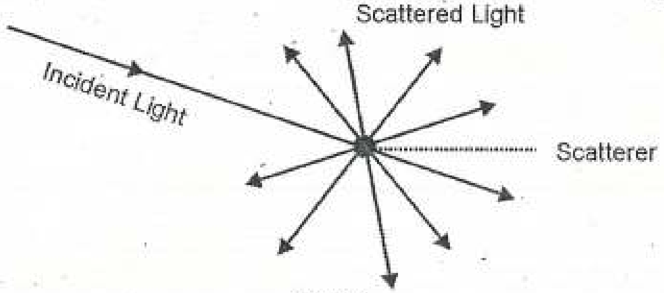


Fig. 2.4

Thus, light rays of helter-skelter on striking obstacles in their path. As sunlight travels through the atmosphere of earth, it gets scattered from the large number of atoms/molecules present on the atmosphere. **Lord Rayleigh** studied this elastic scattering, he established that 'intensity of scattered light (I_s) varies inversely as the fourth power of the wavelength of incident light *i.e.*, $I_s \propto \frac{1}{\lambda^4}$'.

Another important factor in scattering of light is the relative size of the scatters (say x) compared to the wavelength of light (λ).

For $x << \lambda$ *i.e.*, when size of scatters is much less than the wavelength of light, Rayleigh scattering is valid.

For $x >> \lambda$ *i.e.*, when size of scatters is much larger than the wavelength of light, Rayleigh scattering is not valid. In that event, all wavelengths are scattered approve equally.

Tyndall effect

The earth's atmosphere is a heterogeneous mixture of minute particles such as smoke, tiny water droplets, suspended particles of dust and molecule of air. When a beam of light strikes such fine particles, the path of the beam becomes visible. The light reaches us after being reflected diffusely by these particles. The phenomenon of scattering of light by the colloidal particles give rise to Tyndall effect.

Tyndal effect can also be seen when sunlight passes through a canopy of a dense forest. Here, tiny water droplets in the mist scatter light. The colour of the scattered light depends on the size of the scattering particles. Very fine particles scatter mainly blue light while particles of larger size scatter light of longer wavelengths. If the size of the scattering particles is large enough, then the scattered light may even appear white.

Key Note: Very fine particles scatter mainly blue light of smaller wavelength; larger particles scatter mainly red light; when size of the particles are pretty larger, all wavelengths are scattered almost equally and the scattered light appears white.

Key Points

- ✓ Light rays coming from an object enter the eye through cornea, and fall on the eye lens through the pupil of the eye. As the eye lens is double convex lens, it forms a real, inverted and smaller image of the object on the retina.
- ✓ The numerous light sensitive cells contain in the retina of the eye are of the two types : rod shaped cells which respond to brightness or intensity of light; and cone shaped cells, which respond to colour of light. The cone shaped cells enable us to distinguish between different colours.
- ✓ Power of the eye to observe distinctly the objects situated at widely different distances from the eye is called power of accommodation of eye. This is achieved by the action of cilinary muscles holding the eye lens.
- ✓ The most distance point at which an object can be seen clearly is called far point (F) of the eye. For normal eye, far point is at infinity.
- ✓ The point at closest distance, at which an object can be seen clearly by the eye is called near point (N) of the eye. For normal eye, near point is at 25 cm, which is called the least distance of distinct vision of normal eye.
- ✓ Four common defects of vision are — Myopia (short sightedness); Hypermetropia (long sightedness); Presbyopia (old sight); and Astigmatism.
- ✓ When a person suffers from both the myopia as well as hypermetropia, his spectacles for correction have bifocal lenses. The upper half is a concave lens for distant vision and lower half is a convex lens for near vision like reading.
- ✓ Dispersion of light is the phenomenon of splinting of white light into its constituent seven colours on passing through a glass prism. The band of seven colours so obtained is called visible spectrum.
- ✓ Different colours undergo different deviations on passing through the prism. Hence, different colours from the prism along different directions causing dispersion.
- ✓ Rainbow is a good example of dispersion of white light in nature. Sunlight disperses on passing through tiny droplets of water suspended in air during or after a shower.
- ✓ Atmospheric refraction is the phenomenon of bending of light on passing through earth's atmosphere. This is because upper layers of earth's atmosphere are rarer compared to the lower layers.

- ✓ Scattering involves bouncing off of electromagnetic radiations by atoms/molecules of the medium through which they are travelling. When size of scatterer (x) is very much less than wavelength (x) of light, Rayleigh scattering is valid.
- ✓ Tyndall effect deals with the phenomenon of scattering of light by colloidal particles. On the basis of scattering, we can account for blue colour of clear sky, white colour of clouds, reddish colour of sun at sunrise and sunset, etc.

Multiple Choice Questions

1. The far point of a myopic eye is at 50 cm. The power of the lens to correct his vision is
   (a) -4 D
   (b) -2 D
   (c) $+2$ D
   (d) $+4$ D
2. The human eye can see both nearby and distant objects clearly. This is because
   (a) The ciliary muscles connected to the eye lens can adjust its focus
   (b) The least distance of distinct human vision of 25 cm.
   (c) The retina can change position
   (d) All of the above
3. Human eye is more or less like a
   (a) Microscope
   (b) Telescope
   (c) Camera
   (d) None of these
4. A person needs glasses for driving is suffering from which defect in his vision ?
   (a) Hypermetropia
   (b) Presbyopia
   (c) Astamagtism
   (d) Myopia
5. The function of iris is to regulate the amount of light entering the eye by adjusting the size of
   (a) Pupil
   (b) Cornea
   (c) Iris
   (d) Retina
6. The change in focal length of an eye lens to focus the image of the objects at varying distances is done by the action of
   (a) Retina
   (b) Ciliary muscles
   (c) Iris
   (d) Pupil
7. The splitting up of the light into its constituent colours, and the coloured bands so obtained on the screen are called
   (a) Dispersion
   (b) Scattering
   (c) Spectrum
   (d) Refraction
8. The cells which enable us to distinguish between different colours are
   (a) Rod shaped
   (b) Cone shaped
   (c) Both types of cells
   (d) None of these
9. The property of eye which is used in cinematography is
   (a) Persistence of vision
   (b) Power of accommodation
   (c) Colour blindness
   (d) Range of vision
10. Cataract is a flow that arises when eye lens of person becomes
    (a) Hazy (opaque)
    (b) Transparent
    (c) Black
    (d) None of these
11. The essential condition for Rayleigh's elastic scattering is
    (a) Size of scatterer (x) must be much less then the wavelength of light (λ) incident *i.e.*, $x << \lambda$
    (b) $x >> \lambda$
    (c) $x = \lambda$
    (d) independent of x and λ

12. The deviation of a ray of light passing through a prism depends on
    (a) angle of prism
    (b) nature of material of the prism
    (c) angle of incidence of the ray
    (d) All of the above
13. The longest visible wavelength 800.0A° is of ...... colour
    (a) Violet
    (b) Red
    (c) Green
    (d) Orange
14. What is the frequency of violet colour of wavelength 4000 A° ?
    (a) 3.5×10^{14} Hz
    (b) 3.75×10^{14} Hz
    (c) 7.5×10^{14} Hz
    (d) 7.25×10^{14} Hz.
15. The cause of advanced sunrise and delayed sunset is
    (a) Scattering of sunlight
    (b) Dispersion
    (c) Atmospheric refraction
    (d) None of these
16. Blue colour of clear sky is on account of
    (a) Scattering of sunlight
    (b) Dispersion
    (c) Atmospheric refraction
    (d) None of these
17. The intensity of scattered light (I_s) varies inversely as the .... power of wavelength (λ).
    (a) First
    (b) Second
    (c) Third
    (d) Fourth
18. The intensity of scattered violet light is .... times the intensity of scattered red light.
    (a) Four
    (b) Eight
    (c) Sixteen
    (d) Two
19. How many times does a ray of light bend on passing through prism ?
    (a) once
    (b) twice
    (c) thrice
    (d) four times
20. The visible part of electromagnetic spectrum lies in between
    (a) Ultraviolet and infrared rays
    (b) Infrared and microwave rays
    (c) X-ray and infrared rays
    (d) X-ray and gamma rays
21. The refractive index of glass is 3/2. Velocity of light in glass would be
    (a) 3×10^8 m/s
    (b) 2×10^8 m/s
    (c) 10^8 m/s
    (d) 1.33×10^8 m/s
22. A student sitting on the last bench can read the letters written on the blackboard but is unable to read from his textbook. Which of the following statements is correct ?
    (a) The near point A his eyes has receded away
    (b) The near point A his eyes has closer to him
    (c) The far point A his eyes has closed to him
    (d) The far point A his eyes has receded away
23. At noon, the sun appears white as
    (a) Blue colour is scattered the most
    (b) Red colour is scattered the most
    (c) All the colours of white light are scattered away
    (d) Light is least scattered

24. If a body appears red colour in light, the real colour of the body is
   (a) Definitely white
   (b) Definitely red
   (c) Either red or white
   (d) Any colour except red and white

25. Which of the following phenomena of light are involved in formation of a rainbow ?
   (a) Reflection, refraction and dispersion
   (b) Refraction, dispersion and total internal reflection
   (c) Refraction, dispersion and internal reflection
   (d) Dispersion, scattering and total internal reflection

26. Which of the following contributes significantly to the reddish appearance of the sun at sunrise and sunset ?
   (a) Scattering of light
   (b) Dispersion of light
   (c) Total internal reflection of light
   (d) Reflection of light from the earth

27. The bluish colour of water in deep sea is due to
   (a) The presence of algae in water
   (b) Reflection of sky in water
   (c) Scattering of light
   (d) absorption of light by the sea

28. When light rays enter the eye, most of the refraction occrues of the
   (a) Iris
   (b) Pupil
   (c) Outer surface of the cornea
   (d) Crystalline lens

29. The focal length of the eye lens increases when eye muscles
   (a) Are released and lens becomes thinner
   (b) Contract and lens becomes thicker
   (c) Are released and lens becomes thicker
   (d) Contract and lens becomes thinner

30. A glass prism has
   (a) Six rectangular surfaces
   (b) Four rectangular surfaces
   (c) Two triangular bases and their rectangular surfaces
   (d) None of these

31. In passing through a glass prism, a ray of light undergoes how many refractions ?
   (a) One
   (b) Two
   (c) Three
   (d) Four

32. If A is angle of prism D is angle of deviation, i is angle of incidence and e is the angle of emergence through a prism, then the correct relation between the four angles is
   (a) $A + i = D + e$
   (b) $A + D = i + e$
   (c) $A + e = D + i$
   (d) $A + i + e = D$

33. Angle of deviation through a prism of angle 60°, when angles of incidence and emergence are 40° each is
   (a) 40°
   (b) 20°
   (c) 60°
   (d) 30°

34. Dispersion of light through a prism is
   (a) Same as reflection
   (b) Same as refraction
   (c) Splitting of white light into its constituent colours
   (d) None of these

35. …….. is at the lower end and ……is at the upper end of the visible spectrum

(a) Violet, red
(b) Red, blue
(c) Red, violet
(d) Blue, red

36. Wavelength of violet and red colour lights are

(a) 4000 A°, 6000 A°
(b) 7900 A°, 4000 A°
(c) 4000 A°, 9000 A°
(d) 4000 A°, 7900 A°

37. The basic cause of dispersion of white light on passing through a glass prism is

(a) Same wavelength of different colours
(b) Different wavelengths of different colours
(c) Different colours travel through glass prism with same speed
(d) None of these

38. If angle of deviation of light through a prism of angle 60° is 40°, angle of incidence (being equal to angle of emergence) would be

(a) 50°
(b) 60°
(c) 40°
(d) None of these

39. Which phenomenon is not explained on scattering of light ?

(a) Red colour of danger signals
(b) Blue colour of the clear sky
(c) White colour of clouds
(d) Advanced sunrise

40. Which of the following phenomena cannot be explained by scattering of light ?

(a) Blue colour of the sky
(b) White colour of the clouds
(c) Formation of rainbow
(d) Tyndall effect

Answer Key

1. (b)	2. (a)	3. (c)	4. (d)	4. (a)	6. (b)	7. (c)	8. (b)	9. (a)	10. (a)
11. (a)	12. (d)	13. (b)	14. (c)	15. (c)	16. (a)	17. (d)	18. (c)	19. (b)	20. (a)
21. (b)	22. (a)	23. (d)	24. (c)	25. (c)	26. (a)	27. (c)	28. (c)	29. (a)	30. (c)
31. (b)	32. (b)	33. (b)	34. (c)	35. (a)	36. (d)	37. (b)	38. (a)	39. (d)	40. (c)

Hints and Solutions

1. (b)

Here, distance of far point $x = 50$ cm

As $f = -x$ ∴ $f = -50$ cm

Power, $P = \frac{100}{f} = \frac{100}{-50} = -2$ dioptre

Negative sign indicates that the lens used is concave

14. (c)

$F = \frac{C}{\lambda} = \frac{3\times10^8 \text{ m/s}}{4000\times10^{-10}\text{m}} = 7.5\times10^{14}$ Hz

17. (d)

$I_s \alpha \frac{1}{\lambda^4}$

18. (c)

$\frac{(I_s)_v}{(I_s)_r} = \left(\frac{\lambda_r}{\lambda_v}\right)^4 = \left(\frac{8000 \text{ A}^\circ}{4000 \text{ A}^\circ}\right)^4 = 2^4 = 16$

19. (b)

A ray of light entering a prism is refracted twice. Therefore, it bends twice on a passing through the prism

21. (b)

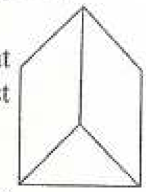
$n = \frac{3}{2}$ $\qquad V_g = 3\times10^8\times\frac{2}{3}$

25. (c)

In the formation of a rainbow, sun rays through rain drops undergo first refraction, then dispersion and finally internal reflection before coming out of the rain droplets.

26. (a)

Reddish appearance of the sun at sunrise or sunset is due to least scattering of red light.



30. (c)

The prism can be seen as the roof top of a hut as shown in the figure.

31. (b)

A ray of light undergoes two refractions at the two faces of the prism

33. (b)

$A = 60^\circ$, $\angle i = \angle e = 40^\circ$

As $A + D = i + e$ ∴ $60^\circ = D = 40^\circ + 40^\circ \Rightarrow D = 80^\circ - 60^\circ = 20^\circ$

38. (a)

$A = 60^\circ$, $D = 40^\circ$, $i + e = A + D \Rightarrow 2i = 2e = A + D$

$i = e$ (given) ∴ $i = e = \frac{A+D}{2} = \frac{60^\circ + 40^\circ}{2} = 50$

39. (d)

Advanced sunrise is due to atmospheric refraction.

3. Electricity

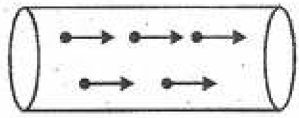
Learning Objectives

* Electric Current and Electric Circuit
* Electric Potential Difference
* Ohm's Law
* Resistance, Factors Affecting it
* Resistively or Apecific Resistance
* Combination of Resistors in Series and Parallel
* Heating Effect of Electric Current
* Electrical Power
* Domestic Circuit

Electric Current

The flow of charges in a conductor is known as **electric current.** In a metallic conductor, there are free electrons which have negative charges, and these electrons can move from one part to another part of the conductor. They are the charge carriers. The flow of these electrons in a conductor constitute electric current.

Definition of electric current: 'An electric current is defined as the amount of the charge flowing through a conductor in unit time.



Charge moving through a wire conducter
Fig. 3.1

Let Q be the charge flowing through a conductor in time **t**, then electric current **I** is given by the equations :

$$\text{Electric current} = \frac{\text{Charge}}{\text{Time}}$$

Or

$$I = \frac{q}{t}$$

Where, I = electric current
q = charge
t = time

Key Notes: (i) S.I. Unit of electric current is Ampere (A). We know that unit of charge (Q) is coulomb (C) and unit of time (t) is second (s). Therefore, $1 \text{ ampre (A)} = \frac{1\text{coulomb(c)}}{1\text{Second(s)}} = 1\text{cs}^{-1}$

(ii) Unit of electric current was named in the honour of Andre Ampere, the French scientist.

(iii) An electron possess a negative charge of 1.6×10^{-19} C.

***Example* 1:** A current of 0.5A is drawn by filament for an electric bulb for 5 minutes. Find the amount of the electric charge that flows through the circuit.

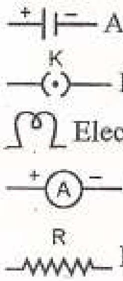
Solution:

$I = 0.5\ A,\ t = 5\ \text{minutes} = 300s$

We know that $I = \frac{Q}{t} \Rightarrow Q = It = 0.5\ A \times 300S = 150\ C$

Electric Circuit

An electric circuit is a closed conducting path containing a source of electric energy (say, a cells or battery) and device (say, a bulb) or load utilising the electric energy. Here, cell is the source of electric energy and electric bulb is the load symbols used in circuit are



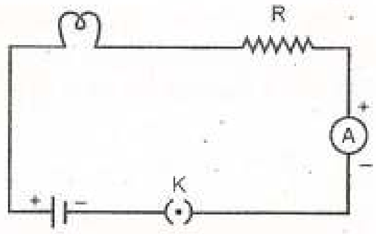
An electric cell

Plug key or closed switch

Electric bulb

Ammeter

Resistance



A closed electric circuit

Fig. 3.2

Electric Potential and Potential Difference

- We define **electric potential** at a point in electric field as the work done in moving a unit positive charge from infinity to that point in the electric field. Electric potential is denoted as V.
- Let W be the work done in moving a charge q from infinity to a point in the electric field, then the electric potential (V) is given as

$$V = \frac{W}{Q}$$

Key Notes: (i) The S.I. unit of potential is volt denoted as V.

(ii) Since work W is measured in Joule and q is in coulomb

Thus, $1\ \text{Volt} = \frac{1\ \text{Joule}}{1\ \text{Coulomb}} = 1\ JC^{-1}$

(iii) Unit of electric potential was named in the honour of the Italian scientist Alessandro Volta.

***Example* 2:** How much work is done in moving a charge of 5 coulomb across two points of a circuit having a potential difference of 15 volts ?

***Solution*:**

$$V = \frac{W}{Q} \Rightarrow W = QV$$

Here, $V = 15,\ Q = 5$

$\therefore\ W = 15\ V \times 5\ C = 75$ Joules

- We define potential difference between two points A and B in an electric circuit carrying some current as the work done to move a unit charge from one point to the other.

Potential difference $(\Delta V) = V_A - V_B = \frac{W}{Q}$

OHM's Law

German physicist George Simon Ohm in 1826 studied the relationship between electric current and potential difference across the ends of a conductor. This relationship is called the Ohm's law. This law states that.

'The electric current flowing in a conductor is directly proportional to the potential difference across the ends of the conductor, provided the temperature and other physical conditions of the conductor remain the same.'

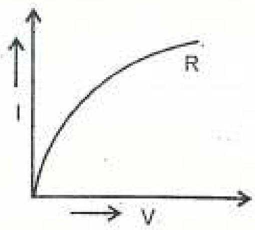


Fig. 3.3

Electric current (I) $\propto$ potential difference (V)

$$I \propto V \Rightarrow V \propto I \quad \text{or} \quad V = IR$$

Here R is a constant.

Where, R is the constant of proportionality and is known as **resistance** of the conductor.

Resistance: Resistance (R) of a conductor is the property of a conductor to oppose the flow of charge through it. It denotes the ratio of potential difference (V) to the current (I) following through the conductor.

$$R = -$$

Unit of resistance is **ohm** denoted by Greek letter **omega**. Its symbol is Ω.

Thus, $1 \text{ ohm} = \frac{1 \text{ volt}}{1 \text{ ampere}} = 1\,VA^{-1}$

Note:

1 Kilo ohm (KW)= $10^3\,\Omega$

1 Mega ohm (MW)= $10^6\,\Omega$

Factors on Which the Resistance of Conductor Depends

There are four factors on which the resistance of a conductor depends.

1. **Length of a conductor:** The resistance of the conductor is directly proportional to the length of the conductor. Hence, longer the wire, more is the resistance and vice versa.

   Resistance R $\propto$ length

2. **Area of cross-section of a conductor:** The resistance of wire is inversely proportional to the area of the cross-section of the wire. If we double the area of cross-section of the wire, the resistance get reduced to half.

   $$\text{Resistance} \propto \frac{1}{\text{Area of cross-section}}$$

   $$R \propto \frac{1}{A}$$

   Thus, the resistance of a thin wire is more than the resistance of thick wire.

3. **Nature of material of wire :** The resistance of the wire also depends on the nature of material of wire. Some material have low resistance and are called **good conductors** like silver, copper, tungsten. Some have, high resistance and are considered **bad conductors** like rubber, glass, dry paper.

4. **Temperature of conductor:** The resistance of the wire is directly proportional to the temperature. The resistance of the pure metal increases with increase in temperature and decreases with the decrease in temperature. But for **alloy** the resistance is almost unaffected by the change in temperature.

   $R \propto T$

Notes: The wire made of copper or aluminium is used for transmission of electricity because they have low resistivity *i.e.*, more current.

Resistivity or Specific Resistance

It is found that resistance of conductor is directly proportional to its length and inversely proportional to its area of cross-section.

$$R \propto l \quad \text{...(i)}$$

$$R \propto \frac{1}{A} \quad \text{...(ii)}$$

From (i) and (ii)

$$R \propto \frac{l}{A} \quad \text{or} \quad R = \frac{\rho l}{A}$$

Where ρ is the constant of proportionality, known as the **resistivity** or **specific resistance** of a conductor. Thus, resistivity of a conductor is defined as the resistance of the conductor of unit length and unit area of cross-section. Thus, resistivity (ρ)

$$\rho = \frac{RA}{l}$$

If, $A = 1$ and $l = 1$, $\rho = R$

Note: In SI, unit of resistivity or specific resistance is **ohm-metre (Ω-m).** Silver has the highest resistivity of 1.6×10^{-8} Ω-m & hence the best conductor of electricity followed by copper with 1.62×10^{-8} Ω-m.

***Example* 3:** Resistance of a metal of length 2 m is 26Ω at 20°C. If the radius of the wire is 0.5 mm, what will be the resistivity of the metal at that temperature ?

***Solution*:** $R = 26\ \Omega$, $l = 2$ m

$$R = 0.5\text{ mm} = 5 \times 10^{-4}\text{ m}$$

Resistivity $$\rho = \frac{RA}{l} = \frac{R\pi r^2}{l}$$

$$\rho = \frac{26 \times 3.14 \times (5 \times 10^{-4})^2}{2} = 1.02 \times 10^{-5}\ \Omega\text{ m}$$

***Example* 4:** A wire of given material having length l and area of cross-section A has resitance of 8 Ω. What would be the resistance of another wire of the same material having length $l/2$ and area of cross-section 2 A.

***Solution*:** For the first wire, $R_1 = \frac{\rho l}{A} = 8\,\Omega$

For the second wire, $R_2 = \rho\frac{l/2}{2A} = \rho\frac{l}{4A}$

Or $$R_2 = \frac{1}{4}\left(\rho\frac{l}{A}\right) = \frac{1}{4}(R_1)$$

$$= \frac{1}{4} \times 8\,\Omega$$

Or $R_2 = 2\ \Omega$

The resistance of the new wire is 2 Ω.

Uses of different materials

- The connecting wires in an electric circuit are made up of copper and Aluminium. Due to low resistivity, electric current passes easily through them.
- Silver is the best conductor of electricity because its resistivity is the lowest among all metals. But due to its high price, copper and aluminium are mostly used for making wires.
- Filament of an electric bulb is made of tungsten metal as tungsten wires does not burn or get oxidised, even at high temperatures. The melting point of tungsten is about 3380°C.
- Heating elements in electric iron, immersion road, toaster, room heater, electric heater are made of nichrome which is an alloy of nickel, iron, chromium and manganese. The melting point of nichrome is 1500 °C.
- Insulators are used to protect ourselves from the severe shock of electric current.

Resistance of System of Resistors

Resistance of series

Two or more resistors (or conductors) are said to be connected in series if they are connected end-to-end, one after the other such that the same current flows through each resistors when some potential difference is applied across the combination.

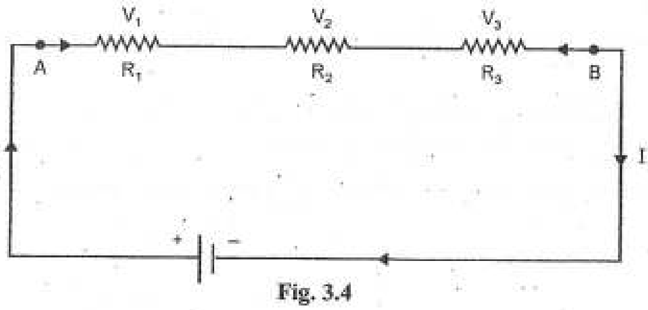


Fig. 3.4

In the above figure, consider three resistors having resistances R_1 R_2 and R_3 connected in series a cell. Let I be the current flowing through each resistance and V be the potential difference across the combination of the resistance between points A and B on the circuit. V_1, V_2 and V_3 be the potential differences across AB, then

$$V = V_1 + V_2 + V_3$$

$$V = IR_1 + IR_2 + IR_3$$

If R_s is the effective resistance of series combination R_1, R_2, and R_3

$$V = IR_s$$

Thus, $$IR_s = IR_1 + IR_2 + IR_3 = I(R_1 + R_2 + R_3)$$

$$R_s = R_1 + R_2 + R_3$$

Or $$R_s = \sum_{i=1}^{3} R_i$$

Key Note: The disadvanta of series combination is that if one component is fused, then the other component of circuit will not function.

Example 5: Resistors R_1, R_2 and R_3 have value 10 Ω, 20 Ω and 30 Ω respectively, connected in series. Calculate their effective resistance. Also calculate current flowing when the combination is connected to a 6V battery.

Solution: Since R_1, R_2 and R_3 are connected end-to-end in continuation,

Effective resistance $R = R_1 + R_2 + R_3 = 10 + 20 + 30 = 60\ \Omega$

Current $I = \frac{V}{R} = \frac{6\text{ V}}{60\,\Omega} = 0.1\text{ A}$

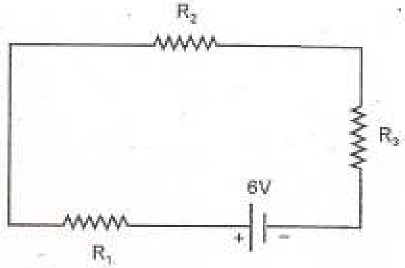


Fig. 3.5

Resistance in parallel

Two or more resistors are said to be connected in parallel if one end of each resistor is connected at one common point (A) and the other end of each resistor is connected at other common point (B) such that the potential difference across each resistor is equal to the applied potential difference across the combination of resistors.

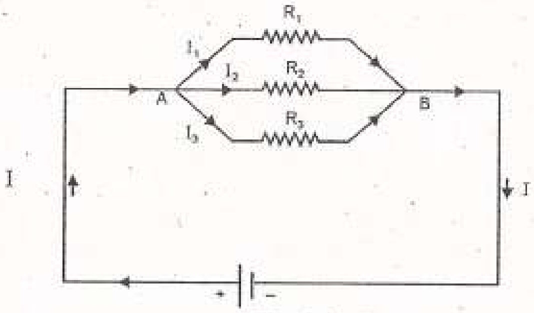


Fig. 3.6

Total current through a parallel resistors combination is equal to the sum of currents through each resistor of the combination

$$I = I + I_2 + I_3$$

$$\frac{V}{R} = +\frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Key Note: If one of the resistors is disconnected, rest of the resistors will not get affected.

Example 6: Let three resistors of 1 Ω, 2 Ω and 3 Ω are connected in parallel. Find the net resistance of the circuit.

Solution: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3} = \frac{11}{6}$

$\therefore R = \frac{11}{6} = 0.55\ \Omega$ which is less than 1 Ω which is less than 1 Ω (least resistance).

Example 7: How many 440 Ω resistors arranged in parallel are required to carry 5 A in a 220 V line ?

Solution : Here, r = 440 Ω, I = 5A, V = 220 V

Let n resistors each of 440 Ω are connected in parallel, Then effective resistance R_e can be calculated as

$$\frac{1}{R_e} = \frac{1}{r}+\frac{1}{r}+ \text{.... Up to n times} = \frac{n}{R}$$

$$\Rightarrow \quad R_e = \frac{R}{n}=\frac{440}{n}$$

Also $V = IR_e$

$$\Rightarrow \quad 220 = 5\times\frac{440}{n}$$

$$\Rightarrow \quad n = 10$$

Thus, 10 resistors of 440 Ω each connected in parallel are required.

Heating Effect of Electric Current

When an electric current is passed through a wire of high resistance, the heat is produced. The resistance present in the wire resists the current to flow through it. Thus, some work must be done by the current to keep itself flowing.

If W be the work done by the current I, flowing through the conductor for time t and Q be the total charge flowing during this time against the potential difference V, then work can be estimated by the equation;

$$W = Q \times V$$

$$Q = I \times t \text{ and } V = I \times R$$

Therefore $W = I \times t \times I \times R$

$$\Rightarrow \quad W = I^2 tR$$

Assuming that all the electric energy consumed during this work done is converted into heat the work done is equivalent to the heat produced (H), which can be measured in **Joules.**

$$H = I^2 t\,R \text{ Joules}$$

Points to remember

1. As per Joules law of heating, the heat produced is directly proportional to the square of current flowing through the conductor, resistance of the conductor, and the time for which of the current flows through the conductor.
2. Home appliances such as electric iron, toaster, immersion rod, oven, etc. uses electrical energy which gets converted into heat energy.
3. The heating effect of electric current is used in electric fuse for the safety purposes. Fuse, earthing and MCB are the three main safety devices in the house hold circuit.

Domestic Circuit

The electric circuit which we use in our houses is called the domestic circuit. In domestic circuits, we normally use parallel connection so that each home appliance works independently and the fault at any point does not interrupt the working of other points. We use separate switches for each points and hence can operate independently.

Each appliance get same 220 V of power supply. The overall resistance of the household circuit is reduced, due to which the current from the power supply is high.

Electrical power: When an electric current flows through the circuit, it uses some amount of the electrical energy to do certain amount of the work. The rate of doing work by the electrical energy to generate heat is called electrical power.

$$\text{Power} = \frac{\text{Electrical work done}}{\text{Time taken}}$$

$$\Rightarrow \qquad P = \frac{W}{T}$$

The SI unit of power is joule per second or Watt, known by the name of the famous physicist James Watt. We can also define electrical power (P) as the rate of consuming electrical energy.

$$P = \frac{W}{T}, W = QV, Q = I \times t$$

Therefore, $P = \frac{I \times t \times V}{t} = IV$

$$\Rightarrow \qquad P = V \times I$$

Potential difference $V = I \times R$

Thus, $\qquad P = I \times R \times I$

$$\Rightarrow \qquad P = I^2 R$$

1 Kilowatt = 1000 watt.

Example 8: How much work is done in flowing an electric current of 5 Ampere for 10 seconds across a resistor of resistance 10 Ω having a potential difference of 220 volts? Also calculate electrical power.

Solution : Here, $I = 5$ A, $V = 220$ V, $R = 10\ \Omega$, $t = 10$ seconds

Work done, $W = QV = I \times t \times V$

$W = 5 \times 10 \times 220 = 11000$ Joules

Electrical power, $P = I^2 R = 25 \times 10$

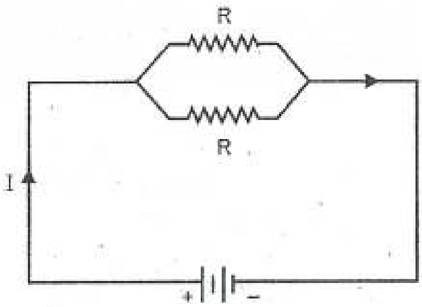
$P = 250$ Watt.

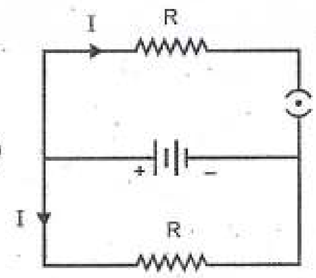
Key Points

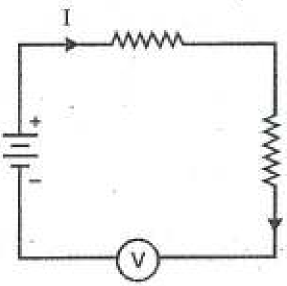
- ✓ An **electric current** is due to the ordered motion of free electrons through a conductor. Its direction is taken to be opposite to that of the electron flow.
- ✓ The rate of flow of charge (Q) and time (t) is called the electric current I *i.e.*, $I = \frac{Q}{t}$ (coulomb/second) or **Ampere**
- ✓ $mA = 10^{-3}$ A and $1\ \mu A = 10^{-6}$ A
- ✓ Electric **potential difference** (V) between two points is the amount of work done (W) to move a unit charge from one point to the other. Thus, $V = \frac{W}{Q} = \frac{1\text{ Joule}}{1\text{ Coulomb}} = 1\text{ volt}$
- ✓ A continuous conducting path between the terminals of a source of electricity (such as a better, cell or an AC power supply) is called an **electric circuit.** A cell or battery provides potential difference which sets electrons in motion.
- ✓ **Ohm's Law** states that $V = RI$ *i.e.*, potential difference across the ends of conductor is directly proportional to the current flowing. R is the resistance.
- ✓ **Resistance** is the property of the conductor due to which it resists the flow of electrons and controls the magnitude of current through it. $R = \frac{V}{I}$, SI unit is Ω (ohm).

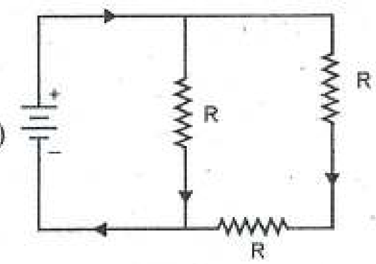
Multiple Choice Question

1. We have three resistors containing 3 ohms each. To get an equivalent resistance of 2 ohms, we should connect them
   (a) In series
   (b) In parallel
   (c) Two in parallel and third in series with combination
   (d) Two in series and third in parallel in a combination
2. Identify the series connection in the given figures

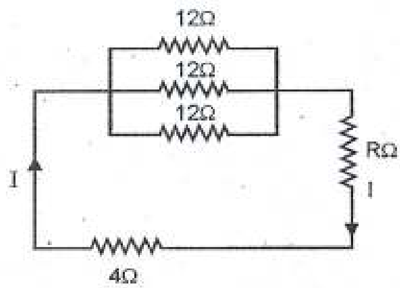
(a)


(b)


(c)


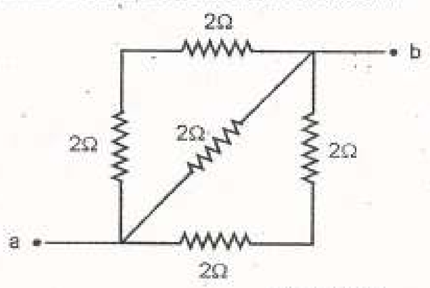
(d)


3. If 50 coulombs of charge flows in 2s, what will be the current flow in the circuit ?
   (a) 20 A
   (b) 50 A
   (c) 45 A
   (d) 25 A
4. Find out the equivalent resistance of the circuit given below



   (a) 6 Ω
   (b) 12 Ω
   (c) 10 Ω
   (d) 8 Ω

5. Calculate the electrical energy consumed by an electric bulb of 200 watt in 15 hours
   (a) 3 kwh (b) 5 kwh
   (c) 6 kwh (d) 30 kwh
6. If two copper wires of length l and $2l$, area A and 2A are taken, then
   (a) The specific resistance of first is greater than that of the second
   (b) The specific resistance of the second wire is greater than that of the first
   (c) The specific resistance of both the wires is same
   (d) The specific resistance is not be predictable
7. A circuit has a fuse of 5 A. What is the maximum number of 100 W (220 V) bulbs, can be safely used in this circuit ?
   (a) 11 (b) 14
   (c) 15 (d) 20
8. Find the amount of the energy given to 5 coulombs of charge passing through a 10 volt battery.
   (a) 20 J (b) 25 J
   (c) 50 J (d) 100 J
9. The flow of electric current can be compared to that of water flow because current flows from
   (a) Higher potential difference to lower potential difference
   (b) Higher resistance to lower resistance
   (c) Higher potential energy to lower potential energy
   (d) Any direction of the circuit
10. If equal resistances of 5 Ω each are connected in parallel with a battery, then
   (a) The total resistance is also 5 Ω
   (b) The current flowing in each resistor will be same
   (c) The potential difference across each resistance is the same
   (d) None of the above
11. Calculate the equivalent resistance of the circuit shown below



   (a) 1 Ω (b) 2 Ω
   (c) 6 Ω (d) 8 Ω
12. What happens to the overall resistance of the electric circuit in parallel connection due to which the current supply from the power is low ?
   (a) Increase (b) Decreases
   (c) No change (d) Can't be determined

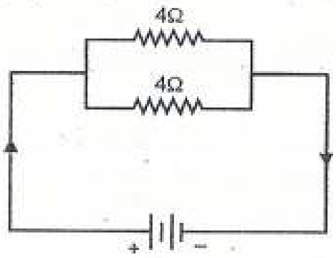
13. How much work is done in moving a charge of 5 C from a point in circuit at 220 volts to another point at 240 volts ?

(a) 50 Joules
(b) 100 Joules
(c) 125 Joules
(d) 250 Joules

14. If the potential difference across the ends of a conductor is doubled, what will be the effect on the current flowing through it ?

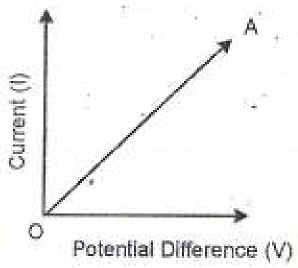
(a) It gets doubled
(b) It gets halved
(c) It remains same
(d) None of these

15. What is the total current flowing in this circuit ?



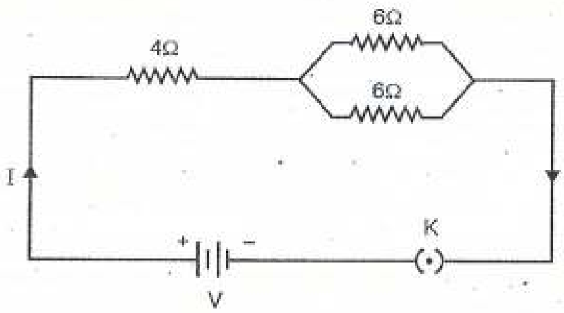
(a) 2 A
(b) 0.5 A
(c) 10 A
(d) 5 A

16. What does this graph with straight line OA represents ?



(a) V is directly proportional to I
(b) V is inversely proportional to I
(c) V is independent of I
(d) V and I goes in opposite directions

17. Three resistors are connected as shown below in a closed circuit. What is the effective resistance of the whole circuit



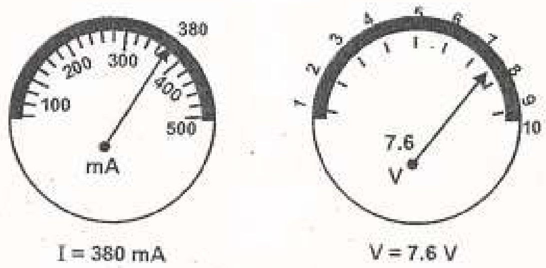
(a) 4 Ω
(b) 7 Ω
(c) 10 Ω
(d) 16 Ω

18. Identify the best conductor of electricity among the following
(a) Pb
(b) Mg
(c) Ag
(d) Fe

19. The proper presentation of series combination of cells of obtain maximum potential is

(a) Fig (i)
(b) Fig (ii)
(c) Fig (iii)
(d) None of these

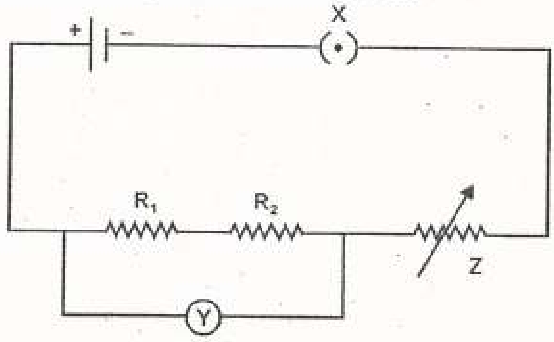
20. The current flowing through a conductor and the potential difference across its two ends are as per the reading of the ammeter and the voltmeter shown below. The resistance of the conductor would be



(a) 0.02 Ω
(b) 2.00 Ω
(c) 12 Ω
(d) 20 Ω

21. The given circuit diagram shows the experimental arrangement of different circuit components for determination of equivalent resistance of two resistors R_1 and R_2 connected in series

The components X, Y and Z shown in the circuit represent

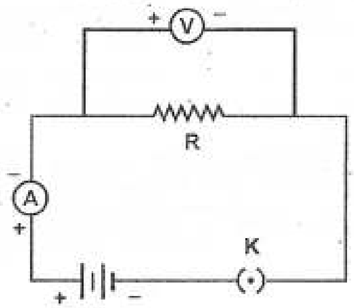


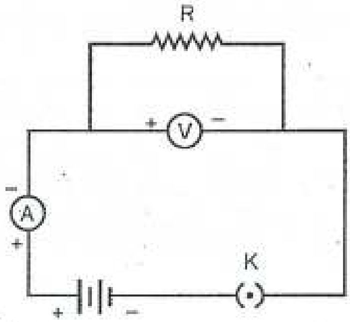
(a) Rheostat, Resistor, Ammeter
(b) Voltmeter, Ammeter, Rheostat
(c) Ammeter, Voltmeter, Rheostat
(d) Rheostat, Ammeter, Resistor

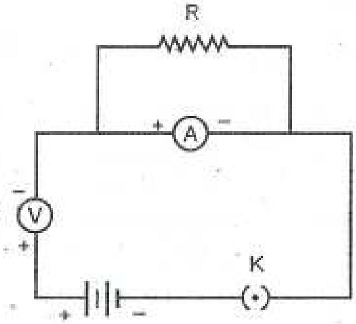
22. A multimeter is used to measure
(a) Current only
(b) Resistance only
(c) Voltage only
(d) All of the above

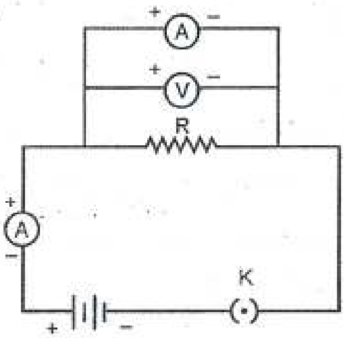
23. A number of cells when connected in series form
(a) A generator
(b) A battery
(c) An inverter
(d) A circuit

24. Which of the following circuit set-ups shows the dependence current on potential difference across a resistor (as per Ohm's Law)

(a) 

(b) 

(c) 

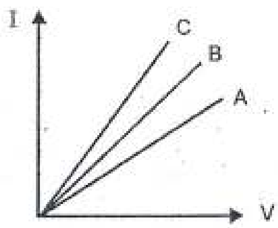
(d) 

25. The resistance of a straight conductor is independent of
(a) Temperature
(b) Material
(c) Cross-sectional area
(d) Shape of cross-section

26. The resistivity of a wire depends on its
(a) Length
(b) Cross-sectional area
(c) Dimensions
(d) Material

27. Two wires A and B are made of silver. Both wires are 3 m long but wire A is 1 mm thick and wire B is 4 mm thick. The resistivity is
(a) More for A
(b) More for B
(c) Same for A and B as both are made of same material
(d) Same for A and B as they have equal length

28. The V-I graph of three resistors A, B and C are as shown in the figure given below. Which resistors has the maximum resistance?

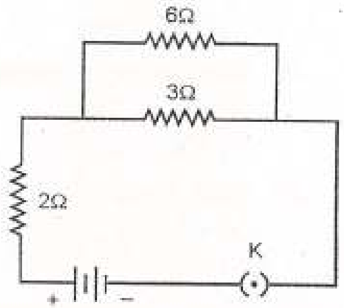


(a) A
(b) B
(c) C
(d) All three have same resistances

29. Which of the following equations does not represent Ohm's Law ?
   (a) Current/potential difference = constant
   (b) Potential difference/current = constant
   (c) Potential difference = current × resistance
   (d) Current = resistance × potential difference

30. If a wire is stretched to make its length twice the present length, its resistance will become
   (a) Two - times (b) Four - times
   (c) Eight – times (d) Remains the same

31. The current flowing through the circuit shown in the circuit is 2 A. The pd across the battery terminals is
   (a) 2 V
   (b) 6 V
   (c) 8 V
   (d) 12 V



32. Two wires of same material and equal length have radii r_1 and r_2 respectively. The ratio between the two resistance R_1 and R_2 of both the wires is
   (a) $\frac{R_1}{R_2} = \frac{r_1^2}{r_1^2}$ (b) $\frac{R_1}{R_2} = \frac{r_2^2}{r_1^2}$
   (c) $\frac{R_1}{R_2} = \frac{r_1}{r_2}$ (d) $\frac{R_1}{R_2} = \frac{r_1}{r_2}$

33. A 60 W bulb carries a current of 0.5A. The charge that passes through it in 2 hours is
   (a) 3600 C (b) 3000 C
   (c) 6000 C (d) 1500 C

34. The resistance of an ideal ammeter and an ideal voltmeter is
   (a) Infinity, infinity respectively (b) Zero, infinity respectively
   (c) Infinity, zero respectively (d) Zero, zero respectively

35. A wire of resistance 1 Ω is divided into two halves and both halves are connected in parallel. The new resistance will be
   (a) 1 Ω (b) 0.5 Ω
   (c) 0.25 Ω (d) 2 Ω

36. In an experiment to find equivalent resistance of a series combination of two resistors R_1 and R_2 a student uses the circuit shown below. The circuit will give
   (a) Correct reading for current but incorrect reading for voltage
   (b) Correct reading for volatmeter but incorrect reading in ammeter
   (c) Correct reading for both current and voltage
   (d) Incorrect reading for both current and voltage

37. Which one of the following shows the application of heating effect of electric current ?

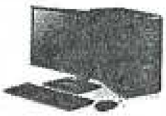
(a) 

Fig Computer

(b) 

Fig Washing machine

(c) 

Fig Toaster

(d) 

Fig Bulb

38. The number of electrons constituting one coulomb of charge is
    (a) 6.25×10^{-18}
    (b) 6.1×10^{-19}
    (c) 6.25×10^{-19}
    (d) 6.25×10^{18}

39. Coils of electric toaster and electric iron are made of
    (a) Copper
    (b) Nichrome
    (c) Silver
    (d) Iron

40. 100 J of heat is produced each second in a 4 Ω resistance. The potential difference across the resistor is
    (a) 50 V
    (b) 25 V
    (c) 100 V
    (d) 20 V

Answer Key

1. (d)	2. (c)	3. (d)	4. (b)	5. (a)	6. (c)	7. (a)	8. (c)	9. (a)	10. (b)
11. (a)	12. (b)	13. (b)	14. (a)	15. (d)	16. (a)	17. (b)	18. (c)	19. (a)	20. (d)
21. (c)	22. (d)	23. (b)	24. (a)	25. (d)	26. (d)	27. (c)	28. (a)	29. (d)	30. (b)
31. (c)	32. (b)	33. (a)	34. (b)	35. (c)	36. (a)	37. (c)	38. (d)	39. (b)	40. (d)

Hints and Solutions

1. (d)

The resistors in series give resistance $= R_1 + R_2 = 3 + 3 = 6$

Third resistor in parallel to the above resistor

Then $\frac{1}{R_e} = \frac{1}{R_3} + \frac{1}{R_1 + R_2} = \frac{1}{3} + \frac{1}{6}$

$\frac{1}{R_e} = \frac{1}{2} \Rightarrow R_e = 2\,\Omega$

3. (d)

$I = \frac{Q}{t} = \frac{50}{2} = 25\text{ A}$

4. (b)

Three resistors of 12 Ω each in parallel have effective resistance R_e, as

$\frac{1}{R_e} = \frac{1}{12} + \frac{1}{12} + \frac{1}{12} = \frac{3}{12} = \frac{1}{4}$

This effective R_e is in series with two other resistors of 2 Ω and 4 Ω. Thus, overall resistance of whole circuit is

$R_e = R_e + R_1 + R_2 = 4 + 2 + 4 = 10\,\Omega$

5. (a)

$P = \frac{W}{t} \Rightarrow w = P \times t = 200 \times 15 = 3000\text{ wh}$

Or W = 3 kwh

6. (c)

$\rho_1 = \frac{RA}{l},\ \rho_2 = \frac{R2A}{2l} = \frac{RA}{l} = \rho_1$

7. (a)

Power, $P = VI = 220 \times 5 = 1100$ Watt

$P = 11 \times 100$ Watt

8. (c)

$W = QV = 5 \times 10 = 50\text{ J}$

11. (a)

It is a parallel combination with two resistors each in series.

$\frac{1}{R_e} = \frac{1}{2+2} + \frac{1}{2+2} + \frac{1}{2} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2} = 1$

$\Rightarrow R_e = 1\,\Omega$

13. (b)

$W = QV = 5 \times (240 - 220) = 100\text{ J}$

14. (a)

As per ohms law, $V \propto I$

15.(d)

$\frac{1}{R} = \frac{1}{4} + \frac{1}{4} \Rightarrow R = 2\,\Omega,\ V = 10\text{ V}$

$I = \frac{V}{R} + \frac{10}{2} = 5\text{A}$

17. (b)

$R_e = 4\,\Omega + R_p$ of 2 resistors of 6 Ω each

$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{6} \Rightarrow R_p = 3\,\Omega$

$\therefore R_e = 4\,\Omega + 3\,\Omega = 7\,\Omega$

19. (a)

For series combination of cells, the negative terminal of first cell should be connected to the positive terminal of the second cell, and so on.

20. (d)

$I = 380\text{ mA} = 380 \times 10^{-3}\text{A},\ V = 7.6\text{ V}$

$R = \frac{V}{I} = \frac{7.6\text{V}}{380 \times 10^{-3}\text{A}} = 20\,\Omega$

24. (a)

The voltmeter should be connected parallel to the resistor and the ammeter should be in series with the resistor.

28. (a)

Slope of the graph $= \frac{I}{V} = \frac{1}{R}$, *i.e.*, $R \propto \frac{1}{\text{slope}}$

Slope is the least for A, hence resistance is maximum for graph A.

30. (b)

When length (l) of a wire doubled ($2\,l$), its cross-sectional area (A) is reduced to half (A/2) as the volume of the wire is constant.

Now resistance of the wire

$R' = \rho\frac{2l}{A/2} = 4\left(\rho\frac{l}{A}\right) = 4\text{ R}$

31. (c)

$V = I\,R$

$\frac{1}{R_1} = \frac{1}{6} + \frac{1}{3} = \frac{1}{2} \Rightarrow R_1 = 2\ \Omega$

$R_2 = 2\ \Omega$ (as shown)

$R_e = 2 + 2 = 4\ \Omega$

Current $I = 2$ A

$\therefore V = 2 \times 4 = 8$ volts

32. (b)

$R \propto \frac{1}{A}$, $A = \pi r^2$ (cross-sectional area of a wire)

33. (a)

$Q = I\,t = 0.5 \times (2 \times 60 \text{ min} \times 60 \text{ sec}) = 3600$ seconds

Note : wattage of the bulb does not affect the flow of charge in this case

35. (c)

Resistance of each half $= \frac{1\,\Omega}{2} = 0.5\,\Omega$ ($R \propto l$)

Since these two halves are in parallel,

Resultant resistance $= \frac{R_1 \times R_2}{R_1 + R_2} = 0.25\ \Omega$

36. (a)

V should be connected in series across $R_1 \times R_2$ to show correct reading in voltameter

38. (d)

The charge on one electron, $e = 1.6 \times 10^{-19}$ C. Number of electrons constituting 1 coulomb is given by $n = \frac{Q}{e}$

$n = \frac{1\,C}{1.6 \times 10^{-19}\,C} = \frac{1}{1.6} \times 10^{19} = 6.25 \times 10^{18}$

39. (b)

The resistivity of an alloy (nichrome – Ni, Cr, Mn, Fe) is generally higher than pure metal; it is has high melting point; it does not oxidise (*i.e.*, burn) when it is red not even at 800°C.

40.(d)

$V = \frac{W}{Q} = \frac{W}{I\,t}$ and $V = I\,R$ (work done is equal to heat generated)

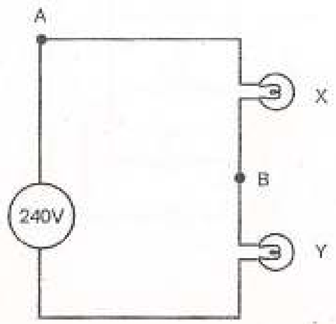
$\Rightarrow W = VI\quad t = I^2 R\, t$

$\Rightarrow I = \sqrt{\frac{W}{Rt}} = \sqrt{\frac{100}{4 \times 1}} = 5\text{ A}$

$V = I\,R = 5\text{ A} \times 4\ \Omega = 20\text{ V}$

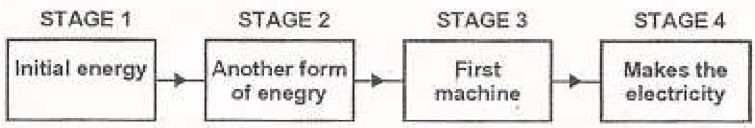
Previous Year's Questions

1. Two identical light bulbs X and Y, which are rated at 60 W and 240 W, are connected in series to a 240 V source as shown in the given diagram. If point A in the circuit is now connected to point B by piece of copper wire with very low resistance, how will the brightness of each bulb change?



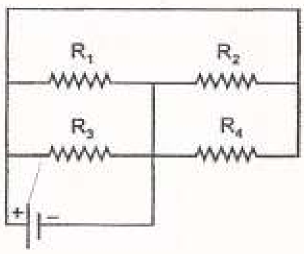
   (a) Both X and Y bulb will light brighter
   (b) Both X and Y bulb will light less brightly
   (c) X will light brighter and Y will not light
   (d) Y will light brighter and X will not light brighter **(NSO 2005)**

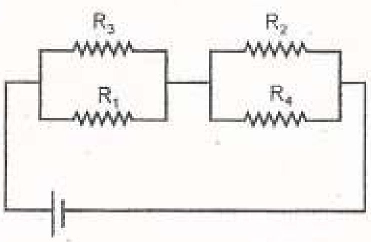
2. The diagram summarises four stages for a way of producing electricity. Which of the following options matches stage 4?

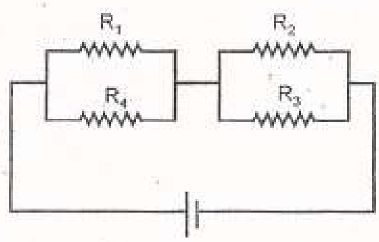


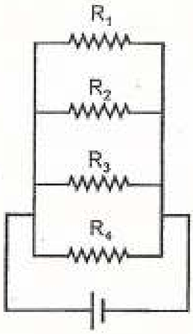
   (a) Move turbine (b) Heat water
   (c) Turn generator (d) Burn fuel **(NSO 2005)**

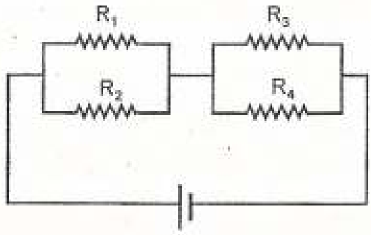
3. The picture on the side shows resistors R1, R2, R3 and R4 wired into a circuit with a battery. Which of the pictures given below shows a circuit that is electrically equivalent to the circuit pictured above?



(a)


(b)


(c) 

(d) 

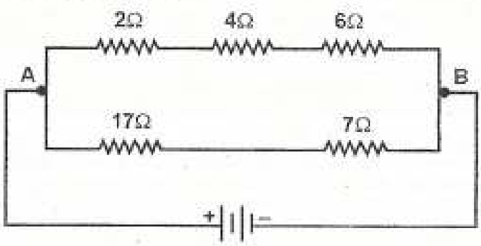
(NSO 2005)

4. If two copper wires of the length l and 2 l, area a and 2a are taken.
   (a) Their specific resistance is the same
   (b) The specific resistance of the second wire is greater than that of the first
   (c) The resistance of the second wire is greater
   (d) The resistance of the first wire is greater **(NSO 2006)**

5. If equal resistances of 3 Ω each are connected in parallel with a battery, then
   (i) The potential difference across each resistance is the same
   (ii) The current flowing in each wire will be the same
   (iii) The potential difference across each resistor will be greater than that of the e.m.f. of the battery
   (iv) The total resistance is 9 Ω
   (v) The total resistance is less than the smallest resistance
   (a) Both (i) and (v) (b) (i), (ii) and (v)
   (c) (i), (iii), (iv) and (v) (d) All of these **(NSO 2006)**

6. V= IR (Ohm's law)
   (a) A resistance of wire is proportional to the potential difference applied
   (b) Resistance of a wire, for a given battery, is inversely proportional to the current
   (c) Resistance is dependent on the current
   (d) Resistance is independent of the voltage
   (e) None of these

7. In the given circuit, the total resistance is



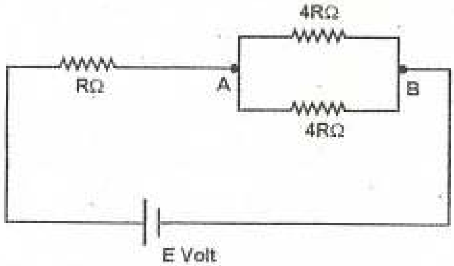
   (a) 24 Ω (b) 12 Ω
   (c) 8 Ω (d) 6 Ω **(NSO 2006)**

8. The flow of electric current can be compared to that of a water flow
   (a) Current flows from higher potential to lower potential
   (b) Current flows from higher potential energy to lower potential energy
   (c) It flows from higher resistance to lower resistance
   (d) The total current in the circuit depends on the direction of resistance **(NSO 2006)**

9. X is an instrument that can detect the presence of the current in a circuit. The pointer remains at zero (the centre of the scale) for zero current flowing through it. It can deflect either to the left or to the right of the zero mark depending on the direction of current. What is X ?
   (a) Galvanometer (b) Ammeter
   (c) Voltmeter (d) Both (a) and (c) **(NSO 2007)**

10. Resistance of a wire to the flow of electric current depends on the
   (a) Material of the wire (b) Area of cross-section
   (c) Length of the wire (d) All of these **(NSO 2007)**

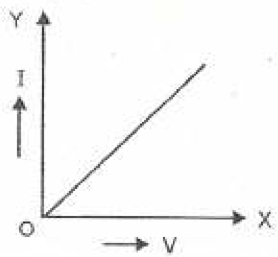
11. As shown in the figure given below, the current flowing in the 2 RΩ resistor is



   (a) $\frac{2E}{R}$ (b) $\frac{3E}{7R}$
   (c) $\frac{E}{7R}$ (d) $\frac{E}{R}$ **(NSO 2008)**

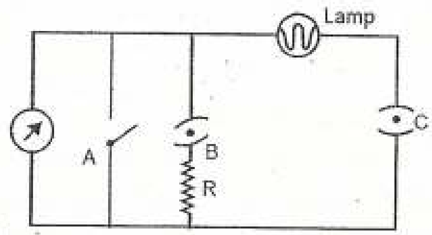
12. 100 J of heat produced each second in 4 Ω resistor. The potential difference across the resistor is
   (a) 20 V (b) 30 V
   (c) 10 V (d) 40 V **(NSO 2008)**

13. The slope of current (I) versus voltage (V) is called



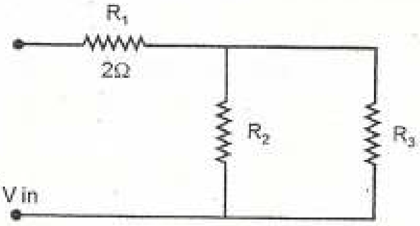
   (a) Resistance (b) Resistivity
   (c) Conductivity (d) Conductor **(NSO 2008)**

14. Which switch in the circuit when closed will produce short-circuiting?



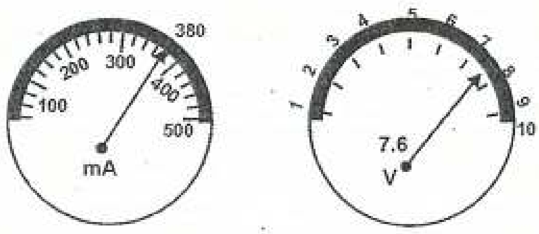
(a) A
(b) B
(c) C
(d) A and B **(NSO 2008)**

15. For ensuring dissipation of the same energy in all three resistance R_1, R_2. And R_3 connected as shown in figure, their values must be related as



(a) $R_1 = R_2 = R_3$
(b) $R_2 = R_3$ and $R_1 = 4\ R_2$
(c) $R_2 = R_3$ and $R_1 = \frac{1}{4}\ R_2$
(d) $R_1 = R_2 + R_3$ **(NSO 2009)**

16. The current flowing through a resistor connected in an electrical circuit and the potential difference developed across its ends are shown in the diagram. The value of resistance of the resistor in ohms is



I = 380 mA   V = 7.6 V

(a) 25
(b) 25
(c) 15
(d) 10

17. The relation between the potential difference (V) and current (I) across the conductor is represented by

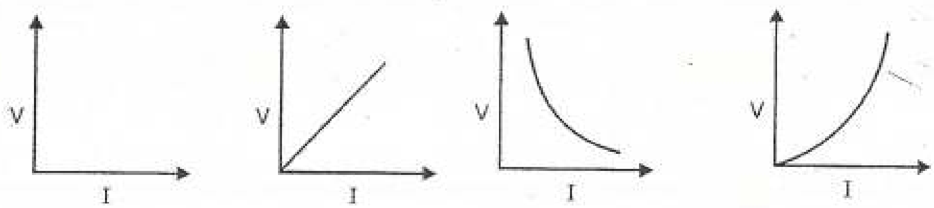


Fig. 1   Fig. 2   Fig. 3   Fig. 4

(a) Fig 1 (b) Fig 2

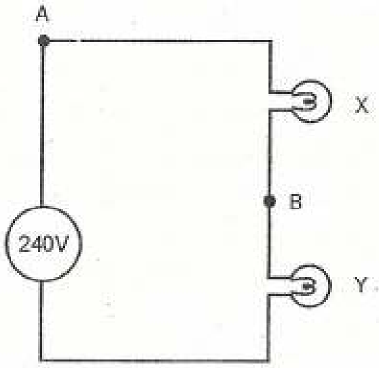
(c) Fig 3 (d) Fig 4 **(NSO 2009)**

Answer Key

1. (d)	2. (c)	3. (a)	4. (a)	5. (a)	6. (e)	7. (c)	8. (a)	9. (b)	10. (d)
11. (b)	12. (a)	13. (b)	14. (d)	15. (c)	16. (d)	17. (b)			

Hints and Solutions

1. **(d)**
When a piece of wire is connected between points A & B the two bulbs will become parallel to each other in the circuit. The current will get divided, thus the bulbs with highest wattage will light more brightly.



2. **(c)**
Stage 1 → Burn fuel (source of energy)
Stage 2 → Heat water (heat energy)
Stage 3 → Rotate turbine (first machine)
Stage 4 → Turn generator (makes electricity)

3. **(a)**
Circuit clearly shows that R_1 and R_3 are in parallel and R_2 and R_4 are also in parallel, but these two pairs are in series with each other.

4. **(a)**
$\rho_1 = R\frac{a}{l}$, $\rho_2 = R\frac{(2a)}{2l} = R\frac{a}{l} = \rho_1$

5. **(a)**
In parallel resistance arrangement, P. d across each resistance always remains the same, only current get divided. Also, the total resistance is less than the smallest resistance as

$$R = \frac{R_1 R_2}{R_1 + R_2}$$

6. **(e)**
Ohm's law gives a direct relationship between potential difference and current only.

7. **(c)**
$2\ \Omega$, $4\ \Omega$ and $6\ \Omega$ in series gives $R_1 = 12\ \Omega$
$17\ \Omega$ and $7\ \Omega$ in series gives $R_2 = 24\ \Omega$
Now, R_1 and R_2 are in parallel
Total resistance $= \frac{R_1 \times R_2}{R_1 + R_2} = \frac{12 \times 24}{12 + 24} = 8\ \Omega$

12. **(a)**
$W = I^2 R t$
$I = \sqrt{\frac{W}{Rt}} = \sqrt{\frac{100}{4 \times 1}} = 5\ A$
$V = IR = 5A \times 4\ \Omega = 20\ V$

13. **(b)**
Slope $= \frac{I}{V} = \frac{1}{R} = \rho$ (resistivity)

16. **(d)**
Ammeter shows reading 180 mA = 0.18 A
Voltameter shows reading = 1.8 V
$R = \frac{V}{I} = \frac{1.8}{0.18} = 10\ \Omega$

17. **(b)**
Only Fig. 2 shows a straight line graph which proves a direct relationship between potential difference and current in circuit.

4. Magnetic Effects of Electric Current

Learning Objectives

* Concept of Magnet
* Magnetic Field and Field Lines
* Magnetic Field Due to a Current Carrying Conductor
* Magnetic Field Due to a Circular Loop
* Magnetic Field Due to a Current-Carrying Solenoid
* Force on Current-Carrying Conductor in a Magnetic Field
* Fleming's Left Hand and Rule (Mtor Rule)
* Electric Motor
* Electromagnetic Induction
* Fleming's Right Hand Rule (Dynamo Rule)
* Electric Generator
* Domestic Circuit

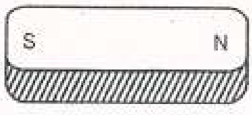
Magnetic Effects of Electric Current

The concept of electromagnetism was introduced by **Hans Christian Oersted** in **1820** through an experiment in which he proved that 'when an electric current passes through a copper wire, there is deflection in the needle of the magnetic compass placed near the wire.'

What does this proves ? It proves that the electric current has produced a magnetic effect, which is called **electromagnetism** or the magnetic effect of current.

Concept of Magnet

It was observed that certain ore could attract bits of iron and pointed in a particular direction when freely suspended. This ore was originally found in the district of **Magnesia** in Western Turkey and was, therefore, named **Magnetic**. The property of attracting small pieces of iron was referred to as magnetism. The mineral exercising this influence was called a natural magnet.



Bat Magnet

Fig. 4.1

The most commonly used magnets are bar magnets, horseshoe magnets, magnet needle compass.

A **bar magnet** is a rectangular bar of uniform cross section which attracts piece of iron, steel, nickel and cobalt etc. It has two poles near its end, **north pole** and **south pole**. Like poles repel each other and unlike poles attract each other. It is used in many electronic devices like radio, TV, MRI etc.

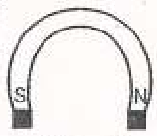


Fig. 4.2

A **horseshoe magnet** is curved shape magnet with two ends (opposite poles). A **magnetic compass** is a rounded glass in which a magnetic needle is pivoted at centre. The north pole of this needle is generally painted red. This compass is used to :

* Test the polarity of a magnet
* Find the direction of magnetic field at a place
* Determine the north-south direction

Magnetic Field and Field Lines

The space around a magnet in which the force of attraction and repulsion due to the magnet can be detected is called the **magnetic field.** The magnetic field has both magnitude and direction. When we place the magnetic compass in the magnetic field of a magnetic bar, the north end of the needle of the compass indicates the direction of magnetic field at that point.

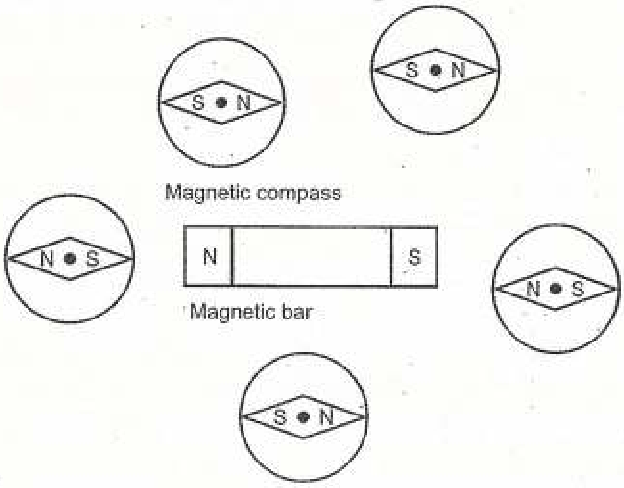


Fig. 4.3

The convenient method to describe the magnetic field around a magnet is to draw magnetic field lines around it. **Magnetic field lines are the lines which are drawn around the magnetic field starting from north pole and ending at the south pole.**

Properties of field lines:

1. It always emerge from north pole and converge at south pole.
2. Magnetic field lines are closed curves.

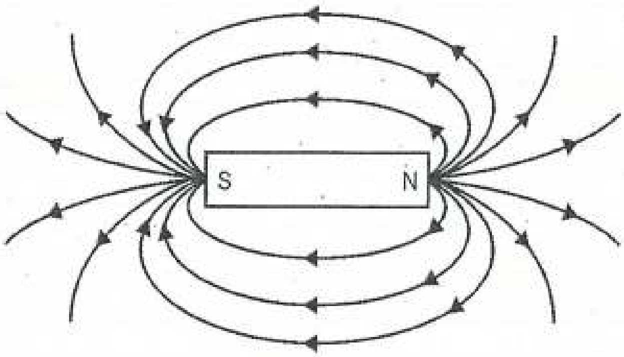


Fig. 4.4

3. The relative strength of the magnetic field is shown by the degree of closeness of the field lines. More closer the field lines are, more stronger is the magnetic field and vice versa.
4. Field lines are denser near the pole and widely spaced near the centre
5. Magnetic lines do no intersect each other because if they do so, there would be two directions of magnetic field at that point which is never possible.
6. In case the field lines are parallel and equidistant, then these represent a uniform magnetic field.

Magnetic Field Due to a Current-Carrying Conductor

Christian Oersted had proved through his experiment that when a current is passed through a straight conductor like a copper wire, a magnetic field is produced around it. It is in the form of the concentric circular field lines with the conductor at the centre, a represented in the figure. XY is a thick copper wire. Its ends X and Y connected to a battery in a closed circuit are in which the current is passed. Concentric circles around point O on a card board shows magnetic field lines. The direction of these lines is anticlockwise.

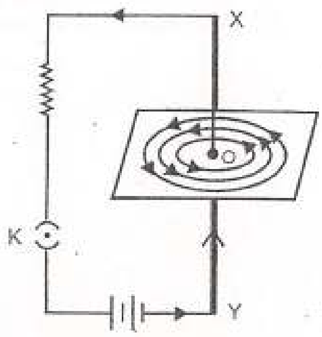


Fig. 4.5

Application of magnetic effect of current

In electrical home appliances like television, electric iron, heater, etc. when an electric current is passed, it produces magnetic field which gives rise to the mechanical forces. This magnetic effect of the electric current is called electromagnetism.

Direction of magnetic field due to straight conductor: Right-hand thumb rule

To find the direction of magnetic field due to a straight copper wire XY, imagine the wire in your right hand such that the thumb points in the direction of the current. The direction of curling of fingers of the right hand gives the direction of magnetic field lines, as shown in the figure.

When current flows upward, magnetic field lines will be in anticlockwise direction. If we reverse the direction of the current the direction of the magnetic field is clockwise.

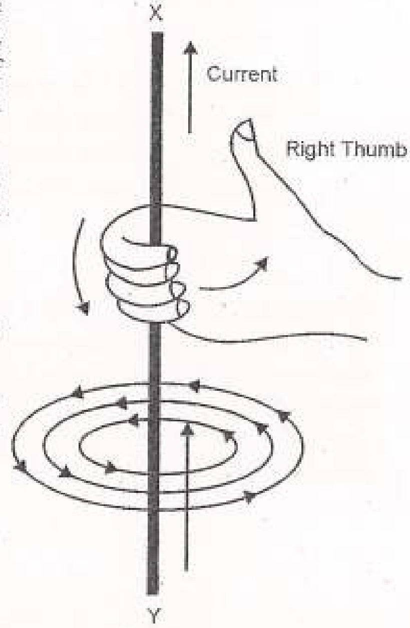


Fig. 4.6

Magnitude (B) of magnetic field

The magnitude of the magnetic field is also called magnetic induction, and is denoted by B.

1. Magnitude of the magnetic field (B) produced by a straight wire at a given point is directly proportional to the current (I) passing through the wire

   $B \propto I$

2. Magnitude of magnetic field (B) is inversely proportional to the distance of that point (r) from the wire.

   $B \propto \frac{1}{r}$

3. Thus, magnetic field will be stronger if more current is flown through the wire and its strength will decrease as we move away from the wire. Intensity of magnetic field will be stronger near the wire.

DYK:

- Unit of magnetic field (B) is expressed in Tesla (T), named in the honour of an American engineer Nikola Tesla. It is bigger unit
- Small unit of B is called Gauss (G) where $1\ T = 10^4\ G$.

Magnetic Field Due to Circular Loop

A circular coil (or loop) is held vertical and is made to pass through a smooth hard board at two points

A and B in such a way that the centre of the coil (O) lies at the cardboard. A current is passed through the coil such that it moves upward at A and downward at B. The pattern of the magnetic field is circular to the current carrying loop. As we move away from the wire the concentric circles become bigger. It gets straighten as we move towards the centre of the loop at point O.

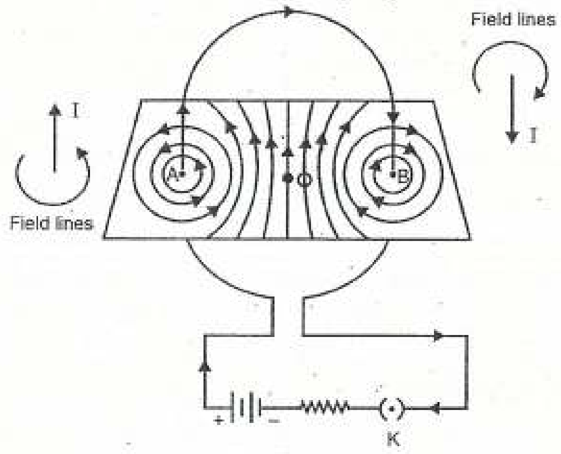


Fig. 4.7

- Magnetic field lines near the coil are circular and concentric.
- Magnetic field at the centre of the coil is uniform and maximum
- Magnetic field is directly proportional to the current (I) flowing through the coil and to the total number of turns (N) in the coil, and is inversely proportional to the radius of the coil (r).

$$B \propto \frac{NI}{r}$$

Magnetic Field Due to Current-Carrying Solenoid

An insulated copper wire wound on cylindrical cardboard tube such that its length is greater than its diameter is called a solenoid. One end of the solenoid behaves like a magnetic north pole while the other behaves as the south pole. The field lines inside the solenoid are in the form of parallel straight lines. This indicates that the magnetic field is the same at all points inside the solenoid. The strength of magnetic field depends on the

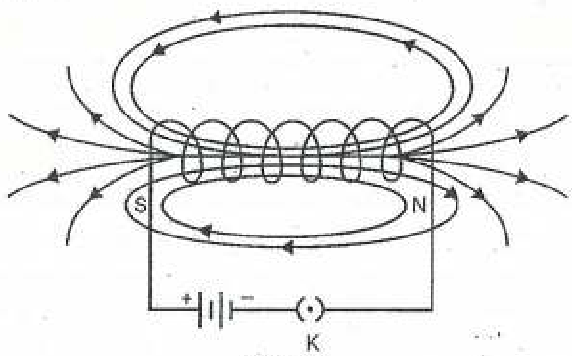


Fig. 4.8

- Number of turns of the solenoid
- Strength of the current flowing through it
- Nature of core material used in the making of solenoid

Normally, soft iron rod is used as the care material of the solenoid as it produces the strongest magnetic force.

Electromagnet is the magnet which is produced when an electric current is passed through the magnetic material. It consists of a long coil of insulated copper wire wound on a soft iron core which strongly gets magnetised when the electric current as passed through it and easily gets demagnetised once the current is switched off. For this reason, electromagnetic is called as the **temporary magnet.**

Force on Current Carrying Conductor in a Magnetic Field

Oersted discovered that a current-carrying conductor exerts a force on a compass needle. **Andre Ampere** suggested that the reverse is also true *i.e.*, a magnet also exerts an equal and opposite force on a current carrying conductor.

This force acting on current-carrying conductor in a magnetic field is due to interaction between magnetic field due to current carrying conductor and external magnetic field in which the conductor is placed. The resultant of these two magnetic fields is not uniform. It is weaker on one side of the conductor than its other side. The conductor, therefore, experiences a resultant force in the direction of the weaker magnetic field.

$F \propto I\,l\,B$

Where,

F = Force acting on current-carrying conductor (Newton)

I = Current flowing through the conductor (Ampere)

l = Length of the conductor inside the magnetic field (Metre)

B = Magnetic field experienced by the conductor (Tesla).

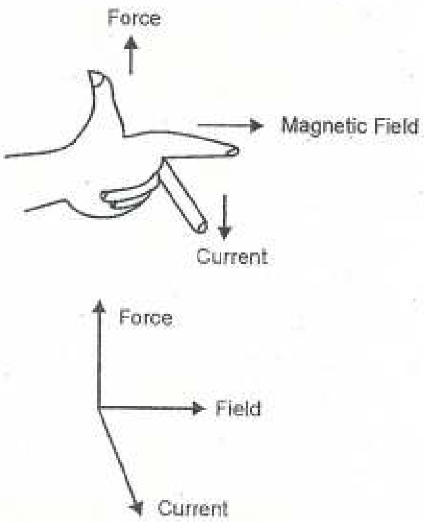


Fig. 4.9

Fleming's left-hand rule (motor rule)

Prof. J. A. Fleming gave a rule which relates the direction of motion (Force) of the conductor to the directions of the current and the magnetic field. This rule is known as Fleming's left hand rule (or motor rule). It states that :

If the first finger points in the direction of the magnetic field, the central finger points in the direction of current, then the thumb points in the direction of motion of conductor (*i.e.*, direction of force on the conductor).

The rule shows that Force, Field and current are mutually perpendicular to each other.

Electric Motor

The electric motor is a rotating device that converts electric energy into mechanical en9rgy. It is just the reverse of an electric generator which converts mechanical energy to electrical energy. Electric motor is used in electric fans, mixers, washing machines, computers etc.

Principle: When a coil carrying current is placed in a magnetic field, it experiences a force. As a result of this force the coil begins to rotate. The coil rotates continuously as long as the current flows through it.

An electric motor consists of an insulated copper wire made in the form of a rectangular coil ABCD placed between the two plates of a magnetic field such the arm AB and CD are perpendicular to the direction of magnetic field.

Force acting on arm AB pushes the coil downwards while the force acting on arm CD pushes it upwards. Thus the coil and Axle which are mounted free to turn about an axis, rotate anti-clockwise.

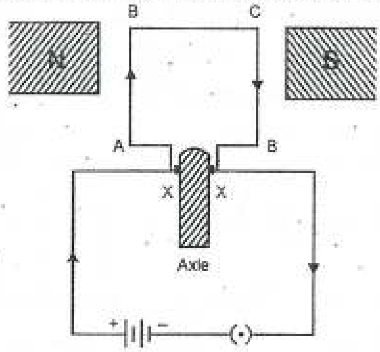


Fig. 4.10

The speed of rotation of the motor can be increased by

- Increasing the strength of the current through the armature
- Increasing the number of turns in the coil of armature
- Increasing the area of the coil and
- Increasing the strength of the magnetic field

Electromagnetic Induction

Michael Faraday in 1831 proved that movement of coil near a magnet or the movement of coil into a magnet produces current which is shown by the deflection in the galvanometer attached to the coil.

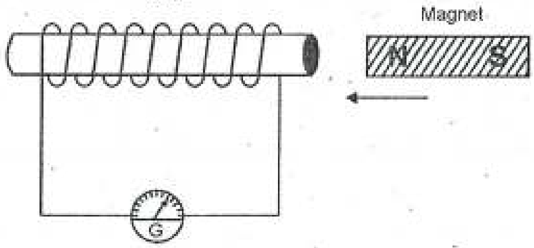


Fig. 4.11

Faraday in his experiment observed that

- Galvanometer shows deflection (*i.e.*, on induced current flows in the coil) only when there is a relative motion between the coil and the magnet.
- The direction of deflection (*i.e.*, of the induced current in the coil) is reversed if the direction of relative motion between the coil and the magnet is reversed.
- The deflection in the galvanometer (*i.e.*, the induced current in the coil) increases if the magnet and the coil are moved rapidly with respect to each other.

The production of electricity from magnetism is called electromagnetic induction. The magnitude of the induced current depends on the rate of the change of magnetic flux in the coil (the total number of magnetic field lines).

$$\textbf{Mechanical Energy} \xrightarrow[\textbf{Field}]{\textbf{Magnetic}} \textbf{Electrical Energy}$$

Fleming's Right Hand Rule (Dynamo Rule)

Stretch the thumb, the fore finger and the central finger of the right hand so that they are mutually perpendicular to each other. If the forefinger points in the direction of the magnetic field, and the thumb points in the direction of motion of the conductor, then the central finger will always points in the direction of induced current.

Memory Trick: Thumb represents Motion

Fore finger represents magnetic field

Central finger represent the flow of current

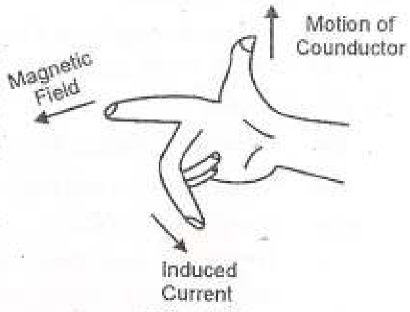


Fig. 4.12

Key Notes: (i) Fleming's Right Hand Rule is used to find the direction of the induced current, due to motion of conductor.

(ii) Fleming's Left Hand Rule is used to find the direction of the force on the conductor *i.e.*, the direction of the motion of the conductor.

Electric Generator (A.C.)

An electric generator converts mechanical energy (produced by motion of armature coil) into electric energy. When a straight conductor is moved in magnetic field, the current is induced in the conductor.

A.C. generator produces Alternating Current which reverses its direction continuously after every half cycle.

Construction of generator: Armature coil ABCD made of large number of turns of insulated copper wire.

Slip rings R_1 and R_2: As the slip rings rotate with the coil, the two carbon pieces called carbon brushes B_1 and B_2 keep contact with them.

Carbon brushes B_1 and B_2: Current generated in the coil passes through these brushes to the external circuit containing a resistance R and a galvanometer G. Brushes are stationary while rings rotate with coil.

Field magnet: Magnetic field is supplied by permanent magnet in a small dynamo and by an electromagnet in case of a big dynamo called a generator. The poles are shown as N and S.

Key Notes: (i) In India, A.C produced is of frequency 50 Hz *i.e.*, the coil is rotated at the rate of 50 revolution per second.

(ii) DC generator is the generator producing Direct Current in which the current do not changes its direction after every half cycle.

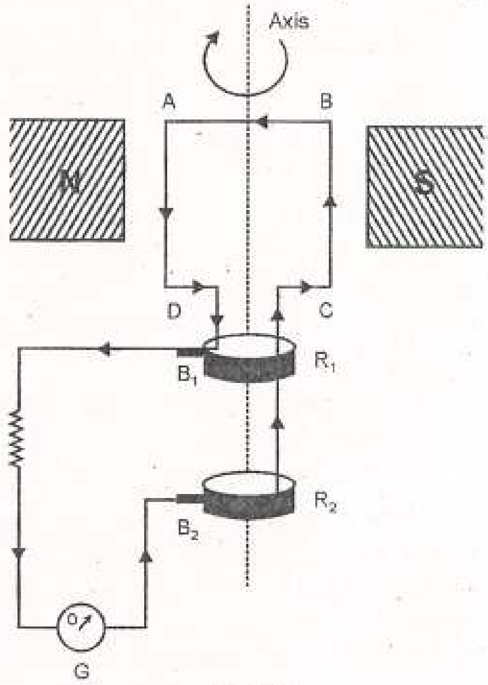


Fig. 4.13

Difference AC and DC generator: The basic difference in construction of AC and DC generatior is that in DC generator slip rings of AC generator are replaced by two **spilt (half) rings (Commutator)** due to which the current always flows in one direction through the coil which is a direct current.

Domestic Circuit

In India, domestic supply of electric power in homes is made through a main supply (also called as mains) through overhead cables fitted on poles or through underground cables. The cable has three insulated wires.

(a) **Live wire (positive):** It has usually red insulation cover.

(b) **Neutral wire (negative):** It has black insulation cover.

(c) **Earth wire:** It has green insulation cover and is called earth. It has connected to a metal plate deep in the earth near the house. It acts as a safety device for those appliances having metallic bodies like air cooler, refrigerator, heater etc.

Earth wire provides low resistance conducting path for the current and prevent any leakage of current to these appliances and keep its potential to that of the earth and prevent any kind of severe electric shock.

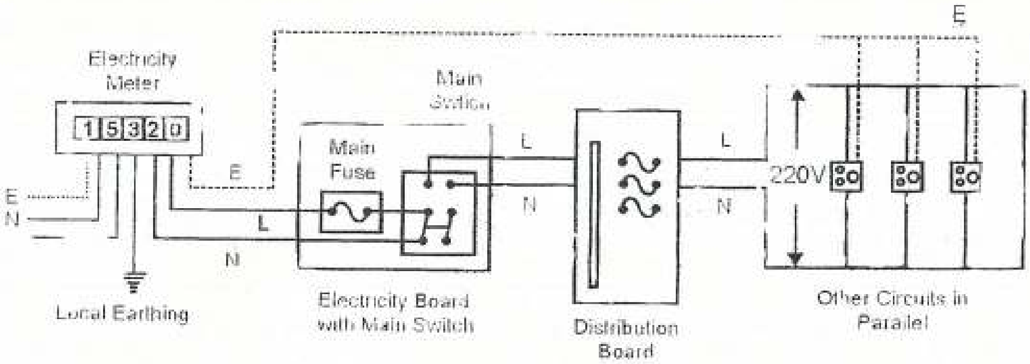


Fig. 4.14

The potential difference between live wire and neutral wire is 220 V. These two wires are connected to our homes via meter board through main switch and main fuse. From there it is connected to the different switch through the wiring in our house which are connected in parallel.

Types of circuits used:

- **15A current circuit** used for appliances that consumes more electricity, thus have higher power ratings such as geysers, ACs, ovens, etc.
- **5A current circuit** used for bulbs, fans, TV, radio etc. that needs less power consumption.

Main electric fuse : Electric fuse is an important safety component of all domestic circuits. A fuse in a circuit prevents damage to the appliances and the circuit due to overloading. **Overloading** can occur when the live wire and the neutral wire come into direct contact due to damage of insulation covering or there is a fault in the appliance. In such a situation, the current in the circuit suddenly increases. This is called **short-circuiting.** Electric fuse wire gets melted due to heating that takes place in the fuse and it breaks the electric circuit. Thus it prevents the appliance from a possible damage by stopping the flow of the high electric current.

Key Points

- ✓ The space around a magnet in which a compass needle tests in a definite direction or any other magnet experiences a force is called the **magnetic field**
- ✓ Magnetic field lines are closer where the magnetic field is strong and farther apart where the magnetic field is weak. A uniform magnetic field is represented by parallel equidistant field lines.
- ✓ The **north pole** of the compass points in the direction of the magnetic field at any point.
- ✓ **Oersted** discovered that a current-carrying conductor produces a magnetic field.
- ✓ **Ampere** demonstrated that such a conductor experience a force when placed in a magnetic field.
- ✓ The force acting on a current-carrying conductor is perpendicular to both the direction of magnetic field and the direction of current which are mutually perpendicular to each other. The direction of this force is given by **Fleming's Left Hand Rule (or Motor Rule).**
- ✓ A **moving charge** experience a force in magnetic field except when it is moving **parallel** to the magnetic field.
- ✓ The motion of a current carrying conductor in a magnetic field is the underlying principle of an **electric motor** where electric energy is converted into mechanical energy.
- ✓ Michael Faraday discovered that if **magnetic flux (total number of magnetic field lines)** in a circuit (coil) changed with time, a current called induced current was produced. This phenomenon is called **electromagnetic induction.**
- ✓ The potential difference corresponding to induced current is called **induced electromotive force (emf).** The magnitude of this induced pd or emf is directly proportional to the rate of the change of magnetic flux.
- ✓ The direction of induced current is given by **Fleming's Right Hand Rule (or Dynamo Rule).**
- ✓ **Electromagnetic induction** in reality, is the conversion of mechanical energy into electrical energy with the help of magnetism. This concept is widely used to construct **generators** which produce large electric power.
- ✓ An AC generator produces **Alternating current** which periodically changes its direction, a DC generator produce **Direct current** which always flows in the same direction.
- ✓ An AC generator can be changed into a DC generator by replacing the slip-ring arrangement with **spilt-ring (commutator)** arrangement.
- ✓ The **household supply** in India is AC at 220 V with a frequency of 50 Hz.
- ✓ The **cable** supplying power to the household has three wire (i) live or positive wire in red colour. (ii) neutral *i.e.*, negative wire in black colour, and (iii) earth wire which is in green colour insulation.
- ✓ The most important safety device is a **fuse** which is made of an alloy of lead and tin and has an low melting point.
- ✓ A fuse protect the electric appliances and circuits from **short-circuiting** (which occurs when live and the neutral wires come in contact).

- ✓ Fuse also protect from **overloading** which occurs when an electric circuit draws more current than the permitted limit value.
- ✓ **Magnetic Resonance Imaging (MRI)** used in medical diagnosis, is based on the fact that there is a very weak magnetic field present on our body due to small electric current travelling along the nerve cells.
- ✓ The metallic bodies of many electrical appliances like Air Cooler, Electric iron, etc. are connected to **earth** as a safety measure to prevent any electric shock to the user.

Multiple Choice Questions

1. Which of the following fact(s) is/are true about a natural magnet ?
   (a) It is a piece of iron ore magnet Fe_3O_4 having attractive and directive property.
   (b) When suspended freely, it points in the north-south direction.
   (c) It is also called ledestone.
   (d) All of the above.
2. Which of the following correctly describes the magnetic field near a long straight wire ?
   (a) The field consists of straight lines perpendicular to the wire
   (b) The field consists of radial lines originating from the wire
   (c) The field consists of concentric circles centred on the wire
   (d) The field consists of the straight lines parallel to the wire
3. When a charged particle moves perpendicular to a magnetic field, then
   (a) Speed of the particle is changed
   (b) Speed of the particle remains the same
   (c) Direction of the particle remains unchanged
   (d) Acceleration of the particle remain unchanged
4. When a charged particle moving with the same velocity is subjected to magnetic field, the force acting on it is non-zero. This implies that
   (a) Angle between them can have any value other than 0° and 180°
   (b) Angle between them can have any value other than 90°
   (c) Angle between them is necessarily 90°
   (d) Angle between them is either 0° or 90°
5. The direction of magnetic field pattern produced by a straight wire can be determined with which one of the following rules ?
   (a) Thumb rule (b) Fleming's left hand rule
   (c) Fleming's right hand rule (d) Any of the these
6. At the time of short circuit, the current in the circuit
   (a) Reduces substantially (b) Does not change
   (c) Increase heavily (d) Vary continuously
7. What type of material is used in the core of an electromagnet ?
   (a) Soft iron (b) Steel
   (c) Alloy (d) Non-metal
8. A straight wire of mass 200 g and length 1.5 m carries a current of 2A. It is suspended in mid air by a uniform horizontal magnetic field whose magnitude in Tesla is
   (a) 2 T (b) 0.65 T
   (c) 1.3 T (d) 0.55 T
9. Which of these factors affect(s) the strength of an electromagnet ?
   (a) The number of turns in a coil (b) The current flowing in the coil
   (c) The length of gap between its poles (d) All of these

10. The magnetic field at a distance of 10 c m from a long wire carrying current is 2 tesla. The magnetic field at a distance of 20 cm is

    (a) 0.5 T (b) 1 T
    (c) 1.5 T (d) 2 T

11. A straight wire of diameter 2.5 mm carrying a current of 2 A is replaced by another thick wire of 5 mm diameter. The strength of the magnetic field far away is

    (a) Twice the earlier value (b) One-half of the earlier value
    (c) One-quarter of the earlier value (d) Same as the earlier value

12. A long solenoid carrying a current produces a magnetic field B along its axis. If the current is doubled and the number of turns per cm is halved, then the new value of magnetic field is :

    (a) B / 2 (b) B
    (c) 2 B (d) 4 B

13. Match the following

    1. Magnetic field due to a current carrying straight conductor. A. $B \propto nI$
    2. Magnetic field due to a solenoid B. B. $B \propto \frac{IN}{r}$
    3. Magnetic field due to circular coil carrying current. C. $B \propto \frac{I}{r}$

    (a) 1 -B, 2 -A, 3-C (b) 1- C, 2- B, 3-A
    (c) 1 - C, 2-A, 3 -B (d) 1-A, 2 –B, 3 –C

14. Match the following

    1. Force acting on a charged particle (q) moving with velocity V in a magnetic field. B in direction perpendicular to the direction of B. A = 0
    2. Force acting on a charged particle (q) moving in a magnetic field B in a direction parallel to it. B.(F = TIB)
    3. Force acting on a conductor when it is placed perpendicular to the direction of B. C.F = qvB

    (a) 1 - C, 2-A, 3-B
    (b) 1 – C, 2-B, 3-A
    (c) 1 - C, 2-B, 3-A
    (d) 1-A, 2-B, 3-C

15. Permanent magnet is made of?

    (a) Ferronite (alloy of Fe, Ni and Mg)
    (b) Alnico (alloy ofAl, Ni and Co)
    (c) Iron ore
    (d) Bauxite Ore

16. In case of a current-carrying Circular coil, the magnetic field is maximum

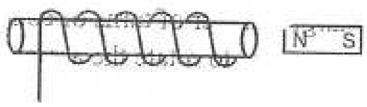
    (a) At its centre
    (b) At the ends of the coil
    (c) Any where inside the coil
    (d) Outside the coil

17. To which wire amongst the following an electric fuse connected?

    (a) Neutral (b) Earth (c) Live (d) None of these

18. What material is used to make a fuse wire ?
(a) Alloy of Ni, Al and Co (b) Allow of Fe, Cu amd Ni
(c) Alloy of Pb and Sn (d) Alloy of Pb and Fe

19. Which polarity is developed on the face of the solenoid when a north pole of a magnet is moving towards it ?
(a) North Pole
(b) South Pole
(c) Neutral
(d) Can't be found



20. An AC of frequency 50Hz changes its polarity after every
(a) 1/25 second
(b) 1/50 second
(c) 1/75 second
(d) 1/100 second

21. The rate of change of flux is greater in case when a magnet is moved towards a coil.
(a) Very quickly (b) Very Slowly
(c) Moderately (d) No change

22. An induces emf is produced when a magnet is plunged into a coild. The magnetic field of induced emf does not depend on
(a) The number of turns in the coie coil
(b) The speed with which the magnet is moved
(c) The strength of the magnet
(d) The resistivity of the material of the coil

23. A dynamo
(a) Creates electrical energy
(b) Creates mechanical energy
(c) Converts mechanical energy into electrical energy
(d) Converts electrical energy into mechanical energy

24. An electric bulb rated 220V is connected to 220 V, 5Hz AC source. The bulb
(a) Does not glow (b) Glows Immediately
(c) Glows continously (d) Gets Fused

25. The magnitude of an induced emf in a generator can be increased
(a) By increasing the speed of roration of the coil
(b) By increasing the area of the armature and number of the turns in the armature
(c) By increasing the strength of the magnetic field in which the coils rotates.
(d) All of the above

26. Which of these fact(s) id TRUE?
(a) AC is more dangerous than DC as it attracts a person
(b) AC cannot be used for electroplating , electrotyping and other such electrolytic processes
(c) The power wastage in AC transmission is negligible as compared to DC
(d) All of these

27. The magnetic field inside a long straight solenoid carrying current
    (a) Is zero
    (b) Decreases as we move towards its end
    (c) Increasing as we move towards its end
    (d) Is uniform at all points
28. Commercial electric motors do not use
    (a) An electromagnet to rotate the armature
    (b) Effectively large number of turns of conducting wire in the current-carrying coil
    (c) A permanent magnet to rotate the armature
    (d) A soft iron core on which the coil is wound
29. What is the potential difference of current in Indian household circuit ?
    (a) 220 V
    (b) 240 V
    (c) 330 V
    (d) 440 V
30. Which one of the following helps on changing the directions of current in AC generator ?
    (a) Carbon brush
    (b) Spilt rings
    (c) Coil armature
    (d) Slip rings
31. What is the current rating of power switch current in our household circuit ?
    (a) 5 A
    (b) 10 A
    (c) 15 A
    (d) 20 A
32. The most important safety method used for protecting home appliances from short-circuiting or overloading is
    (a) Earthing
    (b) Use of fuse
    (c) Use of stabilisers
    (d) Use of the electric meter
33. What are permanent magnets made of ?
    (a) Steel
    (b) Alnico
    (c) Nipermag
    (d) All of these
34. At the time of short-circuit, the current in the circuit
    (a) Increases heavily
    (b) Reduces substantially
    (c) Does not change
    (d) Varies continuously
35. A rectangular coil of copper wires is rotated in a magnetic field. The direction of the induced current changes once in each
    (a) Two revolutions
    (b) One revolution
    (c) Half revolution
    (d) One-fourth of revolution

Answer Key

1. (d)	2. (c)	3. (b)	4. (a)	5. (a)	6. (c)	7. (a)	8. (b)	9. (d)	10. (b)
11. (d)	12. (b)	13. (c)	14. (a)	15. (b)	16. (a)	17. (c)	18. (c)	19. (a)	20. (d)
21. (a)	22. (d)	23. (c)	24. (b)	25. (d)	26. (d)	27. (b)	28. (c)	29. (a)	30. (d)
31. (c)	32. (b)	33. (d)	34. (a)	35. (c)					

Hints and Solutions

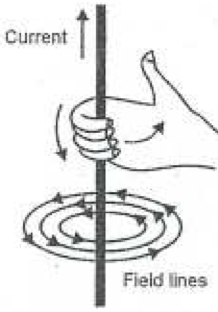
3. (b)

Magnetic force acts perpendicular to the motion of the charged particle and as such the speed of the particle remains unchanged.

4. (a)

No force acts on a charged particle when it is moving either parallel (0°) or antiparallel (180°) to the magnetic field. In all other cases, the charged particle experience a force.

5. (a)



As per the Right-Hand thumb rule, the direction of curling of fingers of the right hand gives the direction of magnetic field lines.

8. (b)

It has been found that Force (F) acting on a current-carrying conductor placed on a magnetic field, in a direction perpendicular to the direction of the magnetic field, is directly proportional to the current, length of the conductor and magnitude of the field

$F = k\,I\,l\,B$. In SI units, constant $k = 1$

Also, Force acting on a suspended mass = mg

$\Rightarrow mg = I\,l\,b$

$$\Rightarrow B = \frac{mg}{I\,l} = \frac{(200\times10^{-3}\ \text{kg})(9.8\ \text{m/s}^2)}{(2\ \text{A})(1.5\ \text{m})} = 0.65\ \text{T}$$

10. (b)

Magnetic field $\propto \frac{1}{r}$

When r doubles (10 cm to 20 cm), the magnetic field becomes half ($2\ T \rightarrow 1\ T$)

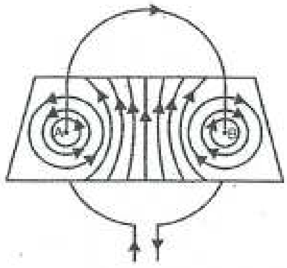
11. (d)

Magnetic field due to current-carrying wire is independent of its diameter or cross-sectional area of so long as the current remains the same.

12. (b)

$$B \propto n\,I,\ B' = \left(\frac{n}{2}\right)^{1} \times 2I = nI = B$$

16. (a)



The two magnetic fields, each due to the semicircular segment of the coil through A and B, assist each other as we move towards the centre of the coil.

18. (c)

Fuse wire is made of an alloy of lead (75%) and tin (25%) which melts at around 200 °C.

20. (d)

In India the frequency of AC is 50 Hz which means that AC changes its polarity after $\frac{1}{100}$ s (*i.e.*, 100 times per second) as it complete one cycle *i.e.*, from + ve to –ve and from –ve to + ve $\frac{1}{50}$ sec.

22. (d)

Resistivity of the coil will determine the resistance of the coil and the induced current through it.

24. (b)

5 Hz means that the bulb glows only 5 times in a second. For the bulb to appear as glowing continuously, the frequency of AC should be at least 16 Hz.

27. (b)

The magnetic field for a point inside a long straight current-carrying solenoid is double then for a point situated at one of its ends.

28. (c)

A permanent magnet is weak.

5. Sources of Energy

Learning Objectives

* Sources of Energy and its Properties
* Classification of Sources of Energy
* Fossil Fuels (Coal Petrolcum, LPG)
* Thermal Power Plant and Hydro Power Plant
* Biomass and Bioenergy
* Biogas
* Wind Energy
* Solar Energy
* Geothermal Energy
* Nuclear Energy
* Management of Sources of Energy

What is Energy?

Energy is the ability or the capacity to do work and make all the movements. Just as we gain body from the food that we eat, same way various sources of energy like coal, petroleum, solar energy, hydel, biogas, etc. are used to generate which is the most common form of energy widely used in households and industry.

Sources of Energy

Any matter which is capable of providing enough useful energy at a steady rate over a long period of time can be called as a source energy.

A wax candle is a source of light energy and heat energy. When we burn the candle, the chemical energy in the wax is converted into heat and light.

Characterstics of sources of energy: A good source of energy is one:

* Which is safe and convenient to use
* Which can do a large amount of work per unit volume or mass.
* Which is easy to transport and easy to store.
* Which is easily accessible
* Which is economical

Classification of Sources of Energy

The sources of energy are usually classified as:

1. Renewable sources of energy
2. Non - Renewable source of energy
3. Conventional source of energy
4. Non - Conventional source of energy

1. Renewable sources of energy

Renewable sources of energy are those which are in-exhaustible, i.e. which can be replaced as we use them and can be used to produce energy again and again. These are available in an unlimited amount in nature and develop within a relatively short period of time.

Examples are :

* Solar energy - obtained from light
* Wind energy - from wind blowing
* Hydro energy - from water falling from a height
* Geothermal energy - obtained from the height of the earth.
* Bioenergy - obtained from biomass
* Tidal Energy - obtained from the ocean tide movements
* Nuclear energy - From Uranium and Thorium

Advantages of Renewable sources of energy :

* These sources will last as long as the earth receives light from the sun
* These sources are freely available in nature.

These are inexhaustible in nature

* These sources do not cause any pollution.

2. Non - Renewable sources of energy

Non- renewable sources of energy are those which are exhaustible and cannot be replenishe once they have been used. These sources have also been accumulated in nature but over a very long period of millions of years.

Examples are : Coal, oil and natural gas.

The non renewable sources of energy need to be conserves wisely for future generation as they are non-replaceble.. This fact led us to look for some alternative sourcesenergy

3. Conventional sources of energy

Conventional sources of energy are those which are used extensively and meet a major portion of our energy requirement. These are most common sources of energy which are most prevalent in the society.

Disadvantages of non renewable sources of energy :

* Due to their extensive use, these sources are fast depleting.
* It is difficult to discover and exploit new deposits of these sources
* These sources are a major cause of environmental pollution.

* Fossil Fuels - Coal, Oil, Pteroleum , Natural Gas
* Hydro energy - energy of water flowing in rivers
* Biomass energy - Firewood, animal during and biodegradable waste.
* Wind energy - From fast blowing winds

4. Non - Conventional Sources of Energy :

Non - Conventional sources of energy are those which are not used as extensively as the conventional ones and meet our energy requirements only on a limited scale.
Examples are : Solar Energy, Ocean Energy, Geothermal Energy and Nuclear Energy.

These sources of energy have been harnessed with the aid of advanced technology to meet our growing energy needs. These sources are also called as alternative sources of energy.

Fossil fuels

Fossil fuels are the remains of pre-historic plants and animals which got buried deep inside the earth millions of years ago due to some natural processes. Coal, petroleum and natural gas are fossil fuels.

Coal: It is the most abundant fossil fuel on the earth. It is a form of carbon and is mainly used as combustion fuel in big factories. Coal provides 27% of the world's energy.

When a coal is burnt, carbon present in it reacts with oxygen to produce carbon dioxide and a lot of heat is generated

$$C + O_2 \longrightarrow CO_2 + \text{heat}$$

Varieties of coal : Coal is available in four varieties depending on the content of carbon percentage in it.

(i) Peat — 27% carbon

(ii) Lignite — 28 % – 30 % carbon

(iii) Bituminous — 78% – 87% carbon

(iv) Anthracite — 94% – 98% carbon

Peat, lignite and bituminous burn faster and release a great deal of pollutants in the atmosphere on account of their lower carbon content. Anthracite has the highest carbon content, so it burn slowly, release very less smoke and delivers more energy and as such is the best quality of coal.

Coke: When coal is heated strongly in the absence of air (destructive distillation), it changes into coke. Coke is a better fuel than coal as it produces almost no smoke on burning.

Petroleum: Petroleum is formed of two words – Petra (rock) and oeleum (oil) which combinedly means rock oil. It is a complex mixture of many compounds of hydrogen and carbon which are called hydrocarbons, small amounts of other compounds of carbon containing nitrogen, oxygen and sulphur are also present in petroleum along with water, salt and earth particles. Thus it is also called crude oil.

Fractional distillation: Crude oil is a thick black liquid and is not used as a fuel in its natural form. It is refined by heating crude oil (petroleum) in a furnace at a very high temperature of 400 °C. The process of fractional distillation is based on the fact that different components of crude oil have different boiling point ranges. Fractional distillation is carried out in a distillation tower. The components extracted from it are

- Fuel oil (350° – 400 °C)
- Diesel oil (250° – 350 °C)
- Kerosene oil (170° – 250 °C)
- Gasoline (Petrol) (40° – 170 °C)
- Petroleum gas (Below 40 °C) are all used as fuels
- Residual oil (Above 400 °C) when heated yields lubricating oil, paraffin wax and Asphalt which are not used as fuels

Liquified petroleum gas (LPG): On liquification, petroleum gas changes into liquid which is called liquified petroleum gas (LPG). The main constituent of LPG is butane, though it contains smaller amounts of ethane and propane also. It is a high calorific value fuel (50 kJ/g) which burns without smoke and is pollutionless.

Natural gas: Natural gas is an important fossil fuel usually found underground near oil source. Natural gas is lighter than air and is a mixture of methane (about 95%), ethane, propane and butane. It is highly inflammable and has no odour and cannot be seen. It is the cleanest burning fuel as it gives off 50% of the CO_2 released by coal and 25% less CO_2 than oil for the same amount of energy produced. Thus, natural gas is an environment-friendly fuel.

Thermal Power Plant

A thermal power plant is a setup is which heat generates electricity by burning coal. Water is heated, turns into steam which spins a steam turbine. The kinetic energy of rotation is converted into electrical energy through electric generator. The steam produced is sent back to the plants are setup near coal fields in order to make transmission of electric power more economical.

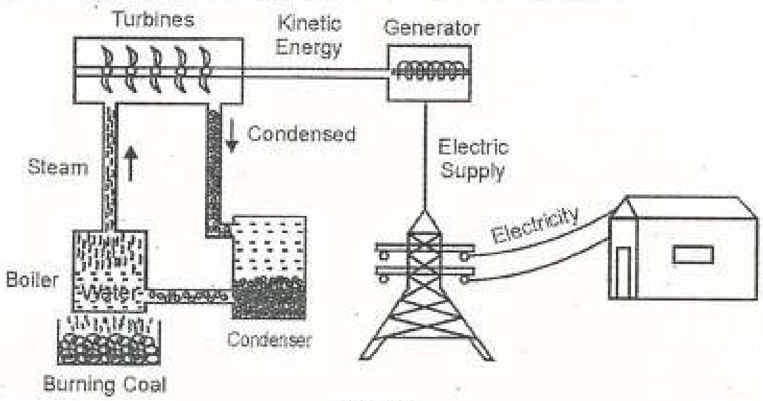


Fig. 5.1

Hydro Power Plant

Hydro power plants convert the potential energy of water at a height into electricity. Since there are very few waterfalls which could be used as a source of potential energy, hydro power plants are linked with dams. The water from high level in dam is carried through pipes, to the turbine at the bottom of the dam. The requirements for a hydroelectric power plant are a strong, fast flow of water and a significant height from where the water can fall. The potential energy of water changes into its kinetic energy which is transferred to the turbine.

Moving turbine rotates the armature of generator to produce electricity.

Advantages of Hydroelectricity

- It is the cheapest and renewable source energy
- Hydel projects have low maintenance cost and have a relatively long like
- They have quick start up and stopping time and rapid response to change in power demand
- The generation of hydel power is pollution free
- For every horse power of hydel power generated, about four metric tonnes of coal is saved.

Biomass and Bioenergy

Biomass can be defined as living matter or its residues and renewable source of energy. The biomass includes – agricultural and forest residues like bagasse, bark, wood shavings, roots, animal droppings, carbonaceous wastes like sewage, garbage, night soil etc; biodegradable organic affluents from industries like sugar, slaughter houses, meat packing plants, distilleries, breweries, etc.

Bioenergy is the energy obtained from biomass in the form of biogas. It is renewable source of energy on account of its production from vastly and continuously available organic wastes.

Anaerobic Degradation : Biogas is produced from the biomass by the process of anaerobic degradation. Anaerobic bacteria present in the biomass live without oxygen. These bacteria decompose (degrade) the biomass which contains carbon compounds through a complex series of reactions into amixture of gases which is called BIOGAS. This process is called anaerobic degradation.

While producing biogas, the manurial volume of biomass is not reduced, instead the left out mass is an enriched manure as it has a higher content of nitrogen phosporous and potassium.

Constituents of bio-gas : Biogas is composed of 75% methane, 25% CO_2 and traces of other gases such as nitrogen and hydrogen, whereas methane is a highly inflammable fuel, CO_2 is an inert gas.

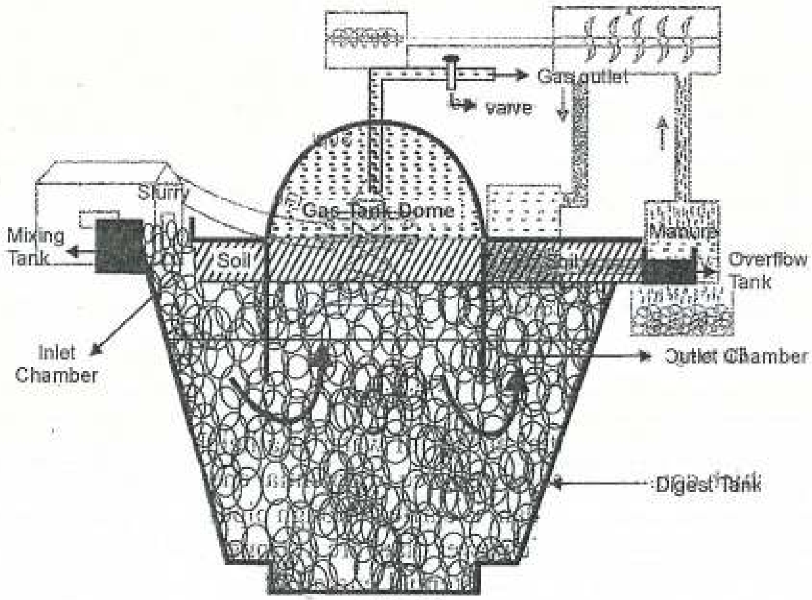


Fig. 5.2

Dome type biogas plant : A fixed dome type biogas plant is built with bricks.

Mixing tank : Slurry of cow-dung and water is mixed here and passed through inlet chamber to a digester tank.

Digester Tank is a sealed chamber underground where no oxygen is present. Slurry passed through **an inlet output chamber** gets accumulated in digester tank where the slurry is decomposed in 50-60 days by anaerobic degradation to produce biogas which gets collected in the **gas dome.** The gas dome as tank is provided with a **gas outlet** having a **valve** attached to it. The dome is built over the digester tank both form a single unit.

As the biogas keeps collecting in the dome, it exerts pressure on the slurry in the digester tank. This pressure forces the spent slurry (which becomes manure after degradation) to flow in the **overflow tank** through an **outlet chamber.**

The spent slurry is removed from overflow tank and is a good source of a manure of decompost. Fresh cow dung (GOBAR) slurry is called periodically to replace the spent slurry from time to time for continous gas supply.

Advantages of Biogas.

- Biogas is clean fuel that burns without smoke and leaves no ash.
- The chief component of biogas i.e. methane has higher calorific value (55kJ/g) then that of Petrol (for kJ/g)
- By using biogas firewood is saved and deforestation is reduced.
- A biogas plant is easy and simple to build and is very economical.

Wind Energy

The movement or flow of air along the surface of the earth is called wind. This wind moves from the regions of higher pressured to those where the air pressure is lower. Solar energy is one of the main factors responsible for the movement of air in the atmosphere i.e wind formation.
The kinetic energy possessed by air due to its velocity is called wind energy. This energy can be harnessed by windmills in the post to do mechanical work like lifting of water from a well. Today wind can be used to generate electricity with the help of a windmill.
Windmill

* A windmill is machine setup which converts the kinetic energy of the wind into mechanical energy, which is further used to rotate roter blades that helps generator to produce electricity.
* In a windmill an electric fan is fitted on a generator which is installed at the top of a high tower.The number of rotor blades and their shape and height of thw windmill depend on their average wind velocity and other such factors. The rotation of the blade helps to rotate the armature of an electric generation. Such a setup is called a wind turbine generator.
* The electric output of a single windmill is quite small and cannot be used for commercial purposes. Therefore a large number of windmills are erected over a large are, and this cluster is called a wind energy farm. The minimum velocity for a windmill to function is 15km/hr.

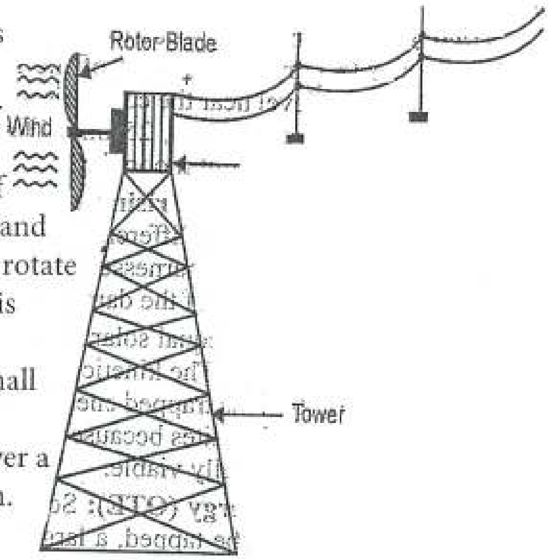


Fig. 5.3

* India's largest wind energy farm is near Kanyakumari, in Tamil Nadu which can generate 380 MW of electric power.

Solar Energy

The energy from the sun in the form of radiation is called solar energy. This energy is in the form of light waves. It is estimated that during a year India receives the energy equivalent to more than 5000 trillion kWh. The solar energy reaches the earth's surface in the form of infrared radiation and visible light. The solar energy is the cause of the wind and storm, ocean waves, rain and snowfall. Only 47% of this energy is absorbed by the surface of the earth, and 40% is lost by reflection due to water, snow and clouds, and about 13% of this energy is absorbed in the atmosphere.

Solar Constant : It is the amount of solar radiation falling per second on 1 m2 area of perfectly black surface at the mean distance of earth from the sun. The approximate value of the solar constant is 1.4kJ per second per square metro or 1.4kW/m2.

Solar Energy = solar constant **x** area **x** time

Solar Cell : Solar energy is useful only at certain times during the day only.This limitation o=is overcome by using solar cells that convert solar energy to electricity. A typical cell develop a voltage of 0.5 - 1V and can produce about 0.7W of electricity when exposed to the sun. A large number of solar cells are combined in a plate called solar cell panel that can deliver enough electricity for practical use.

Silicon is most commonly used to manufacture solar cells. Such cells are called **silicon photovoltaic cells (SPV)** with efficiency as high as 25%.

In a solar cell panel, silver is used to connect solar cells which made it a costly setup. The electricity produced by solar cell panels is stored by charging DC batteries which can be used to operate DC devices. Countries like Dominician Republic, Sri Lanka and Zimbabwe are leading user of solar cell panels.

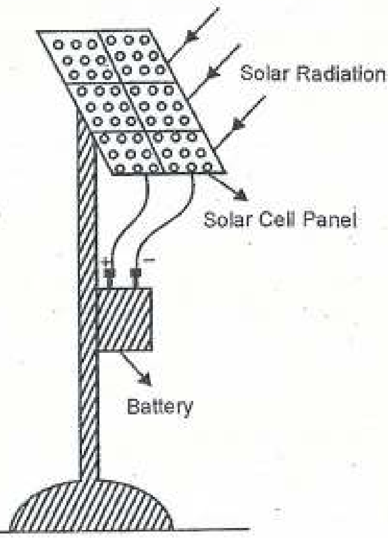


Fig. 5.4

Tidal energy: The energy due to movement of water level in the sea due to gravitational pull of the moon on water is called a tide, Water level near the coasts rises up and falls twice a day with an interval of 12 h, 25 min. High tides occur on every new moon day and full moon day.

The energy derived from rising and falling ocean tides is called tidal energy. The difference in sea-levels gives us tidal energy. This energy is harnessed by constructing a dam across a narrow opening to the sea. A turbine fixed at the opening of the dam converts tidal energy into electricity.

Wave energy: The unequal solar heating of the earth generates wind and this wind blowing over sea water generates waves. The kinetic energy passed by huge waves near the sea shore can be trapped to generate electricity. This trapped energy is called wave energy. This energy is effective in generating electric power in very few sites because only these areas with an average energy density of 40 MW/km of coastline are economically viable.

Ocean Thermal Energy (OTE): Scientist feel that if the large amount of solar energy stored in the oceans and seas can be tapped, a large amount of electric energy will be available to the tropical countries.

Solar energy stored in the oceans in the form of heat is called ocean thermal energy. It is the temperature difference between the warm surface of the ocean and deep cold water layer which is used to produce electric power by the process called ocean-thermal-energy conversion. The OTEC plants can operate if the temperature difference between the water at the surface and water at depths up to 2 km is 20 °C or more. The warm surface-water is used to boil ammonia whose vapours are then used to turn the generator turbines.

Geothermal Energy

Geothermal energy is the heat of the earth inside magma found within molten rocks and the fluids held inside. Earth's heat originates from the original formation of the plant, from radioactive decay of minerals, from volcanic activity, and from solar energy absorbed at the surface.

The **geothermal gradient,** which is the difference in temperature between earth's surface and its core drives a continuous conduction of thermal energy in the form of heat. This heat mixed with water and fluids form steam which moves the turbine to generate electricity. Though the heat stored inside the earth is vast, geothermal energy can be exploited only in particular areas called the **hot spots** formed when geological changes push the molten rocks, called as **magma**, upwards where it gets settled at some depths below the surface to form hot springs, volcanoes, geysers and bubbling mud holes which are hot spots on earth's surface.

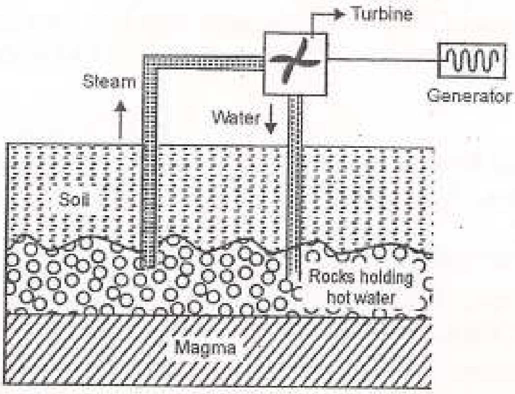


Fig. 5.5

The steam coming out of hot spots is used to turn the turbine of an electric generator to produce electricity. A 5 kW geothermal pilot power plant has been installed at Manikaram in Himachal Pradesh.

Nuclear Energy

The energy which we can obtain from the nucleus of an atom is called nuclear energy or atomic energy. We can obtain this energy from two processes–**Nuclear fission** and **Nuclear fusion**. Nuclear energy is measured in electron volt (eV) where $1eV = 1.6\ 10^{-19}$ J.

Nuclear fission: It is the splitting of an unstable nucleus of a heavy atom like Uranium, plutonium or thorium into two smaller nuclei with the liberation of vast amount of energy. This process is carried out by bombarding the heavy nuclei with suitable projectiles usually slow neutrons. The most prominent products of process are Barium (Mass = 139) and Krypton (Mass = 94). Three neutrons are produced along with huge amount of energy upto 220 MeV.

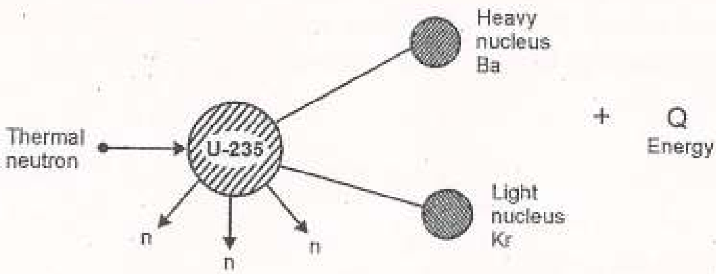


Fig. 5.6

Nuclear fission of U-235 can be shows as

$$^{235}_{92}U + ^{1}_{0}n \xrightarrow[\text{Fission}]{\text{Nuclear}} ^{139}_{56}Ba + ^{94}_{36}Kr + 3\,^{1}_{0}n + \underset{(220\text{ MeV}}{Q}$$

One kilogram of U-235, on fission produces as much energy as 2500 tons of coal produces on burning.

Nuclear fusion: It is the phenomenon of combining (fusing) two or more lighter nuclei to form a more stable heavy nucleus of degrees and high pressure in million of pascals are needed to bring about fusion.

The deuterons $\left(^{2}_{1}H\right)$ can joint to form a helium nucleus $\left(^{3}_{2}He\right)$ and a neutron.

$$^{2}_{1}H + ^{2}_{1}H \longrightarrow ^{3}_{1}He + ^{1}_{0}n + 3.27\text{ MeV}$$

Such nuclear reactions are the source of energy inside the sun and other stars.

In both fission and fussion, disappearance of certain mass in the process which appears in the form of energy. The sum of masses of the products is somewhat less than the sum of masses of the reactant. This difference in masses and after the nuclear reaction is called **mass defect (Δm).** Einstein's mass-energy relation is given by

$E = (\Delta m) C^2$

Δm = mass defect in the form of nuclear energy

C = velocity of light in vacuum.

Management of Sources of Energy

Though the natural resources on earth are available in abundance, the careless and unwisely use of them has compelled us to think about management of these sources of energy. The increasing population, industrialisation and urbanisation put strain on these resources. We need to manage our resources in such a way so that these resources will last for generations. Resources should be exploited in such a way that it must not cause the harm to the environment. The policy of sustainable development should be followed.

Environmental consequences of exploiting sources of energy

- Burning of fossil fuels causes air-pollution
- Using wood as fuel results in deforestation and ecological disbalance
- Construction of dams destroys large ecosystems, creates problem of rehabilitation of living population
- Windmills create noise-pollution and disturbs lives of migratory birds
- Heavy structures used to exploit petroleum beds and wave energy affect marine mammal and seabirds

We should conserve our forest by plantation, should adopt rain water harvesting, use more and more non-conventional sources of energy like wind energy, OCT energy, biomass gas, etc. to protect non-renewable sources of energy like fossil fuels from getting exhausted early.

Key Points

- ✓ Energy is required to perform work.
- ✓ The energy of different sources is used to generate electricity using turbine-generator setup.
- ✓ A source of energy provides enough useful energy at a steady rate over a long period of time.
- ✓ Sources of energy which are used extensively and meet a major portion of our energy demands are called conventional sources of energy like coal, petroleum, kerosene, etc.
- ✓ Non-conventional sources of energy are wind, tide, geothermal, nuclear, ocean wave, solar etc.
- ✓ Coal are of four varieties — Peat, Lignite, Bituminous and Anthracite. Anthracite, with highest carbon content (94% – 98%) is the best quality of like coal.
- ✓ Refining of petroleum by fractional distillation gives different useful fractions and is based on the fact that different fractions have different boiling points.
- ✓ A thermal power plant generates electricity by burning fossil fuels like coal.
- ✓ Hydel energy is the kinetic energy of flowing water and its sources is the solar energy.

- ✓ Biomass, which is the waste of living things and dead decayed part, contains carbon compounds and it is the oldest source of heat energy for domestic purposes. The energy obtained from biomass in form of gas in biogas (bioenergy).
- ✓ Biogas is a mixture of gases obtained from biomass by anaerobic degradation, in the absence of oxygen. It contains 75% methane, 25% carbon dioxide and traces of nitrogen and hydrogen.
- ✓ A windmill that converts wind energy into electrical energy requires a minimum wind velocity of 15 km/h to produce electricity.
- ✓ Solar energy is the energy from the sun in the form of light radiation and heat. The power of sun is 4.5×10^{23} kW.
- ✓ The earth receives on the average 4 kWh/m^2 solar energy daily.
- ✓ The approximate value of solar constant is 1.4 kW/m^2.
- ✓ A solar photovoltaic cell (SPC) directly converts solar energy into Direct current (DC). A number of solar cells arranged using silver form a solar cell panel.
- ✓ Ocean stores energy in many forms like tidal energy, wave energy and ocean thermal energy. The sea waves have both kinetic and potential energy as these rise and fall.
- ✓ Ocean thermal energy is the solar energy stored in the sea water on surface in the form of heat. The world's first OTEC plant with a capacity of 100 MW is to be set up in Tamil Nadu.
- ✓ Geothermal energy is the thermal energy contained in the core of the earth and is a renewable source of energy. Hot spots are those area where geothermal energy can be extracted. These geothermal sites correspond to the regions of earthquakes and volcanic activity.
- ✓ Uncontrolled nuclear chain reaction is the basis of an atom bomb, whereas a controlled nuclear reaction is the basis of hydrogen bomb.
- ✓ A hydrogen bomb is the most powerful weapon of destruction which works on the principle of nuclear fusion.
- ✓ For a given mass, energy obtainable from nuclear fusion is much larger than the energy obtainable from nuclear fission.
- ✓ The products of fusion are not radioactive and hence not harmful. However, we cannot control nuclear fusion reaction so as to use nuclear fusion energy for productive purposes.
- ✓ Hazards of nuclear power generation are due to the harmful effects on the organisms caused by the nuclear radiations emitted by the nuclear fuels and their wastes.

Multiple Choice Questions

1. Most of the sources of energy we use represent stored solar energy. Which of the following is not ultimately derived from the sun's energy ?
   (a) Geothermal energy
   (b) Wind energy
   (c) Nuclear energy
   (d) Bio energy
2. Which is the largest component of biogas?
   (a) Methane
   (b) CO_2
   (c) Nitrogen
   (d) Hydrogen
3. A programme that has been started to replenish the forests by growing more trees and plants is called
   (a) Silviculture
   (b) Tissue culture
   (c) Forestation
   (d) Apiculture
4. On which day the solar water heater cannot be used to get hot water ?
   (a) Sunny day
   (b) Windy day
   (c) Cloudy day
   (d) None of these
5. What type of mirror is used in solar cooker ?
   (a) Concave mirror
   (b) Plane mirror
   (c) Convex mirror
   (d) Any one of choice
6. Which one of these is not renewable source of energy ?
   (a) Solar energy
   (b) Geothermal energy
   (c) Biomass energy
   (d) Natural gas
7. Which one of these is not the conventional source of energy?
   (a) Fossil fuel
   (b) Solar energy
   (c) Biomass energy
   (d) Hydro energy
8. Which of the following is/are non-conventional source(s) of energy?
   (a) Geothermal energy
   (b) Solar energy
   (c) Ocean thermal energy
   (d) All of the above
9. Which country is called 'the country of winds' ?
   (a) Denmark
   (b) Newzealand
   (c) Iceland
   (d) India
10. Which one of the following is used as a fuel at nuclear power plant ?
    (a) Graphite
    (b) Uranium
    (c) Hydrogen
    (d) Radium
11. Which one of the following agent decomposes animal wastes into biogas ?
    (a) Fungus
    (b) Aerobic bacteria
    (c) Anaerobic bacteria
    (d) Virus
12. Which one is the cleanest of all these fuels ?
    (a) Coke
    (b) Bogas
    (c) Natural gas
    (d) Kerosene

13. Is wood a renewable source of energy ?
(a) Yes
(b) No
(c) Cant' be said
(d) Sometime yes

14. Aviation fuels is a special grade
(a) Natural gas
(b) Gasoline
(c) Petroleum
(d) Kerosene oil

15. Decomposition of domestic wastes under natural process is known as
(a) Anaerobic fertilisation
(b) Biodegradable process
(c) Non-biodegradable process
(d) Fractional distillation

16. A strong smelling which is added to LPG cylinders to help in the detection of gas leakage is
(a) Ethyl alcohol
(b) Ethyl acetate
(c) Ethyl mercaptan
(d) Ethyl dichromate

17. The gas which is commonly found an incomplete combustion of fossil fuels is
(a) Ammonia
(b) Carbon Monoxide
(c) Carbon dioxide
(d) Nitrogen

18. The process that forms the basis of hydrogen bomb is
(a) Nuclear fusion
(b) Nuclear fission
(c) Both (a) and (b)
(d) Any of these (a) and (b)

19. The gas leakage out during Bhopal Gas Tragedy was
(a) Carbon Monoxide
(b) Butyle Acetate
(c) Hudrogen peroxide
(d) Methyl isocynide

20. Hydrogen gas has high calorific value but it is not used as domestic fuel because
(a) It is highly combustible
(b) Its production cost is high
(c) Its transporation is difficult
(d) All of these

21. Which one of these substances is obtained as one of the fractions during the fractional distillation of petroleum ?
(a) Coal
(b) Gasoline
(c) Acetyline
(d) Natural gas

22. Name the product obtained by fractional distillation of petroleum which is used as a furnace fuel in metallurgical operation ?
(a) Diesel oil
(b) Gasoline
(c) Fuel oil
(d) Petroleum gas

23. Scientists consider........ as the fuel of future
(a) CNG
(b) Hydrogen
(c) Wave energy
(d) Gasohol

24. Tough charcoal is a better fuel than wood and coal, it cannot be used to meet large scale requirements as
(a) It causes pollution
(b) Its calorific value is less
(c) It cannot be stored easily
(d) It is not economical to use

25. Fuels which are manufactured by chemical process using primary fuels are called
    (a) Secondary fuels
    (b) Industrial fuels
    (c) Clean fuels
    (d) None of these
26. Which one of these is secondary fuel
    (a) Coke
    (b) LPG
    (c) Both (a) and (b)
    (d) None of these
27. A solar photovoltaic cell is made of
    (a) A semiconducting material
    (b) A conducting material
    (c) An alloy
    (d) An insulating material
28. The main limitation of generating nuclear energy through nuclear fission is
    (a) Splitting the nucleus
    (b) Converting nuclear energy into electric energy
    (c) Sustaining chain reaction
    (d) Disposal of nuclear wastes
29. Wind power of a windmill is
    (a) Directly proportional to the square of the wind speed
    (b) Directly proportional to the cube of the wind speed
    (c) Directly proportional to the wind speed of the wind speed
    (d) Directly proportional to the radius of the blades of the windmill
30. Which of the following statement is correct ?
    (a) Tidal energy is a non-reasonable source of energy
    (b) Tidal energy becomes unavailable during dry spell for many years
    (c) Tidal power plant requires large area of valuable land
    (d) There are very few suitable sites available for construction of dams
31. Acid rain happens because
    (a) Sun leads to heating of upper layer of atmosphere
    (b) Electrical charges are produced due to friction amongst clouds
    (c) Burning of fossil fuels release oxides of carbon, nitrogen and sulphur in the atmosphere
    (d) Earth's atmosphere contains acids
32. In a hydro power plant
    (a) Potential energy possessed by stored water is converted into electricity
    (b) Kinetic energy possessed by stored water is converted into electricity
    (c) Electricity is extracted from chemical reactions in water
    (d) Water is converted into steam to generate electricity
33. Which of the following is the ultimate source of energy ?
    (a) Water
    (b) Fossil fuel
    (c) Sun
    (d) Air

34. Ocean thermal energy (OTE) is due to
   (a) Energy stored by waves in the ocean
   (b) Temperature difference at different levels in the ocean
   (c) Pressure difference at different levels in the ocean
   (d) Tides arising out in the ocean
35. Which part of the solar cooker is responsible for greenhouse effect ?
   (a) Glass sheet
   (b) Mirror
   (c) Outer cover of the solar cooker
   (d) Coating with black colour inside the box
36. The electricity generated by a windmill depends on
   (a) Height of the tower
   (b) Velocity of wind
   (c) Size of the blades
   (d) All of these
37. Choose the false statement
   (a) Wave power output is of variable nature
   (b) Wave energy is renewable and pollution free
   (c) Wave power is inexpensive to explore
   (d) Wave power output is of variable nature

Answer Key

1. (c)	2. (a)	3. (a)	4. (c)	5. (a)	6. (d)	7. (b)	8. (d)	9. (a)	10. (b)
11. (c)	12. (c)	13. (a)	14. (d)	15. (b)	16. (c)	17. (b)	18. (a)	19. (d)	20. (d)
21. (b)	22. (c)	23. (b)	24. (d)	25. (a)	26. (c)	27. (a)	28. (d)	29. (b)	30. (a)
31. (c)	32. (a)	33. (c)	34. (b)	35. (a)	36. (b)	37. (c)			

Hints and Solutions

1. (c)

   Only nuclear energy has no role for the sun as it is based on nuclear reaction only.

2. (a)

   Methane-75%; CO_2-25%; Nitrogen and Hydrogen in traces only.

6. (d)

   All fossil fuels like coal, oil and natural gas are non-renewable sources of energy.

7. (b)

   Fossil fuel, hydro energy, bio energy and wind energy are conventional sources of energy. Solar energy, ocean energy (tide, wave and ocean thermal), geothermal and nuclear energy are non-conventional sources of energy.

8. (d)

   Same as Q. No. 10 above.

9. (a)

   Denmark generates 25% of its electric power requirement from wind energy.

10. (b)

    Uranium is used as nuclear fuel is nuclear fission reaction.

11. (c)

    Anaerobic bacteria fermented the biodegradable material such as biomass, manure, sewage, municipal waste, plant waste in the absence of oxygen to produce biogas.

12. (c)

    Natural gas gives off 50% of the CO_2 released by coal and 25% less CO_2 than oil for the same amount of energy produced.

13. (a)

    Yes, if we plant trees in a planned manner to ensure a continuous supply of wood.

21. (b)

    Petroleum on fractional distillation yields diesel, kerosene, petrol or gasoline, petroleum gas, asphalt, lubricating oil, paraffin wax.

23. (b)

    Suitable technologies are being developed to overcome difficulties in the way of using hydrogen as a fuel in near future.

26. (c)

    Coke LPG are secondary fuels whereas wood and petroleum are primary fuels.

27. (a)

    Solar cell is made of silicon which is a good semiconductor.

29. (b)

    Wind power, $P = \pi r^2 \rho v^3$, where, v is the speed and ρv is density of air.

36. (b)

    The minimum wind velocity for a windmill to function is 15 km/h

37. (c)

    Wave power is expensive with the current available harnessing techniques.

6. Chemical Reactions and Equation

Learning Objectives

* Chemical Reactions with some examples
* Characteristics of chemical reactions
* Chemical equation
* Writing of a chemical equation
* Balancing of a chemical equation
* Types of chemical reaction
    * Combintion reaction
    * Decomposition reaction
    * Displacement reaction
    * Double displacement reaction
    * Precipitation reaction
    * Neutralisation reaction
    * Oxidation and reduction (Redox reaction
* Effects of oxidation in daily life
    * Corrosion
    * Rancidity

Chemical Reactions and Equations

Consider the following conditions:

- Milk is left at room temperature during summer
- Burning of coke in air
- We respire

In **these reactions** some physical and chemical changes have taken place we can say, that a chemical reaction has taken place.

Chemical Reactions

'Chemical reaction simply involves rearrangement of atoms'. In chemical reaction the atoms of an element themselves do not undergo any change to form atoms of a new element.

Such processes in which no new chemical substances are formed are called **physical changes.**

Examples :

(i) Melting of ice

(ii) Evaporation of water

(iii) Dissolution of sugar in water

The above processes do not lead to the formation of any new chemical substance. For example: ice, liquid water and water vapour are chemically all same, *i.e.*, water (H_2O). Solution of sugar in water still contains the same chemical substance *i.e.*, sugar and water.

Such processes in which the original substance lose their nature and form a new substance with different properties are called **chemical changes.**

Examples :

(i) Rusting of iron articles such as tawa, pan or nails etc. especially in the rainy reasons.

(ii) Souring of milk in summer, and

(iii) Burning of coke in air.

In the above processes rust is chemically a different compound than the original substance iron. We cannot drink milk which has turned sour because the properties of milk have changed to form a new substance.

Examples of Some Chemical Reactions

1. Burning of magnesium ribbon in air.
2. Reaction between lead nitrate and potassium iodide.
3. Reaction between zinc and dilute sulphuric acid. (or hydrochloric acid).

Characteristics of chemical reactions

Some important characteristics of chemical reactions are:

Formation of a precipitate: Some chemical reactions are accompanied by the formation of a precipitate. For example: In the reaction between lead nitrate and potassium iodide solutions, a yellow precipitate of lead iodide appears.

Evolution of a gas: Some chemical reactions are accompanied by the evolution of a gas, For example: When calcium carbonate is heated or calcium carbonate reacts with dilute hydrochloric acid, carbon dioxide gas is evolved.

Change in colour: Some chemical reactions are accompanied by change in colour, For example: Rust is brown in colour whereas iron is greyish black in colour.

Change in state: Some chemical reactions are accompanied by change in state.

For example:

Hydrogen + Oxygen $\longrightarrow$ water

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

Change in temperature: Some chemical reactions are accompanied by change in temperature, *i.e.*, rise or fall of temperature.

For example:

$$CaO + H_2O \longrightarrow Ca\,(OH)_2 + \text{Heat}$$

Exothermic reactions

Reactions which are accompanied by rise in temperature or those reactions in which heat is evolved. Such reactions are called exothermic reactions.

For example: When zinc pieces react with sulphuric acid in a beaker or a flask, it is found to be warm.

Endothermic reaction: Reactions which are accompanied by fall in temperature or those reactions in which heat is absorbed. Such reactions are called endothermic reactions.

For example: When barium hydroxide, $Ba(OH)_2$ and ammonium chloride, NH_4Cl are taken in a test tube and mixed with a glass rod, then on touching the bottom of the test tube, it is found to be very cool.

$$Ba(OH)_2 + 2NH_4Cl \longrightarrow BaCl_2 + 2NH_4OH$$

Chemical Equations

The short-hand method of representing a chemical reaction in terms of symbols and formulae of the different reactions and products is called a chemical equation.

For example: Zinc reacts with dilute sulphuric acid to form zinc sulphate and give out hydrogen gas

$$\underbrace{\text{Zinc + Sulphuric acid}}_{\text{Reactants}} \longrightarrow \underbrace{\text{Zinc + Sulphate + Hydrogen}}_{\text{Products}}$$

The above reactions can be written in the form of chemical equation as follows:

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$$

Note: The chemical substances taken originally are called *reactants* and the new chemical substances formed after reaction are called *products*.

Writing a Chemical Equation

Writing a chemical equation involves the following steps:

(i) The symbols and formulae of the reactants are written on left hand side (LHS) with plus (+) sign between them.

(ii) The symbols and formulae of the products are written on right hand side (RHS) with (+) sign between them.

(iii) An arrow ($\longrightarrow$) sign is put between the reactants and the products, pointing from reactant towards products.

Balanced chemical equation

According to the law of conservation of mass, the total mass of products must be equal to the total mass of reactants. This is possible only if the number of atoms of each element is equal on the two sides of the equation.

'Such an equation in which the number of atoms of each element on the two sides of the equation is equal is called a balanced chemical equation.'

Steps involved in the balancing of a chemical equation: Write word equation for the reaction with reactants on LHS and products on RHS separated by an arrow head.

e.g., Aluminium + Hydrochloric acid $\longrightarrow$ Aluminium Chloride + Hydrogen

Convert the word equation into symbols / formula of the compounds.

e.g., $Al + HCl \longrightarrow AlCl_3 + H_2$

Equate the number of each type of atoms on both side of the reaction one by one.

e.g., $2\,Al + 6\,HCl \longrightarrow 2\,AlCl_3 + 3\,H_2$

Finally count the number of atoms of each element on reactant and product sides and if they are equal then the equation is balanced.

Important Caution:

(i) To make the number of atoms of any element equal on both sides of the equation, we cannot change the subscripts of the formula. We can only place a suitable whole number coefficient before the formula. For e.g., to have four O-atoms, we write $4\,H_2O$ and not H_2O_4 or $(H_2O)_4$.

(ii) The coefficient placed before the formula multiplies every atom of that formula by that number. For example, $2NH_3$ means 2N atoms and 6 H atoms. Similarly, $3H_2O$ means 6 H atoms and 3 O atoms.

Types of Chemical Reaction

Depending upon the nature of reaction, the chemical reactions have been broadly.

Classified into the following types:

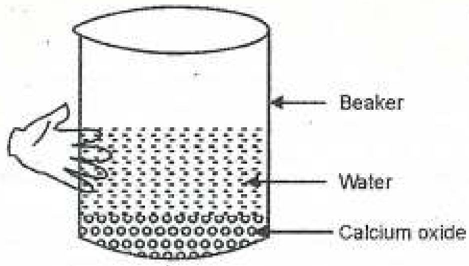
1. Combination reaction
2. Decomposition reaction
3. Displacement reaction
4. Double displacement reaction
5. Precipitation reaction
6. Neutralisation reaction
7. Reduction-oxidation (Redox) reaction

Combination reaction

'A reaction in which a single product is formed from two or more reactions is known as a combination reaction.'

For example: Calcium oxide reacts vigorously with water to produce slaked lime (calcium hydroxide) releasing a large amount of heat.

$$\underset{\text{(Quick lime)}}{CaO\,(s)} + \underset{\text{(water)}}{H_2O_{(l)}} \longrightarrow \underset{\text{(Slaked lime)}}{Ca\,(OH)_{2\,(aq)}}$$



Formation of slaked lime by the reaction of calcium oxide with water :

There are three types of combination reaction:

(a) Combination reaction between two elements:

Examples: 1. $\underset{\text{Carbon}}{C_{(s)}} + \underset{\text{Oxygen}}{O_{2(s)}} \longrightarrow \underset{\text{Carbondioxide}}{CO_{2(g)}}$

2. $\underset{\text{Hydrogen}}{2\,H_2} + \underset{\text{Oxygen}}{O_{2(s)}} \longrightarrow \underset{\text{Water}}{2\,H_2O\,(l)}$

3. $\underset{\text{Magnesium}}{2\,Mg_{(s)}} + \underset{\text{Oxygen}}{O_{2(g)}} \longrightarrow \underset{\text{Magnesium oxide}}{2\,MgO\,(s)}$

(b) Combination reaction between two compounds:

Examples: 1. $\underset{\text{Ammonia}}{NH_{3(g)}} + \underset{\text{Hydrogen Chloride}}{HCl_{(g)}} \longrightarrow \underset{\text{Ammonium Chloride}}{NH_4Cl(s)}$

2. $\underset{\text{Calcium Oxide}}{CaO_{(s)}} + \underset{\text{Carbondioxide}}{CO_{2(g)}} \longrightarrow \underset{\text{Calcium Carbonate}}{CaCO_{3\,(s)}}$

3. $\underset{\text{Ammonia}}{2\,NH_{(3)\,(g)}} + \underset{\text{Sulphuric Acid}}{H_2SO_{4\,(aq)}} \longrightarrow \underset{\text{Ammonium Sulphate}}{(NH_4)\,SO_{4\,(aq)}}$

(c) Combination reaction between an element and a compound:

Examples: 1. $\underset{\text{Carbon Monooxide}}{2\,CaO_{(g)}} + \underset{\text{Oxygen}}{O_{2(g)}} \longrightarrow \underset{\text{Carbondioxide}}{2CO_{2(g)}}$

2. $\underset{\text{Sulphurdioxide}}{2\,SO_{2(g)}} + \underset{\text{Oxygen}}{O_{2\,(g)}} \longrightarrow \underset{\text{Sulphur trioxide}}{2SO_{3\,(g)}}$

3. $\underset{\text{Carbondioxide}}{CO_{2(g)}} + \underset{\text{Carbon}}{C_{(s)}} \xrightarrow{\Delta} \underset{\text{Carbon monoxide}}{2CO}$

Decomposition reaction

A reaction in which a single compound breaks down to give two or more simpler substances is called decomposition reaction.

For example: Ferrous sulphate crystal on heating loses water and decomposes to form ferric oxide, sulphur dioxide and sulphur trioxide.

$$\underset{\text{(Ferrous sulphate)}}{FeSO_4} \xrightarrow{\text{heat}} \underset{\text{(Ferric oxide)}}{Fe_2O_{3(s)}} + SO_{2\,(g)} + SO_{3(g)}$$

Note: Common name of ferrous sulphate is **Green Vitriol.**

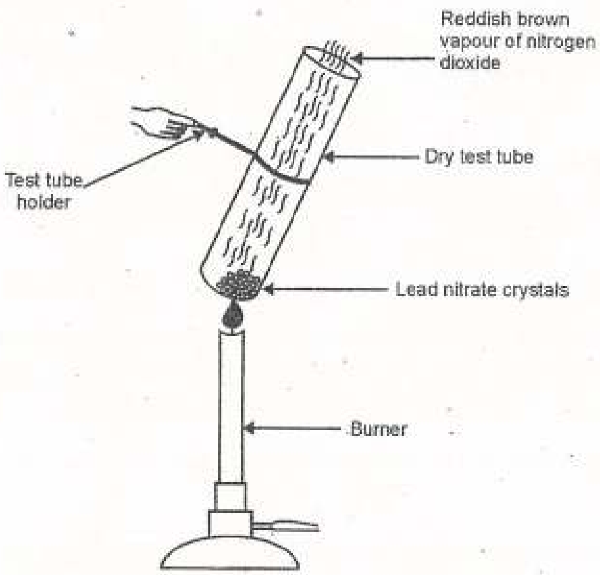
Decomposition reaction takes place only when the energy in the form of heat, electricity on light is supplied. Thus, there are three types of decomposition reactions possible. These are :

(a) **Thermal decomposition reactions:** Decomposition reactions which take place by absorption of heat.

Example:

Thermal decomposition of lead nitrate: Take powdered lead nitrate in a dry test tube. Hold it in the test tube holder. Heat it over the flame. Brown fumes of nitrogen dioxide are found to evolve and a yellow residue of lead oxide is left behind, in the test tube. This is due to the following decomposition reaction:

$$\underset{\substack{\text{Lead nitrate}\\\text{(white)}}}{2\,Pb(NO_3)_{2\,(s)}} \xrightarrow{\Delta} \underset{\substack{\text{Lead oxide}\\\text{(yellow)}}}{2\,PbO_{(s)}} + \underset{\substack{\text{Nitrogen dioxide}\\\text{(Brown fumes)}}}{4\,NO_{2(g)}} + \underset{\text{Oxygen}}{O_2(g)}$$



Experiment to illustrate decomposition reaction

(b) **Electrolytic decomposition reactions :** Decomposition reactions which take place when electric current is passed through the compound in the molten state or in aqueous solution.

Example: Electrolytic decomposition of molten sodium chloride: On passing electric current through molten sodium chloride, it decomposes to give sodium metal and chlorine gas,

$$\underset{\text{Sodium Chloride (molten)}}{2\,NaCl_{(s)}} \xrightarrow[\text{Current}]{\text{Electric}} \underset{\text{Sodium metal}}{2\,Na} + \underset{\text{Chlorine}}{Cl_2 \uparrow}$$

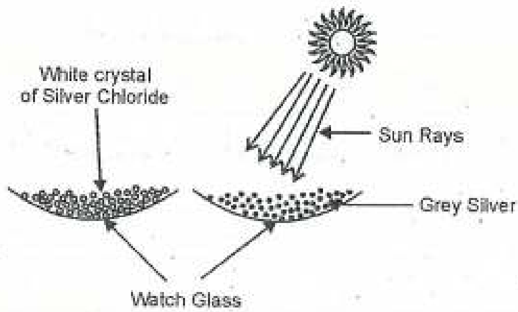
(c) **Photo decomposition reactions: (Photolysis):** Decomposition reactions which take place on absorption of light.

Examples: Decomposition of silver chloride or silver bromide: In the presence of sunlight white silver chloride or yellow silver bromide turns grey. This is because, in the presence of sunlight, these salts decompose to form silver metal as follows :

$$\underset{\substack{\text{Silver chloride}\\\text{(white)}}}{2\,Ag\,Cl} \xrightarrow{\text{Sunlight}} \underset{\substack{\text{Silver}\\\text{(Grey)}}}{2Ag} + Cl_2$$

$$\underset{\substack{\text{Silver bromide}\\\text{(yellow)}}}{2\,Ag\,Br} \xrightarrow{\text{Sunlight}} \underset{\substack{\text{Silver}\\\text{(grey)}}}{2\,Ag} + Br_2$$

Black and white photography is based upon these reactions as the photographic film is coated with these salts:



Displacement reaction

'A reaction in which a more active element displaces a less active element from its compound is called displacement reaction.'

For Example:

(i) If we put iron nail in blue coloured copper sulphate solution, the colour will change to green. It is because of the iron being more reactive than copper and hence displaces it from its salt solution.

$$Fe\,(s) + \underset{\text{Blue}}{Cu\,SO_4(aq)} \longrightarrow \underset{\text{Green}}{Fe\,SO_4\,(aq)} + Cu\,(s)$$

(ii) If a copper wire is dipped in silver nitrate solution, copper, being more reactive, displaces silver from silver nitrate solution. This silver is deposited on the copper wire giving it a white shining surface. This solution acquires blue colour due to the formation of copper nitrate.

$$\underset{\text{Copper}}{Cu\,(s)} + \underset{\substack{\text{Silver nitrate}\\\text{(Colourless)}}}{2\,Ag\,NO_3\,(aq)} \longrightarrow \underset{\substack{\text{Coppernitrate}\\\text{(Blue)}}}{Cu\,(NO_3)_2\,(aq)} + \underset{\text{Silver}}{2\,Ag\,(s)}$$

Note: If silver plate is dipped in copper nitrate, no reaction will take place because silver is less reactive than copper.

(i) On strongly heating ferric oxide with aluminium powder, the more active Al displaces the less active Fe from Fe_2O_3. The temperature is so high that iron is obtained in the molten state. This reaction is used for welding, broken parts of iron machinery or girders and is called ***aluminothermy or termite welding.***

$$\underset{\text{Ferrioxide}}{Fe_2O_{3(s)}} + \underset{\text{Aluminium}}{2\,Al_{(s)}} \xrightarrow{\Delta} \underset{\text{Aluminium oxide}}{Al_2O_3\,(s)} + \underset{\substack{\text{Iron}\\ \text{(molten)}}}{2\,Fe_{(l)}}$$

Reactivity series or activity series

The arrangement of metals in a vertical coloumn in order of their decreasing reactivity from top to bottom is called reactivity series or activity series

Metals more reactive than Hydrogen

Element	**Symbol**	
Potassium	K	← Most reactive
Barium	Ba	
Calcium	Ca	
Sodium	Na	
Magnesium	Mg	
Aluminium	Al	
Zinc	Zn	
Iron	Fe	
Nickel	Ni	
Tin	Sn	
Lead	Pb	
Hydrogen	**H**	
Copper	Cu	
Mercury	Hg	
Silver	Ag	
Platinum	Pt	
Gold	Au	← Least reactive

Metal less reactive than Hydrogen

Reactivity decreasing down ward

Double Displacement Reaction

'Reaction in which two ionic compounds in the solution react by exchange of their ions to form new compounds is called double displacement reaction.

For Example :

(i) When a solution of barium chloride is powered into the solution of sodium sulphate, a white precipitate is formed. It is due to chloride ions of $BaCl_2$ have been replaced by sulphate ions of Na_2SO_4 whereas sulphate ions of Na_2SO_4 have been replaced by chloride ions of $BaCl_2$.

$$\underset{\text{Barium Chloride}}{BaCl_{2(aq)}} + \underset{\text{Sodium Sulphate}}{Na_2SO_{4(aq)}} \longrightarrow \underset{\substack{\text{Barium Sulphate}\\ \text{(white ppt.)}}}{BaSO_{4(s)}} + 2\,NaCl_{(aq)}$$

(ii) $$\underset{\text{Copper Sulphate}}{CuSO_{4(aq)}} + \underset{\text{Ammonium Hydroxide}}{2\,NH_4OH_{(aq)}} \longrightarrow \underset{\substack{\text{Copper Hydroxide}\\ \text{(Bluish white ppt.)}}}{Cu(OH)_2\downarrow} + (NH_4)_2SO_4$$

(iii) $\underset{\text{Aluminium Chloride}}{AlCl_{3(aq)}} + \underset{\text{Ammonium Hydroxide}}{3\,NH_4OH_{(aq)}} \longrightarrow \underset{\text{Aluminium Hydroxide (white ppt.)}}{Al(OH)_3} + \underset{\text{Ammonium Chloride}}{3\,NH_4Cl}$

(iv) $\underset{\text{Copper Sulphate}}{CuSO_{4(aq)}} + \underset{\text{Hydrogen Sulphide}}{H_2S_{(g)}} \longrightarrow \underset{\text{Copper Sulphide (Black ppt.)}}{CuS\downarrow} + \underset{\text{Sulphuric acid}}{H_2SO_{4(aq)}}$

(v) $\underset{\text{Lead Nitrate}}{Pb(NO_3)_2} + 2\,KI \longrightarrow \underset{\text{Lead Iodide (Yellow ppt.)}}{PbI_{2(s)}} + 2\,KNO_3(aq)$

Precipitation Reaction

Precipitation reaction is double displacement reaction in which one of the compounds is insoluble. This insoluble compound is called **precipitate** and it settles at the bottom.

For Example:

$$\underset{\text{Silver Nitrate}}{Ag\,NO_3(aq)} + \underset{\text{Sodium Chloride}}{NaCl_{(aq)}} \longrightarrow \underset{\text{Silver Chloride (White ppt.)}}{Ag\,Cl_{(s)}\downarrow} + \underset{\text{Sodium Nitrate}}{NaNO_3\,(aq)}$$

Neutralisation Reaction

A reaction in which an acid reacts with a base to form salt and water is called neutralisation reaction.

For Example: Acid + Base $\longrightarrow$ Salt + Water

(i) $\underset{\text{Sodium hydroxide (Base)}}{NaOH} + \underset{\text{Hydrochloric acid (Acid)}}{HCl} \longrightarrow \underset{\text{Sodium Chloride (Salt)}}{NaCl} + \underset{\text{Water}}{H_2O}$

(ii) $\underset{\text{Ammonium hydroxide (Base)}}{NH_4OH} + \underset{\text{Hydrochloric acid (Acid)}}{HCl} \longrightarrow \underset{\text{Ammonium Chloride (Salt)}}{NH_4Cl} + \underset{\text{Water}}{H_2O}$

(iii) $\underset{\text{Oxalic acid}}{(COOH)_2} + \underset{\text{Sodium hydroxide}}{2\,NaOH} \longrightarrow \underset{\text{Sodium oxalate}}{(COONa)_2} + \underset{\text{Water}}{2\,H_2O}$

(iv) $\underset{\text{Potassium hydroxide}}{KOH} + \underset{\text{Hydro chloride}}{HCl} \longrightarrow \underset{\text{Potassium Chloride}}{KCl} + \underset{\text{Water}}{H_2O}$

Oxidation – Reduction (Redox) Reaction

A reaction in which simultaneous oxidation and reduction reactions take places.

Oxidation is defined as s process which involves (i) gain of oxygen or (ii) loss of hydrogen

Reduction is defined as a process which involves (i) gain of hydrogen or (ii) loss of oxygen

For Example:

(i) Oxidation of copper to copper oxide and reduction of copper oxide to copper

On heating reddish brown copper powder changes into a black substance. It is because oxygen is added to copper and copper oxide is formed.

$$\underset{\text{Copper (Reddish brown)}}{2\,Cu(s)} + \underset{\text{Oxygen (from Air)}}{O_2\,(g)} \longrightarrow \underset{\text{Copper(II) oxide (Black)}}{2\,CuO(s)}$$

If hydrogen gas is passed over this heated material (CuO), the black coating on the surface turns brown as the reverse reaction takes place and copper is obtained

$$\underset{\text{Copper(II) oxide (Black)}}{2\,CuO\,(s)} + H_{2(g)} \xrightarrow{\text{Heat}} \underset{\text{Copper (Reddish brown)}}{Cu(s)} + \underset{\text{Water vapour}}{H_2O_{(g)}}$$

During this reaction the copper (II) oxide is losing oxygen and is being reduced. The hydrogen is gaining oxygen and is being oxidised. In other words, one reactant gets oxidised while the other gets reduced during a reaction.

Oxidation

$$CuO + H_2 \xrightarrow{\text{Heat}} Cu + H_2O$$

Reduction

(ii) $ZnO + C \longrightarrow Zn + CO$

(iii) $MnO_2 + 4\,HCl \longrightarrow MnCl_2 + 2\,H_2O + Cl_2$

Note: Oxidising agent is a substance which (i) gives oxygen or (ii) gains hydrogen

Reducing agent is a substance which (i) gives hydrogen or (ii) gains oxygen

$$\underset{\text{(Oxidising agent)}}{ZnO_{(s)}} + C_{(s)} \longrightarrow \underset{\text{(Reducing agent)}}{Zn_{(s)}} + CO_{(g)}$$

Effects of Oxidation Reactions in Everyday life

There are a number of oxidation reactions taking place around us which affect our daily life. Common oxidation reactions are :

1. **Corrosion:** 'The process of slowly eating up of the metals due to attack of atmospheric gases such as oxygen, carbon dioxide, hydrogen sulphide, water vapour etc. On the surface of the metals so as to convert the metal into oxide, carbonate, sulphide etc. is known as **corrosion.**'

   For Example: Most common example of corrosion is **rusting,** *i.e.*, corrosion of iron. When an iron article remains exposed to moist air for a long time. Its surface is covered with a brown, flaky (non-sticky) substance called rust. Rust is mainly hydrated Ferric oxide ($Fe_2O_3.xH_2O$)

$$\underset{\text{Iron}}{2\,Fe_{(s)}} + \underbrace{\underset{\text{Oxygen}}{3/2\,O_{2(g)}} + \underset{\text{Moisture}}{xH_2O(l)}}_{\text{From air}} \longrightarrow \underset{\substack{\text{Hydrated Ferric oxide}\\\text{(Rust)}}}{Fe_2O_3xH_2O_{(s)}}$$

   Copper objects lose their lusture or shine after some time. The surface of these objects acquires a green coating of basic copper carbonate, $CuCO_3.Cu(OH)_2$ when exposed to air.

$$\underset{\text{Copper}}{2\,Cu(s)} + \underbrace{CO_{2(g)} + O_{2(g)} + H_2O_{(l)}}_{\text{From air}} \longrightarrow \underset{\substack{\text{Basic copper carbonate}\\\text{(Green)}}}{CuCO_3.Cu\,(OH)_2}$$

   Surface of silver metal gets tarnished on exposure to air, due to the formation of a coating of black silver sulphide (Ag_2S) on its surface.

$$\underset{\text{Silver}}{2\,Ag_{(s)}} + \underset{\substack{\text{Hydrogen Sulphide}\\\text{(From air)}}}{H_2S_{(g)}} \longrightarrow \underset{\substack{\text{Silver sulphide}\\\text{(Black)}}}{Ag_2S_{(s)}} + H_{2(g)}$$

Methods to prevent rusting: Some common methods generally used are given below :

(i) **By painting** the iron articles such as window grills, iron gates, steel furniture, railway coaches, buses etc.

(ii) **By galvanisation** *i.e.*, coating the surface of iron objects with a thin layer of zinc.

(iii) **By greasing and oiling** the iron articles such as mechanical tools, machine parts etc.

Sometimes, corrosion of metals is an advantage because it prevents the metal underneath from further damage. For example, aluminium objects lose their lustre and become dull due to the formation of layer of aluminium oxide (Al_2O_3). This layer does not allow moist air to come in contact with the metal and hence protects the metal underneath from further damage. Thus, **a common metal which is highly resistant to corrosion is aluminium.**

2. **Rancidity:** The oxidation of oils or fats in a food resulting into a bad smell and bad taste is called **rancidity.**'

Methods to prevent rancidity: The different methods used to prevent or slow down rancidity:

1. By adding anti-oxidants
2. Vacuum packing
3. Replacing air by nitrogen
4. Refrigeration of the food-stuff

Key Points

- ✓ A chemical reaction simply involves rearrangement of atoms.
- ✓ A chemical equation is balanced so that the number of atoms of each type involved in a chemical reaction are the same on the reactant and product sides of the equation. Equations must be balanced.
- ✓ In a combination reaction two or more substances combine to form a new single substance.
- ✓ The chemical substances taken originally are called reactants and the new chemical substances formed are called products.
- ✓ Decomposition reactions are opposite to combination reactions.
- ✓ Reactions in which heat is given out along with the products are called exothermic reactions.
- ✓ Reactions in which energy is absorbed are known as endothermic reactions.
- ✓ Those reactions in which a more active element displaces a less active element from its compound are called displacement reactions.
- ✓ Two different atoms or groups of atoms (ions) are exchanged in double displacement reactions.
- ✓ Precipitation reactions produce insoluble salts.

  (i) Oxidation is a process which involves gain of oxygen or loss of hydrogen.

  (ii) Reduction is a process which involves gain of hydrogen or loss of oxygen.
- ✓ Symbols used:

  (s) : It represents the solid state

  (l) : It represents the liquid state

  (g) : It represents the gaseous state

  (*aq*) : Aqueous state *i.e.*, solution in water

  (ppt) : precipitate

Multiple Choice Questions

1. Which of the following is not a physical change ?
   (a) Boiling of water to give water vapour
   (b) Melting of ice to give water
   (c) Dissolution of salt in water
   (d) Combustion of liquefied petroleum Gas (LPG)
2. Which one of the following is not a combination reaction ?
   (a) $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$
   (b) $NH_3 + H_2O \longrightarrow NH_4OH$
   (c) $2H_2 + O_2 \longrightarrow 2\,H_2O$
   (d) $2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2\,SO_4$
3. When ferrous sulphate crystals are strongly heated, the gas/vapour not evolved are of
   (a) SO_2 (b) SO_3
   (c) O_2 (d) H_2O
4. The following reaction
   $4\,NH_{3(g)} + SO_{2(g)} \longrightarrow 4\,NO_{(g)} + 6H_2O_{(g)}$ is an example of a
   (i) Displacement reaction (ii) Combination reaction
   (iii) Redox reaction (iv) Neutralization reaction
   (a) (i) and (iv) (b) (ii) and (iii)
   (c) (i) and (iii) (d) (iii) and (iv)
5. What is the corresponding change in colour when iron nail is dipped in the blue copper sulphate solution ?
   (a) Red (b) White
   (c) Green (d) Black
6. When a black and white photographic film is exposed to light, the grey colour on the photographic film is due to presence of
   (a) Ag_2O (b) Ag
   (c) Br_2 (d) All of these
7. Which of the following statements about the given reaction are correct ?
   $3\,Fe_{(s)} + 4\,H_2O_{(g)} \longrightarrow Fe_3O_4\,(s) + 4\,H_{2(g)}$
   (i) Iron metal is getting oxidised (ii) Water is getting reduced
   (iii) Water is acting as reducing agent (iv) Water is acting as oxidising agent.
   (a) (i), (ii) and (iii) (b) (iii) and (iv)
   (c) (i), (ii) and (iv) (d) (ii) and (iv)
8. Electrolysis of water is decomposition reaction. The mole ratio of hydrogen and oxygen gases liberated during electrolysis of water is
   (a) 1 : 1 (b) 2 : 1
   (c) 4 : 1 (d) 1 : 2

9. Which one of the following is an example of addition reaction

(a) $Cl_2 + 2\,KBr \longrightarrow 2\,KCl + Br_2$
(b) $Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$
(c) $2\,H_2S + SO_2 \longrightarrow 2H_2O + 3S$
(d) $CaO + H_2O \longrightarrow Ca\,(OH)_2$

10. The process of coating iron with zinc is called

(a) Electroplating
(b) Reduction
(c) Polishing
(d) Galvanisation

11. Which of the following gases can be used for storage of fresh sample of an oil for a long time ?

(a) Carbon dioxide or oxygen
(b) Carbon dioxide or helium
(c) Nitrogen or oxygen
(d) Nitrogen or helium

12. The following reaction is used for the preparation of oxygen gas in the loboratory

$$2\,KClO_{3(s)} \xrightarrow[\text{Catalyst}]{\text{Heat}} 2KCl_{(s)} + 3O_{2(g)}$$

Which of the following statement is correct about reaction for a decomposition reaction and endothermic in nature

(a) It is a decomposition reaction and accompanied by release of heat
(b) It is a combination reaction
(c) It is photochemical decomposition reaction and exothermic in nature

13. Which of the following metal will react with dilute hydrochloric acid to give out hydrogen gas

(a) Cu
(b) Pb
(c) Ag
(d) Hg

14. Which one of the following reaction will not take place ?

(a) $Zn + FeSO_4 \longrightarrow Zn\,SO_4 + Fe$
(b) $Fe + NiSO_4 \longrightarrow Fe\,SO_4 + Ni$
(c) $2\,Al + 3\,Mg\,SO_4 \longrightarrow Al_2\,(SO_4)_3 + 3\,Mg$
(d) $Cu + 2\,Ag\,NO_3 \longrightarrow Cu\,(NO_3)_2 + 2\,Ag.$

15. Rancidity is due to

(a) Combination of oils and fats
(b) Displacement of oils and fats
(c) Oxidation of oils and fats
(d) Reduction of oils and fats

16. Green coating on copper in rainy season is due to the formation of

(a) $CuCO_3$
(b) $Cu(OH)_2$
(c) $CuCO_3.Cu(OH)_2$
(d) CuS

17. Respiration is

(a) An exothermic process
(b) An endothermic process
(c) Neither exothermic nor endothermic
(d) Can be exothermic or endothermic

18. Which of the following are exothermic processes ?

(i) Reaction of water with quick lime
(ii) Dilution of an acid
(iii) Evaporation of water
(iv) Sublimation of camphor (crystals)

(a) (i) and (ii)
(b) (ii) and (iii)
(c) (i) and (iv)
(d) (iii) and (iv)

19. Which among the following is called double displacement reaction (s) ?

(i) $Pb + CuCl_2 \longrightarrow PbCl_2 + Cu$

(ii) $Na_2SO_4 + BaCl_2 \longrightarrow BaSO_4 + 2\,NaCl$

(iii) $C + O_2 \longrightarrow CO_2$

(iv) $CH_4 + 2\,O_2 \longrightarrow CO_2 + 2H_2O$

(a) (i) and (iv)
(b) (ii) and (i)
(c) (ii) only
(d) (iii) and (iv)

20. A dilute ferrous sulphate solution was added to the beaker containing acidified permanganate solution. The light purple colour of the solution fades and finally disappears. Which of the following is the correct explanation for the observation ?

(a) $KMnO_4$ is an oxidising agent, it oxidises $FeSO_4$
(b) $FeSO_4$ acts an oxidising agent and oxidises $KMnO_4$
(c) $KMnO_4$ is an unstable compound and decomposes in presence of $FeSO_4$ to a colourless compound
(d) The colour disappears due to the dilution : no reaction is involved

21. Which of the following is (are) on endothermic process(es) ?

(i) Dilution of sulphuric acid
(ii) Sublimation of dry ice
(iii) Condensation of water vapours
(iv) Evaporation of water

(a) (i) and (ii)
(b) (ii) and (iv)
(c) (ii) only
(d) (iii) only

22. Which of the following substance is reduced in the given reaction below ?

$PbS_{(s)} + 4H_2O_2\,(aq) \longrightarrow PbSO_{4(s)} + 4\,H_2O$

(a) Lead sulphide
(b) Hydrogen peroxide
(c) Both lead sulphide and Hydrogen peroxide
(d) Water

23. Which one of the following is not a chemical change ?

(a) Cooking of food
(b) Evaporation of water
(c) Burning of candle wax
(d) Digestion of food in our body

24. Which one of the following solution on mixing will not form a precipitate ?

(a) Lead acetate and potassium iodide
(b) Lead nitrate and sulphuric acid
(c) Iron sulphide and dilute sulphuric acid
(d) Potassium bromide and silver nitrate

25. Which one of the following on mixing with water will result in rise of temperature ?

(a) Sodium chloride
(b) Sodium hydroxide
(c) Potassium nitrate
(d) $CuSO_4.5H_2O$

26. In which of the following chemical equations, the abbreviations represent the correct states of the reactants and products involved at reaction temperature ?

(a) $2\,H_2\,(g) + O_2\,(l) \longrightarrow 2\,H_2O\,(l)$
(b) $2\,H_2\,(l) + O_2\,(l) \longrightarrow 2\,H_2O\,(g)$
(c) $2\,H_2\,(g) + O_2\,(g) \longrightarrow 2\,H_2O\,(g)$
(d) $2\,H_2\,(g) + O_2\,(g) \longrightarrow 2\,H_2O\,(l)$

27. Which one of the following does not result in the evolution of H_2 gas ?

(a) Zinc and hydrochloric acid
(b) Iron and sulphuric acid
(c) Magnesium and very dilute nitric acid
(d) Aluminium and nitric acid

28. $Fe_2O_3 + 2\,Al \longrightarrow Al_2O_3 + 2\,Fe$

The above reaction is an example of a

(a) Combination reaction
(b) Double displacement reaction
(c) Displacement reaction
(d) Decomposition reaction

29. A balanced chemical equation is in accordance with which one of the following laws given below

(a) Law of conservation of mass
(b) Law of conservation of energy
(c) Law of constant proportion
(d) Low of multiple proportion

30. Rust is

(a) Fe_2O_3
(b) $FeSO_4$
(c) $Fe_2O_3.xH_2O$
(d) $Fe_2O_3\,H_2O$

Answer Key

1. (d)	2. (a)	3. (c)	4. (c)	5. (c)	6. (b)	7. (c)	8. (b)	9. (d)	10 (d)
11. (d)	12. (a)	13. (b)	14. (c)	15. (c)	16. (c)	17. (a)	18. (a)	19. (c)	20. (a)
21. (b)	22. (b)	23. (b)	24. (c)	25. (a)	26. (c)	27. (d)	28. (c)	29. (c)	30. (c)

Hints and Solutions

1. Combustion of LPG (a mixture of propane (C_3H_8), butane (C_4H_{10}) etc. in liquified form) involves a chemical reaction.

4. It is a displacement reaction because H of NH_3 has been displaced by oxygen. It is also redox reaction because NH_3 has been oxidised to NO whereas O_2 has been reduced to H_2O.

8. $2H_2O(l) \xrightarrow{\text{Electrolysis}} 2H_{2(g)} + O_{2(g)}$

   Mole ratio of H_2 to O_2 liberated = 2 : 1.

10. Galvanisation is the process of coating iron with zinc in order to prevent its rusting.

11. Nitrogen and helium are inert gases and prevent the oxidation of oil and hence prevent the rancidity.

19. Only reaction (ii) is a double displacement reaction because cations/anions of both the salts are exchanged.

26. At the reaction temperature, H_2 gas combine with O_2 gas to form H_2O vapour.

7. Acids, Bases and Salts

Learning Objectives

* Classification of acids, bases and salts
* Indicators
* Properties of acids and their uses
* Properties of bases and their uses
* Properties of salts
* pH scale
* Role of pH in daily life
* More about some salts

Acids, Bases and Salts

The **chemical substance** obtained from animals and plants are called **organic compounds** whereas those obtained from minerals and rocks are called **inorganic compounds.** These compounds are present in food stuff as well as in a number of other materials that we use in our daily life like washing soda, lime etc.

On the basis of their taste, the compounds were classified into the following three categories:

(i) Acids (ii) Bases and (iii) Salts

Acids: Acids are the substances which have sour taste. The term has been derived from the Latin word, **acidus,** which means sour. For *e.g.*, lemon juice, tomatoes, vinegar etc.

According to **Arrhenius**, acids are those substances which give hydrogen ions in water. Since hydrogen ion does not exit, it combines with water to form hydronium ion.

$H^+ + H_2O \longrightarrow H_3O^+$

e.g., $HCl + H_2O \longrightarrow H_3O^+ + Cl^-$

$H_2SO_4 + 2H_2O \longrightarrow 2H_3O^+ SO_4^{-2}$

Bases: Bases are bitter in taste. **For example** : washing soda, baking soda etc.

According to Arrhenius bases are those substances which give hydroxide ions in aqueous solution.

For example: $NaOH_{(aq)} \longrightarrow Na^+ + OH^-$

$KOH_{(aq)} \longrightarrow K^+ + OH^-$

Note: The water soluble bases are called **alkalis.** All alkalies are base, but all bases are not alkalies.

Salts: Salts are the compounds formed from acids and bases. **For Example** : Sodium Chloride, copper sulphate, silver nitrate, calcium carbonate. Salt having taste similar to that of common salt are called salty.

Salts are those substance which are formed by neutralization of an acid with a base.

For example: $\underbrace{\text{Zinc + Sulphuric acid}}_{\text{Reactants}} \longrightarrow \underbrace{\text{Zinc + Sulphate + Hydrogen}}_{\text{Products}}$

Indicators

There are some substances which show one colour in acidic medium and another colour in the basic medium. These are called **acid-base indicators.**

There are some substances whose odour changes in acidic or basic media. These are called **olfactory indicators Acid-Base indicators.**

The three well known indicators belonging to this category are Litmus, Phenolphthalein and Methyl orange. Litmus is a **natural indicator** (found in plants) whereas **phenolphthalein** and methyl orange are **synthetic indictor** (synthesised in the laboratory or industry.)

(i) **Natural indicator:** (Litmus) On the basis of changing the colour of litmus paper we can identify acids and bases:

Acids change the colour of blue litmus to red	Bases change of the colour of Red litmus to blue
Vinegar	Baking soda solution
Lemon juice, orange juice	Washing soda solution
Tamarind (imli) juice	Bitter gourd (loki) extract
Juice unripe mangoes	Cucumber (Kheera) extract

Note: Litmus solution itself is neither acidic nor basic. It is neutral and has a purple colour.

(ii) **Synthetic indicators:** The two most common are phenolphthalein and methyl orange. Their colours in the acidic or basic solution are given in the table below :

Indicator	Colour in the neutral solution	Colour in the acidic solution	Colour in the basic solution
Phenolphthalein	Colourless	Colourless	Pink
Methyl orange	Orange	Red	Yellow

Olfactory indicators: Vanilla, Onion and Clove oil are most commonly olfactory indicators.

Properties of Acids

1. Acids are sour in taste
2. Methyl orange turns red when 1–2 drops of its solution are added to the solution of an acidic substance.
3. Acids turn blue litmus solution red.
4. Acids are corrosive in nature
5. Acids reacts with metals above hydrogen in the activity series to liberate hydrogen gas

   (i) $\underset{\text{Zinc}}{Zn\,(s)} + \underset{\substack{\text{Sulphuric acid}\\ \text{(dil)}}}{H_2SO_{4\,(aq)}} \longrightarrow \underset{\text{Zinc sulphate}}{ZnSO_4} + \underset{\text{Hydrogen}}{H_{2(g)}}$

   (ii) $Zn\,(s) + 2\,HCl\,(aq) \longrightarrow ZnCl_2\,(aq) + H_2\,(g)$

   [**Note :** Hydrogen gas evolved produces 'POP' sound on burning.]
6. Acids react with metal carbonates and bicarbonates to give out carbon dioxide with effervescence and forming the corresponding salt and water.

In general:

[Metal carbonates or hydrogen carbonate + Acid $\longrightarrow$ Salt + CO_2 + H_2O]

Limestone, chalk and marble react with acid as follows:

$$\underset{\substack{\text{Calcium carbonate}\\\text{(Limestone/chalk/marble)}}}{CaCO_3} + 2HCl \longrightarrow \underset{\text{Calcium Chloride}}{CaCl_2} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2}$$

7. The solutions of acids in water conduct electricity.
8. Acids reacts with a base form salt and water. This process is called **neutralization.**

$$\underset{\text{Potassium hydroxide}}{2\,KOH} + \underset{\text{Hydro Chloric acid}}{HCl} \longrightarrow \underset{\text{Potassium Chloride}}{KCl} + \underset{\text{Water}}{H_2O}$$

9. Acids react with metal oxides to form salt and water

For example:

$$C_{(g)} + O_{2(g)} \longrightarrow CO_{2(g)}$$

In general:

$$\boxed{\text{Metal oxide + Acid} \longrightarrow \text{Salt + Water}}$$

Note :1. Metal oxides show neutralization reaction so metallic oxides are basic oxides.

2. Like metal oxides, metal hydroxides are also basic in nature.

$$\underset{\substack{\text{Magnesium hydroxide}\\\text{(Milk of magnesia)}}}{Mg\,(OH)_{(2)}} + 2\,HCl \longrightarrow \underset{\text{Magnesium Chloride}}{Mg\,Cl_2} + \underset{\text{Water}}{2\,H_2O}$$

10. Acids react with sulphites and hydrogen sulphites to form water and sulphur dioxide.

$K_2SO_3 + H_2SO_4 \longrightarrow K_2SO_4 + H_2O + SO_2$

Some naturally occurring acids: A few naturally occurring substances and the acids present in them are given in table below:

Natural source	Acid present
Orange, lemons	Citric acid
Vinegar	Acetic acid
Proteins	Amino acids
Apples	Malic acid
Tomatoes	Oxalic acid
Sour milk or curd	Lactic acid
Tamarind (imli)	Tartaric acid

Uses of Some Common Acids

1. Sulphuric acid – In industry and called the **king of chemicals**
2. Acetic acid – For cooking
3. Tartaric acid – For baking powder
4. Boric acid – For washing eyes
5. Oxalic acid – For removing stains

6. Citric acid – Food preservative
7. Carbonic acid – In soft drinks

Properties of Bases

1. Bases are bitter in taste
2. They possess a slippery touch like soaps
3. They turn red litmus blue
4. They turn phenolphthalein solution pink
5. Some bases like caustic soda (sodium hydrogen) caustic potash etc. produce a burning sensation on the skin *i.e.*, they are **corrosive** in nature.
6. Bases react with acids to form salt and water.

   For example:

   $$\underset{\text{(Base)}}{2\,NaOH} + \underset{\text{(Acid)}}{H_2SO_4} \longrightarrow \underset{\substack{\text{Sodium sulphate}\\ \text{(Salt)}}}{Na_2SO_4} + \underset{\text{(water)}}{2\,H_2O}$$

7. Bases react with metals to liberate hydrogen gas along with the formation of salt

   e.g.,

   (i) $\underset{\text{Sodium hydroxide}}{2\,NaOH} + \underset{\text{Zinc}}{Zn} \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + \underset{\text{Hydrogen}}{H_2}$

   (ii) $2\,NaOH + 2\,Al + 2\,H_2O \longrightarrow \underset{\text{Sodium aluminate}}{2\,NaAlO_2} + 3\,H_2$

8. Bases react with non-metal oxides (like CO_2, SO_2, SO_3, P_2O_5 to form salt and water.

   Base + Non-metal oxide $\longrightarrow$ Salt + Water

   e.g., $Ca\,(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

   Note : This shows that non-metal oxide are **acidic in nature**

9. Like acids, the solution of bases in water also conduct electricity.
10. Bases react with ammonium salts to liberate ammonia gas:

    $NaOH + NH_4Cl \longrightarrow NaCl + H_2O + \underset{\text{Ammonia}}{NH_3}$

    $2\,KOH + (NH_4)_2\,CO_3 \longrightarrow K_2CO_3 + 2\,H_2O + NH_3$

    Ammonia has pungent odour. When a glass rod dipped in dilute hydrochloric acid is brought near the mouth of the test tube containing ammonia and white fumes of ammonium chloride is formed.

11. Hydroxides of zinc, lead and aluminium are **amphoteric** in nature *i.e.*, they behave both acids as well as base.

    $Zn\,(OH)_2 + H_2SO_4 \longrightarrow Zn\,SO_4 + 2H_2O$

    $Zn\,(OH)_2 + NaOH \longrightarrow Na_2\,ZnO_2 + 2\,H_2O$

    $Al\,(OH)_3 + 3\,HNO_3 \longrightarrow Al\,(NO_3) + 3\,H_2O$

    $Pb\,(OH)_2 + 2\,NaOH \longrightarrow Na_2\,PbO_2 + 2H_2O$

Uses of Some Common Bases

1. NaOH (caustic soda) $\rightarrow$ For removing stains from cloths.
2. KOH (caustic potash) $\rightarrow$ For manufacturing soaps and in alkaline batteries.

3. $Ca(OH)_2$ (Slaked lime) → In manufacture of bleaching powder, in white washing and testing of CO_2 gas.
4. Mg $(OH)_2$ (Milk of lime) → As an anta acid to neutralize acid in the stomach
5. Al $(OH)_3$ → As a foaming agent in extinguishing fire
6. NH_4OH → For removing grease from clothes in dry cleaning and in cleaning window panes.

Properties of Salts

1. Some salts are **hydroscopic** in nature *i.e.*, they absorb water vapours from air.
   e.g., Quick lime (CaO), concentrated sulphuric acid, anhydrous calcium chloride etc.
2. Some salts are **deliquescence** in nature *i.e.*, they absorb water vapour from atmosphere and completely dissolves in it to from a saturated solution
   e.g., NaOH, KOH, Anhydrous $CaCl_2$
3. Salts shows **efflorescence** *i.e.*, certain hydrated salts loose their water of crystallization partially or completely when exposed to air
   $Na_2CO_3.10\,H_2O \longrightarrow Na_2CO_3 \,.\, H_2O + 9\,H_2O$
   Such substances are called **efflorescent substances.**
4. It is the number of water molecules which enter into lattice structure of a salt during its crystalization. Such salts are called **hydrous or hydrated salts.**
   e.g.,
   1. Calcium chloride ($CaCl_2 \,.\, 6\,H_2O$)
   2. Gypsum or calcium sulphate $CaSO_4 \,.\, 2\,H_2O$
   3. Plaster of paris or calcium sulphate hemihydrate $\left(CaSO_4.\frac{1}{2}H_2O\right)$
   4. Epsom salt or copper sulphate ($MgSO_4 \,.\, 7\,H_2O$)
   5. Blue nitrate or copper sulphate ($CuSO_4 \,.\, 5\,H_2O$)
   6. Glauber salt or sodium sulphate ($Na_2SO_4 \,.\, 10\,H_2O$)
   7. Green vitriol or ferrous sulphate ($FeSO_4 \,.\, 7\,H_2O$)
   8. White vitriol or Zinc sulphate ($ZnSO_4 \,.\, 7\,H_2O$)
   9. Washing soda or sodium carbonate deca hydrate ($Na_2\,CO_3 \,.\, 10\,H_2O$)

Acidity or Alkalinity of a Solution in Terms of pH

Sorenson, a Danish biochemist in 1909 suggested a method of expressing molar concentration of H^+ ions in terms of pH which in Denish language stands for potenz de hydrogen (means power of H^+ ions). It is defined as follow's:

pH of a solution is the magnitude of the negative power to which 10 must be raised to express the hydrogen ion concentration of the solution in moles per litre.

$[H^+ = 10^{-pH}]$

For example:

(i) What will be the pH of 0.01 mole of sulphuric acid in 2 litres of the solution ?

Solution: Molar concentration of H_2SO_4 solution $= \frac{0.01\text{ mol}}{2\text{ L}} = 0.005\text{ mol L}^{-1}$

As H_2SO_4 is a strong acid, it completely ionizes as:

$$H_2SO_4 \xrightarrow{+\text{ Water}} 2H^+ + SO_4^{2-}$$

Thus 1 molecule of H_2SO_4 gives 2 H^+ ions

$\therefore$ $[H^+] = 2 \times [H_2SO_4] = 2 \times 0.005 = 0.01 \text{ mol L}^{-1} = 10^{-2} \text{ mol L}^{-1}$

Hence pH = 2

(ii) The pH 10^{-5} M NaOH solution

Solution: NaOH is strong base. It ionizes completely in aqueous solution as

$$NaOH \xrightarrow{+\text{ Water}} Na^+(aq) + OH^-(aq)$$

$\therefore$ $[H^+] = [NaOH] = 10^{-5}$ M

To calculate the pH of the solution, we should know $[H^+]$. This can be calculated by using the formula

$$[H^+]\,[OH^-] = K_W = 10^{14}\ M^2$$

$$\text{Or } H^+ = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}}{10^5} = 10^{-9}\ M$$

pH = 9

Note: For any solution (neutral, acidic or basic) the product of H^+ ion concentration and OH^- ion concentration (in mole per litre) is always constant and equal to 10^{-14} at 25° C. This is called as **ionic product** of water. It is represented by the symbol (K_w).

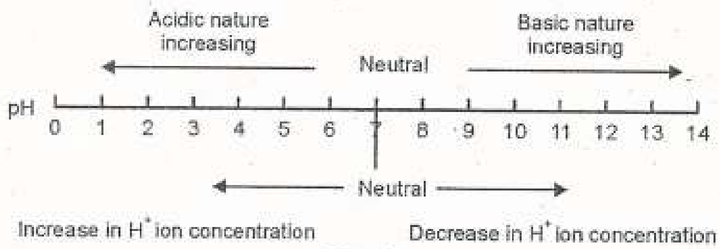
$$K_W = [H^+]\,[H^-] = 10^{-14} \text{ at } 25°\text{ C}$$

Variation of pH with change in concentration of H^+ and OH^- ions:

(i) For neutral solution, pH = 7

(ii) For acidic solution, pH < 7 and greater than the H^+ ion concentration than 10^{-7}M, less is the pH value then more acidic is the solution.

(iii) For basic or alkaline solution, pH > 7 and greater than OH^- ion concentration than 10^{-7}M less is the H^+ ion concentration and hence greater is the pH value and more basic is the solution.



pH scale

Example: The pH of two solutions A and B are 2 and 4 respectively which one of them is more acidic ? What is the ratio of H^+ ion concentration of the solutions ?

Solution : pH = 2 means $[H^+] = 10^{-2}$ M

pH = 4 means $[H^+] = 10^{-4}$ M

As $10^{-2} > 10^{-4}$ solution, Thus, A is more acidic than solution B

$$\frac{[H^+] \text{ in solution A}}{[H^+] \text{ in solution B}} = \frac{10^{-2}\ M}{10^{-4}\ M} = 10^2 = 100$$

i.e., $[H^+]$ in solution A is 100 times more than that in solution B.

pH Values of Some Common Solutionst

1. Pure water (7.4)
2. Human blood and tears (7.4)
3. Gastric juice (1.0 – 3.0)
4. Lemon juice (2.2 – 2.4)
5. Wine (2.8 – 3.8)
6. Coffee (4.5 – 5.5)
7. Milk (6.8)
8. Milk of magnesia (10) (saturated Mg $(OH)_2$
9. 0.1 M NaOH (13)
10. 1 M NaOH (4)

Role of pH in Daily Life

(a) In plants and animals: Our body works within the pH range of 7.0 to 7.8. Living organisms can survive only in a narrow range of pH change. When pH of rain water is less than 5.6, it is called acid rain. When acid rain flows into the rivers, it lowers the pH of the river water. The survival of aquatic life in such of the rivers becomes difficult.

(b) In soil: Plants require a specific pH range for their healthy growth. Citrus crops grow better in alkaline soils, while sugarcane grow better in neutral soil. The pH of soil is to be tested before growing the crop.

(c) In digestive system: Our stomach produces hydrochloric acid. It helps in the digestion of food without harming the stomach. During indigestion the stomach produces too much acid and this causes pain and irritation. This problem is called 'acidity'. It is cured by taking medicines called 'antacid'. The most commonly used antacid contains magnesium hydroxide (milk of magnesia) which is a weak base and neutralize the excess acid.

(d) Tooth decay: When pH of our mouth reaches a value of less than 5.5, the enamel of tooth starts decaying. In presence of sugar and food particles in the mouth the bacterial action starts and acid is produced. This acid is neutralized by alkaline saliva in the mouth. The acid which is not neutralized can be removed by brushing with tooth paste as they are alkaline and hence prevents the tooth decay.

(e) Self defence of animals and plants through chemical warfare: The sting of honey bee is very painful as it contains methanoic acid. To get relief, a milk solution of baking soda can be applied.

Muscular fatigue caused by and formation: It is interesting to know that the stiffness and pain that we feel after the exercise is due to the formation of an acid called lactic acid when we do excessive physical labour aerobic metabolism is not sufficient to provide the required energy. Hence muscles will depend over the aerobic metabolism. This result in the production of lactic acid and that accumulates in the muscles and we feel stiffness and pain.

More about Salts

Sodium hydroxide (NaOH)

It is manufactured by **Chlor-alkali process** because of the products formed chlor for chlorine and alkali for sodium hydroxide. When electricity is passed through an aqueous solution of sodium chloride (called brine). It decomposes to form sodium hydroxide.

$$2\,NaCl(aq) + 2H_2O\,(l) \longrightarrow 2\,NaOH\,(aq) + Cl_2(g) + H_2(g)$$

Uses: Hydrochloric acid used for cleaning steel, cosmetics, NaOH is used in paper making, De-greasing metals.

Baking soda ($NaHCO_3$) (sodium hydrogen carbonate)

(i) In laboratory it is prepared by passing carbon dioxide through cold saturated solution of sodium carbonate.

$$Na_2CO_3 + H_2O + CO_2 \longrightarrow 2\,NaHCO_3$$

(ii) On large scale it is obtained as an intermediate in the **Solvay's process**

$$NH_3 + H_2O + CO_2 \longrightarrow NH_4HCO_3$$

$$NH_4 + HCO_3 + NaCl \longrightarrow NaHCO_3 + NH_4Cl$$

Properties of $NaHCO_3$

- It is white solid
- It is sparingly soluble in water. Its aqueous solution is basic. It reacts with acid to form salt, water and carbon dioxide.

$$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$$

Uses of $NaHCO_3$: For making baking powder, which is a mixture of sodium hydrogen carbonate and tartaric acid.

- As an ingredient in antacids
- In soda acid fire extinguishers.

Bleaching powder ($CaOCl_2$) (calcium oxychloride)

Bleaching powder is produced by the action of chlorine on dry slaked lime [Ca(OH)2]

$$\underset{\substack{\text{Calcium hydroxide}\\\text{(Slaked lime)}}}{Ca(OH)_{2(s)}} + Cl_{2(g)} \longrightarrow \underset{\text{Calcium oxychloride}}{CaOCl_2} + H_2O_{(l)}$$

Because of this reaction bleaching powder is also called **chloride of lime.**

Properties of $CaOCl_2$: Yellowish white powder of calcium oxychloride has strong smell of chlorine.

- When left open in air, it decomposes slowly and liberate chlorine gas

$$CaOCl_2 + CO_2 \longrightarrow CaCO_3 + \underset{\text{Chlorine gas}}{Cl_2}$$

- On reaction with dilute acids of liberates chlorine gas

$$CaOCl_2 + \underset{\text{Hydrochloric acid}}{2\,HCl} \longrightarrow CaCl_2 + Cl_2 + H_2O$$

$$CaOCl_2 + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow CaSO_4 + H_2O + Cl_2$$

Uses of $CaOCl_2$: For bleaching cotton and linen in the textile industry.

- In manufacture of chloroform
- For making wool unshrinkable
- For disinfecting drinking water to make it free of germs.

Plaster of Paris ($CaSO_4.\frac{1}{2}H_2O$) **(calcium sulphate hemidrate):** It is prepared by heating gypsum at 373 K.

$$\underset{\text{(Gypsum)}}{2\,CaSO_4.2H_2O_{(s)}} \longrightarrow (CaSO_4)_2H_2O + 3H_2O$$

Or

$$CaSO_4.2H_2O \longrightarrow \underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O} + 1\frac{1}{2}H_2O$$

Properties of $CaSO_4.\frac{1}{2}H_2O$ **:**

- It is a white powder
- It absorbs water at room temperature and large amount of heat is liberated.
- On mixing with water, it changes to gypsum once again giving a hard solid mass.

$$\underset{\text{(Plaster of paris)}}{CaSO_4.\frac{1}{2}H_2O} + 1\frac{1}{2}H_2O) \longrightarrow \underset{\text{(Gypsum)}}{CaSO_4.2\,H_2O}$$

Uses of $CaSO_4.\frac{1}{2}H_2O$ **:**

- For making toys, materials for decoration
- For making chalks
- As a fire proofing material
- In hospitals for immobilizing the affected part in case of sprain or fracture.
- For making surfaces smooth.

Washing soda $Na_2CO_3.10H_2O$ (sodium carbonate decahydrate)

- Sodium carbonate decahydrate is manufacutured by **Solvay's process** also known as **ammonia soda process.**

Steps involved

$$NH_3 + H_2O + CO_2 \longrightarrow \underset{\text{ammonium hydrogen carbonate}}{NH_4HCO_3}$$

$$NH_4HCO_3 + NaCl \longrightarrow NH_4Cl + NaHCO_3$$

$$2NaHCO_3 \longrightarrow Na_2CO_3 + CO_2 + H_2O$$

$$Na_2CO_3 + 10\,H_2O \longrightarrow \underset{\text{(Washing soda)}}{Na_2CO_3.10\,H_2O}$$

Properties of $Na_2CO_3.10H_2O$

- It is white transparent crystalline solid
- It contains ten molecules of water of crystallization

- It shows efflorescence
- $Na_2CO_3 . 10 H_2O \longrightarrow Na_2CO_3 . H_2O + 9 H_2O$
- Its aqueous solution is alkaline
- It reacts with dilute acids to give effervescence of carbon dioxide
- $Na_2CO_3 + 2 HCl \longrightarrow NaCl + H_2O + CO_2$
- On heating, it undergoes following changes
- $Na_2CO_3 . 10 H_2O \longrightarrow Na_2CO_3 . H_2O \longrightarrow Na_2CO_3$

Uses of Na_2CO_3.10 H_2O

- Used for removing permanent hardness of water.
- Used in glass, paper and soap industries.
- Used as a cleaning agent for domestic purposes.
- Used in the manufacture of sodium compounds such as forax.

Key Points

✓ Acidic nature of a substance is due to the formation of H^+ (aq) ions in solution. Formation of OH^- (aq) ions in solution is responsible for the basic nature of a substance.

✓ Acidic and basic solutions in water conduct electricity because they produce hydrogen and hydroxide ions respectively.

✓ Acid-base indicators are dyes or mixtures of dyes which are used to indicate the presence of acids and bases.

✓ Acids turn blue litmus red. Bases turn red litmus blue.

✓ Phenolphthalein has colourless in acidic medium and pink colour in basic medium.

✓ Methyl orange has red colour in acidic medium and yellow colour in basic medium.

✓ Mixing concentrated acids or bases with water is a highly exothermic process.

✓ The reaction between an acid and a base to form salt and water is called neutralization

✓ The strength of an acid or an alkali can be tested by using a scale called the pH scale (0–14) which gives the measure of hydrogen ion concentration in a solution.

✓ A neutral solution has a pH of exactly 7, while an acidic solution has a pH less than 7 and basic solution has a pH more than 7.

Multiple Choice Questions

1. Which of the following statements is true for acids ?
   (a) Bitter and change blue litmus to red
   (b) Sour and change blue litmus to red
   (c) Bitter and change red litmus to blue
   (d) Sour and change red litmus to blue
2. Which of the following are present in a dilute aqueous solution of hydrochloric acid ?
   (a) $H_3O^+ + Cl^-$
   (b) $Cl^- + OH^-$
   (c) $H_3O + OH^-$
   (d) Unionized HCl
3. Lemon juice and coffee are
   (a) Both acidic
   (b) Both basic
   (c) Lemon juice is acidic, coffee is basic
   (d) Lemon juice is basic, coffee is acidic
4. Match the entries of column I with appropriate entries of column II. Choose the correct answer using the code given below the columns

Column-I (Phenomenon)	Column-II (Compound/material showing the phenomenon)
(i) Deliquescence	(A) Washing soda
(ii) Hygroscopy	(B) Caustic soda
(iii) Efflorescence	(C) Oily food
(iv) Rancidity	(D) Common salt

   (a) (i) → A, (ii) → C, (iii) → D, (iv) → B
   (b) (i) → C, (ii) → B, (iii) → D, (iv) → A
   (c) (i) → B, (ii) → D, (iii) → A, (iv) → C
   (d) (i) → D, (ii) → A, (iii) → C, (iv) → B
5. When sodium hydroxide is added to ammonium carbonate salt and then a glass rod dipped in dilute hydrochloric acid is brought near the test tube, we observe
   (a) Brick efflorescence
   (b) Dense white fumes
   (c) Reddish brown gas
   (d) Yellowish green vapours
6. A salt on treatment with excess of ammonium hydroxide produces a complex tetraammine copper (II) ions. The salt contains
   (a) Cuprous ions
   (b) Chloride ions
   (c) Cupric ions
   (d) Calcium ions
7. Which of the following phenomenon occur, when a small amount of acid is added to water ?
   (i) Ionisation
   (ii) Neutralization
   (iii) Dilution
   (iv) Salt formation
   (a) (i) and (ii)
   (b) (ii) and (iii)
   (c) (iii) and (iv)
   (d) (i) and (iii)
8. What is pH of a solution whose hydrogen ion concentration is 1×10^{-3} modes ?
   (a) 2
   (b) 3
   (c) -3
   (d) $=7$

9. What will be pH of solution when 0.02 mole of hydrochloric acid in 2 litres of the solution

(a) 2
(b) 1
(c) -2
(d) 10

10. When dilute hydrochloric acid is poured over powdered calcium carbonate, efflorescence are formed, it is because

(a) Acids are corrosive
(b) Calcium oxide is formed
(c) Carbon dioxide is evolved
(d) Calcium carbonate is very reactive

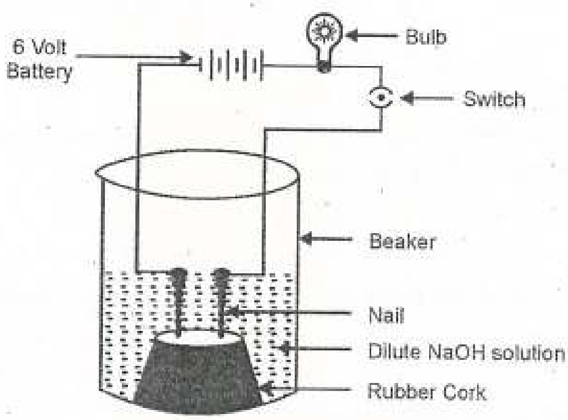
11. Solutions A, B, C and D have pH 3, 4, 6 and 8. The solution with highest acidic strength is

(a) A
(b) B
(c) C
(d) D

12. pH of two solutions A and B are 3 and 6 respectively. This means that

(a) Solution A is twice as acidic as B
(b) Solution B is twice as acidic as A
(c) Solution A is 1000 times more acidic than B
(d) Solution B is 1000 times more acidic than A

13. In an attempt to demonstrate electrical conductivity through an electrolyte, the following apparatus was set up



Which among the following statement(s) is (are) correct ?

(i) Bulb will not glow because electrolyte is not acidic
(ii) Bulb will not glow because NaOH is a strong base and furnishes ions for conduction
(iii) Bulb will not glow because circuit is incomplete
(iv) Bulb will not glow because it depends upon the type of electrolytic solution

(a) (i) and (iii)
(b) (ii) and (iv)
(c) (ii) only(d)
(iv) Only

14. Which of the following substances will not give carbon dioxide on treatment with dilute acid ?

(a) Lime
(b) Limestone
(c) Marble
(d) Baking soda

15. Which of the following is not a mineral acid ?

(a) Hydrochloric acid
(b) Nitric acid
(c) Citric acid
(d) Sulphuric acid

16. Match the columns

Column A	Column B
(A) Bleaching powder	(i) Preparation of glass
(B) Baking soda	(ii) Production of H_2 and Cl_2
(C) Washing soda	(iii) Decolourisation
(D) Sodium chloride	(iv) Antacid

(a) A – (ii), B – (i), C – (iv), D – (iii)
(b) A – (iii), B – (iv), C – (i), D – (ii)
(c) A – (iii), B – (ii), C – (iv), D – (iii)
(d) A – (ii), B – (iv), C – (i), D – (iii)

17. Washing soda ($Na_2CO_3.10\ H_2O$) on exposure to air gives
(a) $Na_2CO_3.9\ H_2O$
(b) $Na_2CO_3.7\ H_2O$
(c) $Na_2CO_3.5\ H_2O$
(d) $Na_2CO_3.H_2O$

18. Aqueous solution of sodium carbonate is
(a) Acidic
(b) Basic
(c) Neutral
(d) Amphoteric

19. Which of the following statements is not correct ?
(a) All metal carbonates react with acid to give a salt, water and carbon dioxide
(b) Some metal react with acids to give salt, water and hydrogen
(c) All metal oxides react with water to give a salt and acid
(d) Some non-metal oxides react with water to form an acid

20. When hydrogen of an acid are partially neutralized by hydroxyl ion of a base we get
(a) Normal salt
(b) Complex salt
(c) Acidic salt
(d) Basic salt

21. Which among the following is not a base ?
(a) NaOH
(b) NH_4OH
(c) C_2H_5OH
(d) KOH

22. Which of the following is used for dissolution of gold ?
(a) Hydrochloric acid
(b) Sulphuric acid
(c) Nitric acid
(d) Aqua regia

23. Plaster of Paris on mixing with water sets to form
(a) $CaSO_4.H_2O$
(b) $CaSO_4.1\frac{1}{2}H_2O$
(c) $CaSO_4.2H_2O$
(d) $CaSO_4.2\frac{1}{2}H_2O$

24. Match the columns

Column-A	Column-B
(A) Plaster of Paris	(i) $Ca(OH)_2$
(B) Gypsum	(ii) $CaSO_4.\frac{1}{2}H_2O$
(C) Bleaching Powder	(iii) $CuSO_4.2H_2O$
(D) Slaked lime	(iv) $CaOCl_2$

(a) A → (ii), B → (iii), C → (iv), D → (i)
(b) A → (iii), B → (ii), C → (i), D → (iv)
(c) A → (ii), B → (iv), C → (i), D → (iv)
(d) A → (i), B → (iv), C → (ii), D → (iii)

25. Common salt besides being used in kitchen can also be used as the raw material for making
(a) Washing soda
(b) Bleaching powder
(c) Baking soda
(d) Slaked lime
(a) (i) and (ii)
(b) (i) and (iii)
(c) (i), (ii) and (iii)
(d) (i), (iii) and (iv)

26. Each volumes of solutions with pH = 4 and pH = 10 are mixed. What is the pH of the resulting solution ?
(a) 4
(b) 10
(c) 7
(d) 14

27. The water of crystallization of green vitriol is
(a) 10
(b) 9
(c) 7
(d) 5

28. A solution when reacts with zinc material liberates a gas which burn with a pop sound. The pH of the solution is
(a) Equal to 7
(b) Greater than 7
(c) Less than 7
(d) Between 8 and 14

29. Glauber's salt is
(a) Sodium sulphate
(b) Sodium sulphate decahydrate
(c) Sodium carbonate decahydrate
(d) Sodium carbonate monohydrate

30. The acid used for washing eyes is
(a) Boric acid
(b) Acetic acid
(c) Oxalic acid
(d) Carbonic acid

31. Match the entries of column I with appropriate entries of column II and III

Column-I (Salt)	Column-II (Nature of the solution)	Column-III (pH)
(i) Common salt	(a) Acidic	(A) < 7
(ii) Blue vitriol	(b) Basic	(B) > 7
(iii) Baking soda	(c) Neutral	(C) = 7
(iv) Soda ash		

(a) (i) → (a) → (A), (ii) → (b) → (B), (iii) → (b) → (B), (iv) → (c) → (C)
(b) (i) → (c) → (C), (ii) → (c) → (C), (iii) → (a) → (A), (iv) → (b) → (B)
(c) (i) → (c) → (C), (ii) → (a) → (A), (iii) → (b) → (B), (iv) → (b) → (B)
(d) None of these

32. Calcium phosphate is present in tooth enamel. Its nature is
(a) Acidic
(b) Basic
(c) Neutral
(d) Amphoteric

33. What happens when a solution of an acid is mixed with a solution of a base in a test tube ?
(i) The temperature of the solution increases
(ii) The temperature of the solution decreases
(iii) The temperature of the solution remains the same
(iv) Salt formation takes place
(a) (i) only
(b) (i) and (iii)
(c) (ii) and (iii)
(d) (i) and (iv)

34. Which of the following gives the correct increasing order of acid strength ?
(a) Acetic acid < water < Hydrochloric acid
(b) Hydrochloric acid < Water < Acetic acid
(c) Water < Acetic acid < Hydrochloric acid
(d) Water < Hydrochloric acid > Acetic acid

35. A sample of soil is mixed with water and allowed to settle. The clear supernatant solution turns the pH paper yellowish – orange. Which of the following would change the colour of this pH paper to greenish blue
(a) Common salt
(b) Vinegar
(c) An antacid
(d) Lemmon juice

36. If a few drops of a concentrated acid accidentally spill over the hand of a student, what should be done ?
(a) Wash the hand with saline solution
(b) Neutralise the acid with a strong alkali
(c) After washing with plenty of water apply solution of sodium hydroxide on the hand.
(d) Wash the hand immediately with plenty of water and apply a paste of sodium hydrogen carbonate

Answer Key

1. (a)	2. (a)	3. (a)	4. (c)	5. (b)	6. (c)	7. (d)	8. (b)	9. (a)	10. (c)
11. (a)	12. (c)	13. (c)	14. (a)	15. (c)	16. (b)	17. (d)	18. (c)	19. (c)	20. (c)
21. (c)	22. (d)	23. (c)	24. (a)	25. (b)	26. (c)	27. (c)	28. (c)	29. (b)	30. (a)
31. (c)	32. (b)	33. (d)	34. (c)	35. (c)	36. (d)				

Hints and Solutions

2. (a)

$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$

6. (c)

Cupric ions, as they react with excess of ammonia solution to form $[Cu(NH_3)_4]^{2+}$

8. (b)

$pH = -\log [H^+]$

$pH = -\log (1 \times 10^{-3}] = -(-3) \log_{10}$

$pH = 3$

9. (a)

Molar concentration of HCl acid solution

$= \frac{0.02}{2L} = 0.01 \text{ mol } L^{-1}$

$= 10^{-2} \text{ mol } L^{-1}$

$pH = -\log [H^+]$

$pH = -\log (10^{-2})$

$pH = 2 \log 10$

$pH = 2$

14. (a)

Line (CaO) reacts with HCl acid to form $CaCl_2$ and H_2O. NO CO_2 is produced.

15. (c)

Citric acid is not a mineral acid but an organic acid present in citrus fruits

19. (c)

Some metal oxides (like Na_2O, CaO, etc.) react with water to form metal hydroxides (bases) only and not salt and acid.

21. (c)

C_2H_5OH is ethyl alcohol which does not give OH^- ions in the solution.

Hence, it is not base.

36. (c)

pH = 4 means $[H^+] = 10^{-4}$ M. pH = 10 means $(H^+) = 10^{-10}$ M or $[H^-] = 10^{-4}$ M

Thus, one solution is acidic and the other is basic. Further, they have same molarity. On mxing equal volumes, then will neutralize each other completely. The resulting solution will be neutral with pH = 7.0

27. (c)

Green vitriol or ferrous sulphate is $FeSO_4.7H_2O$

29. (b)

Glauber's salt is sodium sulphate decahydrate $Na_2SO_4.10H_2O$

33. (d)

Mixing of solution of an acid with the solution of base (neutralization) is exothermic *i.e.* temperature increase and salt formation takes place.

35. (c)

Turning of the pH paper yellowish – orange shows that the solution is acidic $(pH \approx 5)$. To change it to greens blue means we want to change it to basic ($pH \approx 8$) This can be done by adding an antacid [like $Mg(OH)_2$)]

Previous Year's Questions

1. Baking powder gives the following gas on reacting with an acid
   (a) Hydrogen
   (b) Oxygen
   (c) Methane
   (d) Carbon dioxide **(NSO 2005)**
2. The product formed, when chlorine gas passes through dry slaked lime is
   (a) $CaOCl_2$
   (b) $CaCl_2$
   (c) CaOCl
   (d) CaO **(NSO 2005)**
3. pH of a solution changes from 5 to 4. How many times do you expect a change in hydrogen ion concentration ?
   (a) 2 times
   (b) 5 times
   (c) 10 times
   (d) 20 times **(NSO 2006)**
4. $CaSO_4.XH_2O \xrightarrow[\Delta]{373\,K} C + D$

   Find out X, C and D in the above reaction. Also identity the names of compounds C and Y.

   (NSO 2007)

X	C	D	C	Y
(a) 2	$CaSO_4.5H_2O$	1.5 H_2O	Calcium Sulphate Hemidrate	Gypsum
(b) 5	$CaSO_4.3H_2O$	2 H_2O	Gypsum	Plaster of Paris
(c) 10	$CaSO_4.5H_2O$	5 H_2O	Calcium Sulphate Hemidrate	Plaster of Paris
(d) 2	$CaSO_4.2H_2O$	H_2O	Plaster of Paris	Gypsum

5. Calculate the pH of 0.05 M H_2SO_4, if the acid is fully dissociated.
   (a) −1
   (b) 1
   (c) 0
   (d) 2 **(NSO 2007)**
6. Match the following columns: **(NSO 2009)**

Column-I (acid)	Column-II (Source)
(p) Acetic acid	(i) Sting of bees
(q) Butyric acid	(ii) Apples
(r) Formic acid	(iii) Vinegar
(s) Lactic acid	(iv) Rancid butter
(t) Maleic acid	(v) Sour milk

(a) p – (iii), q – (i), r – (ii), s – (v), t – (iv)
(b) p – (ii), q – (v), r – (iii), s – (iv), t – (i)
(c) p – (iii), q – (iv), r – (i), s – (v), t – (ii)
(d) p – (i), q – (ii), r – (v), s – (iii), t – (iv)

7. Sodium chloride is added to the solution after saponification to cause the ...

(a) Hydrolysis of soap
(b) Precipitation of soap
(c) Sedimentation of soap
(d) Hardening of soap

8. A dentist advices his patient to rinse his mouth using mouthwash after every meal. What should be the approximate pH of the mouthwash ?

(a) $pH > 5.5$
(b) $pH = 5.5$
(c) $pH = 7$
(d) $pH > 7$

9. $ZnO + 2HCl \rightarrow X + H_2O$ and $ZnO + 2\ NaOH \rightarrow Y + H_2O$

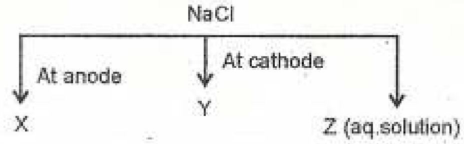
Identify X, Y and the nature of ZnO best described by the above reactions

	X	Y	Nature of ZnO
(a)	$ZnCl_3$	$NaZnO_2$	Amphoteric
(b)	$ZnCl_2$	Na_2ZnO_2	Amphoteric
(c)	$ZnCl_2$	Na_2ZnO_2	Acidic
(d)	$ZnCl_3$	$Zn(OH)_2$	Basic

10. 'X' is obtained by the action of Cl_2 on dry slaked lime. One of the importance of 'X' is disinfecting drinking water. 'X' is

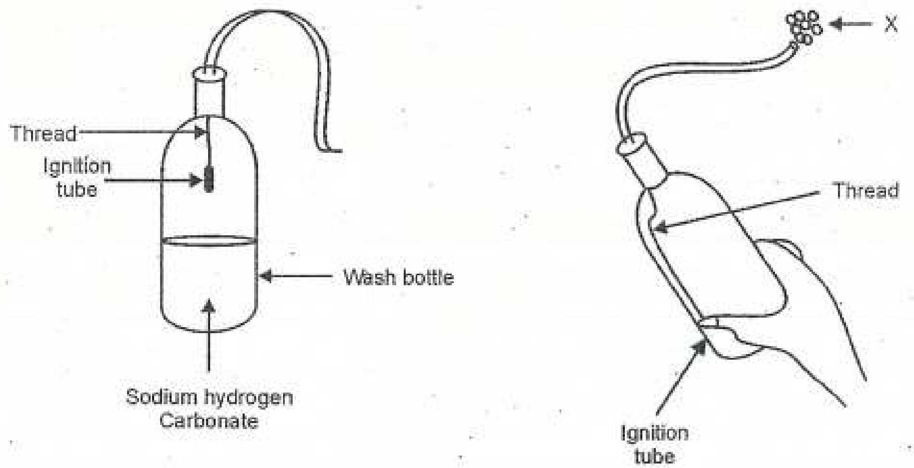
(a) CaO
(b) CaOCl
(c) $CaOCl_2$
(d) $CaOCl_3$

11. The given figure shows important products of chlor-alkali process. What are X, Y, and Z, respectively?



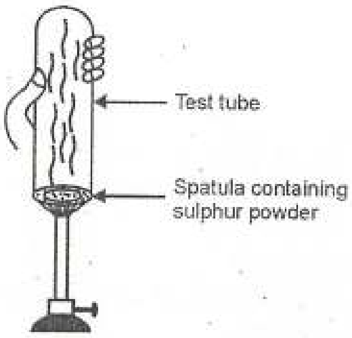
(a) $NaOH, Cl_2, H_2$
(b) $H_2, Cl_2, NaOH$
(c) $Cl_2, H_2, NaOH$
(d) $Cl_2, NaOH, H_2$

12. Gas X when directed towards a burning candle, extinguishes it. The compound in ignition tube is



(a) H_2S
(b) dil $H_2\ SO_4$
(c) NaCl
(d) NaOH

13. Suresh took some sulphur powder on a spatual and heated it. He collected the gas evolved by inverting a test tube as shown in figure. When he brought a wet litmus paper near the test tube then he observed **(NSO 2009)**



(a) No effect on litmus paper
(b) Blue litmus turns red
(c) Red litmus turns blue
(d) Unpredictable

14. Three students were given colourless liquids of water, lemon juice and a mixture of water and lemon juice. After testing these liquids with pH paper, a sequence in colour change of pH paper was reported. Which is the correct sequence ?

(a) Blue, red and green
(b) Orange, green and green
(c) Green red and red
(d) Red and green. **(NSO 2010)**

Answer Key

1. (d) 2. (a) 3. (c) 4. (a) 5. (b) 6. (c) 7. (b) 8. (b) 9. (b) 10. (c)
11. (c) 12. (b) 13. (b) 14. (c)

8. Metal and Non-Metal

Learning Objectives

* Classification of elements into metals, non-metals and metalloids
* Physical properties of metals and non-metals
* Chemical properties of metals
* Activity (Reactivity) series of metals
    * Reaction of metals with solution of other metal salts
* Chemical properties of non-metals
* Properties of metalloids
* Importance of metals and non-metals
* How do metals and non-metals combine
* Properties of ionic compounds
* Occurrence of metals
* Extraction of metals (metallurgy)
* Corrosion
    * Condition neccessary for rusting of iron
    * Prevention of rusting
* Alloys
    * Types of alloys
    * Objective of alloy making
    * Alloying of gold

Classification of Elements

More than 118 different elements have been discovered so far. Many of them are found to occur in nature whereas some of them have been made by artificial methods and are called synthetic elements. So far 20 synthetic elements have been created (those with atomic numbers 99-118). Based on their properties, elements have been mainly classified into three categories : metals, non-metals and metalloids:

Metals

Metals are those elements which possess luster when freshly cut and are malleable and ductile and good conductor of heat and electricity. They may also be defined as those elements which lose electrons and form positive ions *i.e.*, they are electropositive elements. For example : Sodium (Na) Potassium (K), Magnesium (mg) etc.

$$Na \longrightarrow Na^{++} e^-$$

Non-metals

Non metals are those elements which do not possess luster and are neither good conductor of heat and electricity nor malleable and ductile but are brittle. They may also be defined as those elements which may gain electrons and form negative ions *i.e.*, they are electronegative elements. For example : Chlorine (Cl), Hydrogen (H), Oxygen (O) etc.

$$Cl + e^- \longrightarrow Cl^-$$

Metalloids

There are those elements which behave as metals as well as non-metals. They have four valence electrons. For example, Carbon (C), Silicon (Si).

Physical properties of metals

1. Metals are generally hard. Their hardness varies from metal to metal.
2. Metals in the pure state possess lustre, *i.e.*, a shining surface.
3. Metals are generally malleable, *i.e.*, they can be beaten into thin sheets.
4. Metals are generally ductile, *i.e.*, they can be drawn into wires except zinc, antimony, bismuth and arsenic.

   [**Note:** Gold is the most ductile metal.]
5. Metals have high tensile strength.
6. Metals are good conductor of heat and electricity.

   [**Note:** Silver is the best conductor of heat whereas lead is the poorest conductor of heat.]
7. Metals have high melting points. However, sodium, potassium, gallium and caesium have very low melting point. Gallium and caesium will melt if we keep them in our palm.
8. All metals are solid at room temperature except mercury and gallium which are liquid at room temperature.
9. Metals have high density except lithium, sodium and potassium which have low densities.
10. Metals are sonorous *i.e.*, they produce sound when hit against hard surface

Physical properties of non-metals

1. Non metals are soft and brittle except diamond, which is an allotrope of carbon.

   [**Note:** Diamond is the hardest known substance]
2. Non metals do not possess any lustre (except iodine which is a non metallic solid but has luster)
3. They are neither malleable nor ductile.
4. They have low tensile strength *i.e.*, they are easily broken except carbon fibres
5. They are generally bad conductors of heat and electricity except graphite
6. They have low melting and boiling points except boron, diamond and graphite which are non metals but have high melting points.
7. They may be solids, liquids or gases at room temperature.

   For example: Carbon, sulphur, phosphorus, and iodine are solid, bromine is a liquid, while hydrogen, oxygen, nitrogen and chlorine are gaseous non metals.
8. They have low density except bromine, iodine which are quite heavy.
9. Non metals are non sonorous *i.e.*, they do not produce any sound when hit with a hard object.

Chemical properties of metals

Metals and non metals can be distinguished on the basis of their chemical properties:

Metals form oxides which are basic in nature whereas non metals form oxides which are acidic in nature or we can say that, they are neutral

Metals are electropositive elements. Due to their electropositive character, metals show a number of characteristics properties:

Reaction with oxygen:

Most of the metals react with oxygen to form metals oxides.

$$\text{Metal} + \text{Oxygen} \longrightarrow \text{Metals oxide}$$

$$4\,Na + O_2 \longrightarrow \underset{\text{Sodium oxide}}{2\,Na_2(O)\,(s)}$$

$$2\,K + O \longrightarrow \underset{\text{Potassium oxide}}{K_2O\,(s)}$$

- Some metal oxides dissolved in water to form alkali.

$$Na_2O + H_2O\,(l) \longrightarrow \underset{\text{Sodium hydroxide}}{2\,NaOH\,(aq)}$$

$$K_2O + H_2O\,(l) \longrightarrow \underset{\text{Potassium hydroxide}}{2\,KOH\,(aq)}$$

- Some metal oxides show basic as well as acidic character.

  Such metals oxides are called **amphoteric oxides**

$$\underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Hydrochloric acid}}{6\,HCl} \longrightarrow \underset{\text{Ammonia}}{2\,NH_{(3)(g)}} + \underset{\text{Sulphuric Acid}}{H_2SO_{4\,(aq)}} \longrightarrow \underset{\text{Ammonium Sulphate}}{(NH_4)\,SO_{4\,(aq)}}$$

$$Al_2O_3 + \underset{\text{Sodium hydroxide}}{2\,NaOH} \longrightarrow \underset{\text{Sodium aluminate}}{2\,Na\,AlO_2} + H_2O$$

Similarly,

$$\underset{\text{Zinc oxide}}{ZnO} + 2HCl \longrightarrow \underset{\text{Zinc chloride}}{ZnCl_2} + H_2O$$

$$\underset{\text{Zinc oxide}}{ZnO} + 2\,NaOH \longrightarrow \underset{\text{Sodium Zincate}}{Na_2ZnO_2} + H_2O$$

Key Note: (i) Silver, gold and platinum do not combine with the oxygen of the air even at high temperature. This shows that they are least reactive.

(ii) **Anodizing:** It is a process of coating a thick layer of aluminium oxide on the surface of aluminium articles. It protects the surface of aluminium articles from corrosion. Aluminium develops a thin oxide layer when exposed to air. Anodizing is done electrolytically by taking dilute sulphuric acid in the electrolytic tank and making the aluminium article to be anodized as anode. The oxygen liberated at the anode on electrolysis combines with aluminium. The process is continued till a required thickness of the oxide layer is formed. This oxide layer can also be dyed easily to give aluminium articles an attractive finish.

Reaction with water: Metals react with water to form a hydroxide or an oxide along with the evolution of hydrogen gas.

$$[\text{Metal} + \text{Water} \longrightarrow \text{Metal oxide or hydroxide} + \text{Hydrogen}]$$

- Sodium and potassium react with cold water very violently and the reaction is highly exothermic. Hence hydrogen evolved catches fire.

$$2\,Na\,(s) + 2\,H_2O\,(l) \longrightarrow \underset{\text{Sodium hydroxide}}{2\,NaOH\,(aq)} + H_2 + \text{heat energy}$$

$$2\,K\,(s) + 2\,H_2O\,(l) \longrightarrow \underset{\text{Potassium hydroxide}}{2\,KOH\,(aq)} + H_2 + \text{heat energy}$$

- The reaction of calcium with water is less violent. The heat evolved is not sufficient for the hydrogen to catch fire.

$$Ca(s) + 2\,H_2O\,(l) \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2\,(aq)} + H_2\,(g)$$

- Bubbles of hydrogen gas produced, stick to the surface of calcium and hence it starts floating on the surface of water.
- Magnesium does not react with cold water. It reacts with hot water to form magnesium hydroxide and hydrogen. It also starts floating due to bubbles of hydrogen gas sticking to its surface.

$$Mg\,(s) + \underset{\text{(Hot water)}}{2\,H_2O\,(l)} \longrightarrow \underset{\text{Magnesium hydroxide}}{Mg\,(OH)_2} + \underset{\text{Hydrogen}}{H_2}$$

Note: With steam, magnesium forms magnesium oxide and hydrogen.

$$Mg\,(s) + \underset{\text{(Steam)}}{H_2O\,(g)} \longrightarrow \underset{\text{Magnesium oxide}}{MgO\,(s)} + H_2(g)$$

- Aluminium, zinc and iron neither react with cold water nor with hot water. They react only with steam to form metal oxide and hydrogen.

$$\underset{\text{(Aluminium)}}{2\,Al\,(s)} + \underset{\text{Steam}}{3\,H_2O\,(g)} \longrightarrow \underset{\text{Aluminium oxide}}{Al_2O_3(s)} + 3\,H_2(g)$$

$$\underset{\text{(Zinc)}}{Zn\,(s)} + \underset{\text{Steam}}{H_2O} \longrightarrow \underset{\text{Zinc oxide}}{ZnO\,(s)} + H_2(g)$$

$$\underset{\text{(Iron)}}{2Fe\,(s)} + \underset{\text{Steam}}{3H_2O\,(g)} \longrightarrow \underset{\text{Iron (II,III) oxide}}{Fe_2O_3} + 3H_2\,(g)$$

Note : Lead, copper, silver and gold do not react with water and steam

Order of reactivity of different metals towards water may be written as :

$K > Na > Ca > Mg > Al > Zn > Fe > Pb > Cu > Ag > Au$

Reaction with acids: Metals react with acids to give a salt and hydrogen gas.

$$\text{Metal} + \text{Dilute acid} \longrightarrow \text{Salt} + \text{Hydrogen}$$

- Sodium and potassium react very violently with dilute hydrogen chloric acid forming their chlorides along with the evolution of hydrogen gas.

$$2\,K\,(s) + 2\,HCl\,(aq) \longrightarrow 2\,KCl\,(aq) + H_2\,(g)$$

$$2\,Na\,(s) + 2\,HCl\,(aq) \longrightarrow 3\,NaCl\,(aq) + H_2\,(g)$$

- Calcium react vigorously though less than sodium and potassium

$$Ca\,(s) + 2\,HCl\,(aq) \longrightarrow CaCl_2\,(aq) + H_2\,(g)$$

- Magnesium reacts quite rapidly but the reaction is less vigorous than that with calcium

$$Mg(s) + 2\,HCl\,(aq) \longrightarrow MgCl_2\,(aq) + H_2\,(g)$$

- Aluminium, zinc and iron reacts very slowly and give their chlorides and hydrogen gas.

$$2\,Al\,(s) \longrightarrow 6\,HCl\,(aq) \longrightarrow 2\,AlCl_3\,(aq) + 3H_2\,(g)$$

$$Zn\,(s) \longrightarrow 2\,HCl\,(aq) \longrightarrow ZnCl_2\,(aq) + H_2\,(g)$$

$$Fe\,(s) \longrightarrow 2\,HCl\,(aq) \longrightarrow FeCl_2\,(aq) + H_2\,(g)$$

Note : Copper, mercury and silver do not react with dilute hydrochloric acid or sulphuric acid Order of reactivity of metals towards acid may be written as:

$K > Na > Ca > Mg > Al > Zn > Fe > Cu > Hg > Ag$

Further, it is important to note that if dilute nitric acid used in place of dilute HCl or dilute H_2O_4, no hydrogen gas is evolved. It is because HNO_3 is a strong oxidizing agent. It oxidizes the hydrogen formed into water and itself, it is reduced to an oxide of nitrogen such as N_2O, NO, NO_2 etc. But magnesium (Mg) and magnese (Mn) react with very dilute HNO_3 giving out hydrogen gas.

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{Nitric acid}}{2\,HNO_3} \longrightarrow \underset{\text{Magnesium nitrate}}{Mg(NO_3)_2} + H_2$$

$$\underset{\text{Maganese}}{Mn} + 2\,HNO_3 \longrightarrow \underset{\text{Maganese nitrate}}{Mn(NO_3)_2} + H_2$$

Note: Gold and platinum do not react with any pure acid, That is why they are called **noble metals.** However, these metals can dissolve in a mixture of concentrated hydrochloric acid and concentrated nitric acid taken in the ratio of 3 : 1 by volume. This mixture is called **aqua regia** which in Latin means **"royal water"**. It is highly corrosive and fuming liquid.

The dissolution of gold and platinum in aqua regia is due to the formation of nascent (newly born) chlorine which attacks gold and platinum.

$$\underbrace{3\,HCl + HNO_3}_{\text{Aqua regia}} \longrightarrow \underset{\text{Nitrosyl Chloride}}{NOCl} + 2\,H_2O + \underset{\text{Nascent}}{2\,Cl}$$

$$\underset{\text{Gold}}{Au} + 3\,Cl \longrightarrow \underset{\text{Gold (III) chloride}}{AuCl_3}$$

$$\underset{\text{Platinum}}{Pt} + 4\,Cl \longrightarrow \underset{\text{Platinum (IV) chloride}}{PtCl_4}$$

Reaction with chlorine: Metals react with non-metals to form ionic compound

$$2\,Na + Cl_2 \longrightarrow 2\,NaCl$$

$$Ca + F_2 \longrightarrow CaF_2$$

Ionic compounds are the compounds formed by losing and gaining of electrons.

$$Na + Cl \longrightarrow [Na^+][Na^-] \longrightarrow NaCl$$

Reaction with hydrogen: Metals react with hydrogen to form metal hydrides. But only reactive metals like sodium, potassium and calcium form their hydrides.

$$2Na(s) + H_2(g) \longrightarrow \underset{\text{(Sodium hydride)}}{2NaH(s)}$$

$$Ca(s) + H_2(g) \xrightarrow{\text{Heat}} \underset{\text{(Calcium hydride)}}{CaH_2}$$

Reducing behaviour: Metals acts as reducing agents. For example, sodium metal reduces chlorine to chloride ion forming sodium chloride as follows:

$$2\,Na + Cl_2 \longrightarrow 2\,NaCl$$

$$\left[\begin{array}{l} Na \xrightarrow{\text{Oxidation}} \underset{\text{Sodium ion}}{Na^+} + e^- \\ Cl + e^- \xrightarrow{\text{Oxidation}} \underset{\text{Chloride ion}}{Cl^-} \\ Na^+ + Cl^- \longrightarrow NaCl \end{array}\right]$$

Reactivity series: On the basis of reactions of metals with oxygen, water, acids, etc. it is found that some metals are highly reactive, some are less reactive. Thus, metals can be arranged on the basis of their relative reactivity.

The arrangement of metals in a vertical column in order of their decreasing reactivity downwards is called the activity series or reactivity series of metals.'

	Metal	Symbol	
Metals more reactive than Hydrogen	Potassium	k	⟶ Most reactive
	Calcium	Ca	Reactivity decrease ↓
	Sodium	Na	
	Magnesium	Mg	
	Aluminium	Al	
	Zinc	Zn	
	Iron	Fe	
	Nickel	Ni	
	Tin	Sn	
	Lead	Pb	
	Hydrogen	**H**	
Metal less reactive than Hydrogen	Copper	Cu	
	Mercury	Hg	
	Silver	Ag	
	Platinum	Pt	
	Gold	Au	⟶ Least reactive metal

Activity series of some common metals: Metal lying above hydrogen in the activity series are more reactive than hydrogen. Hence they can displace hydrogen from its compounds like water or acids. On the other hand, metals lying below hydrogen in the activity series are less reactive than hydrogen and cannot displace hydrogen from water or acids.

Reaction of metals with solution of other metals salts (Displacement reactions): The relative reactivity of metals is found on the basis of displacement reactions. The basic principle of these reactions is that a more reactive metal can displace a less reactive metal from the solution of its salt. This, if a metal A is more reactive than metal B. then metal A can displace metal B from the salt solution of metal B *i.e.*,

Metal A + Salt solution of metal B $\longrightarrow$ Salt solution of metal A + metal B

(more reactive than B)

For example:

1. $\underset{\text{Zinc}}{Zn\,(s)} + \underset{\substack{\text{Copper sulphate}\\(\text{Blue})}}{CuSO_4\,(aq)} \longrightarrow \underset{\substack{\text{Zinc sulphate}\\(\text{colourless})}}{ZnSO_4\,(aq)} + \underset{\substack{\text{Copper}\\(\text{Reddish brown})}}{Cu\,(s)}$

   The reaction shows that zinc is more reactive than copper. If copper plate is dipped in zinc sulphate solution, no reaction is found to occur.

   $Cu\,(s) + ZnSO_4\,(aq) \longrightarrow$ No reaction

   This proves that copper is less reactive than zinc.

2. $Cu\,(s) + 2\,\underset{\substack{\text{Silver nitrate}\\(\text{Colourless})}}{Ag\,NO_3\,(aq)} \longrightarrow \underset{\substack{\text{Copper nitrate}\\(\text{Blue})}}{Cu\,(NO_3)} + \underset{\text{Silver}}{2\,Ag}$

   $Ag + Cu\,(NO_3)_2 \longrightarrow$ No reaction

   This shows that copper is more reactive than silver,

3. $Fe(s) + CuSO_4(aq) \longrightarrow FeSO_4(aq) + Cu(s)$
Copper (II) Sulphate (Blue) — Iron (II) Sulphate (Green)

$FeSO_4 + Cu \longrightarrow$ No reaction

This shows that iron is more reactive than copper.

Chemical properties of non-metals

Non-metals are electro negative in nature, *i.e.*, they can accept- electrons and form anions. Some important chemical reactions of non-metals are:

1. **Reaction with oxygen**: When heated, non-metals react with oxygen to form oxides. These oxides may be either acidic or neutral. They never form basic oxides. Acids oxides turn blue litmus to red.

$$C + O_2 \longrightarrow CO_2$$
$$S + O_2 \longrightarrow SO_2$$
$P_4 + 5O_2 \longrightarrow P_4O_{10}$ (Phosphorus pentaoxide)
$$N_2 + O_2 \longrightarrow 2NO$$
$$N_2 + 2O_2 \longrightarrow 2NO_2$$

Hence, NO (Nitric oxide) is neutral, while NO_2 (nitrogendioxide) is acidic

2. **Reaction with water**: Generally they do not react with water except with highly reactive non metals like F_2.

$$\underset{\text{Fluorine}}{2F_2(g)} + 2H_2O(l) \longrightarrow \underset{\text{Hydrogen fluoride}}{4HF(aq)} + \underset{\text{Oxygen}}{O_2(g)}$$

$$3F_2 + 3H_2O \longrightarrow 6HF(aq) + O_3(g)$$

3. **Reaction with dilute acids**: They do not react with acids.

Note: Non metals do not react with acid to displace hydrogen gas. In order to displace hydrogen from acids, electrons must be supplied to the H^+ ions of the acids.

$$H_2SO_4(aq) \longrightarrow 2H^+(aq) + SO_4^{2-}(aq)$$
$$2H^+(aq) + 2e^- \longrightarrow H_2(g)$$

Since a non metal is an electron acceptor, it can not supply electrons to the H^+ ions to reduce them to hydrogen gas. Therefore it cannot displace hydrogen gas from acids. Thus when a non metal is placed in test tube containing either dil HCl or dil H_2SO_4, hydrogen is not evolved.

4. **Reaction with chlorine**: Non-metals reacts with chlorine to form chlorides

$$H_2 + Cl_2 \longrightarrow HCl$$
$$P_4 + 6Cl_2 \longrightarrow \underset{\text{Phosphorus trichloride}}{4PCl_3}$$

5. **Reaction with hydrogen**: Non-metals combine with hydrogen to form covalent hydrides.

$$\underset{\text{Hydrogen}}{8H_2(g)} + \underset{\text{Sulphur}}{S_8(l)} \xrightarrow{713\,K} \underset{\text{Hydrogen sulphide}}{8H_2S}$$

$$N_2(g) + 3H_2(g) \xrightarrow[Fe]{723-773\,K} \underset{\text{Ammonia}}{2NH_3(g)}$$

Catalyst

6. **Reaction with salts**: A more reactive non metal displaces a less reactive non-metal from the solution of its salt.

$$\underset{\text{Sodium bromdie}}{2NaBr(aq)} + \underset{\text{Chlorine}}{Cl_2(g)} \longrightarrow \underset{\text{Sodium chloride}}{2NaCl(aq)} + \underset{\text{Bromine}}{Br_2(l)}$$

$$\underset{\text{Potassium Iodide}}{2KI(aq)} + \underset{\text{Chlorine}}{Cl_2(g)} \longrightarrow \underset{\text{Potassium Chloride}}{2KCl(aq)} + \underset{\text{Iodine}}{I_2(s)}$$

7. **Oxidizing behaviour**: As they accept electrons, they act as oxidizing agent. For example: Fluorine is strong oxidizing agent it oxidizes water to oxygen, sulphur to sulphur hexafluoride and phosphorus to phosphorus penta fluoride

$$2\,H_2O\,(l) + 2\,F_2\,(g) \longrightarrow 4\,HF\,(aq) + O_2\,(g)$$
$$S_8\,(s) + 24\,F_2\,(g) \longrightarrow 8\,SF_6\,(g)$$
$$P_4\,(s) + 10\,F_2\,(g) \longrightarrow 4\,PF_5\,(s)$$

Properties of metalloids

1. They can form alloys
2. They have metallic lustre
3. They are good conductors of electricity
4. They form stable hydrides
5. Their chlorides are covalent in nature

   e.g., Silicon, germanium, arsenic, antimony, tellarium

Importance of metals

Metals are used in making utensils, buildings, bridges, automobile parts, coins, jewellery, machine parts etc. Metals like Ti, Cr, Mn and Zr are called strategic metals as they are used in country's defence.

Importance of non-metals

Carbon and hydrogen which are non-metals are present in carbohydrates, proteins, oils, fats etc, which are required for growth and maintenance of living organism carbon also used in making electrodes. Hydrogen is used in hydrogenation of oils to make ghee.

Oxygen is important in breathing and combustion. Nitrogen is present in NH_3, HNO_3 and fertilizers. Sulphur is fungicide and a constituent of *gun powder*.

How Do Metals and Non-metals Combine with Each Other

(Formation of ionic bond): As metal atoms have 1, 2 or 3 electrons in their valence shell, they can lose these electrons easily to acquire the stable nearest noble gas configuration. On the other hand, non-metal atoms generally have 5, 6 or 7 electrons in their outermost shell, they can gain 3, 2, or 1 electron to acquire the stable nearest noble gas configuration. The metal atom which loses the electrons becomes a positive ion and non-metal atom which gains electrons becomes a negative ion and for this reason the bond formed between them is called ionic bond or electrovalent bond.

A chemical bond formed between two atoms by complete transference of electrons from one atom to another so as to complete their octets and hence acquire the stable nearest noble gas configuration is called ionic bond or electrovalent bond. The number of electrons lost or gained by the atom is called its electrovalency. The compounds thus formed are called ionic compounds or electrovalent compounds.

For example:

Formation of sodium chloride

Atomic number of sodium (Na) = 11

Its electronic configuration is 2, 8, 1.

It has only one electron in the valence shell. It loses this electron to acquire the stable electronic configuration 2, 8 and form sodium ion (Na^+) :

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

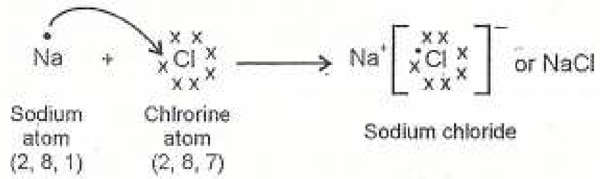
Atomic number of chloride (Cl) = 17

Its electronic configuration = 2, 8, 7

It has 7 electrons in the valence shell. It gains an electron to acquire the stable electronic configuration 2, 8, 8 and form chloride ion (Cl^-) :

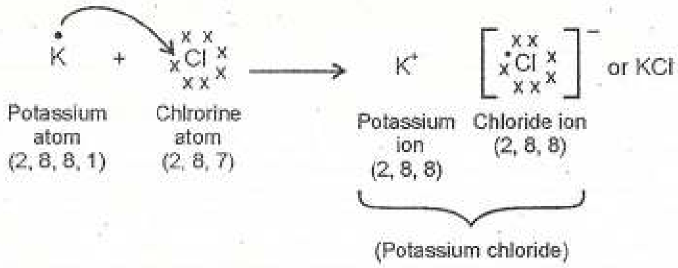
$$\underset{2,8,7}{Cl} + e^- \longrightarrow \underset{2,8,8\,\text{(chloride anion)}}{Cl^-}$$

Thus when a sodium atom and a chlorine atom approach each other, an electron is transferred from sodium atom to chorine atom. These oppositely charged ions are then held together by electrostatic forces of attraction forming the compound Na^+ Cl^- or NaCl.

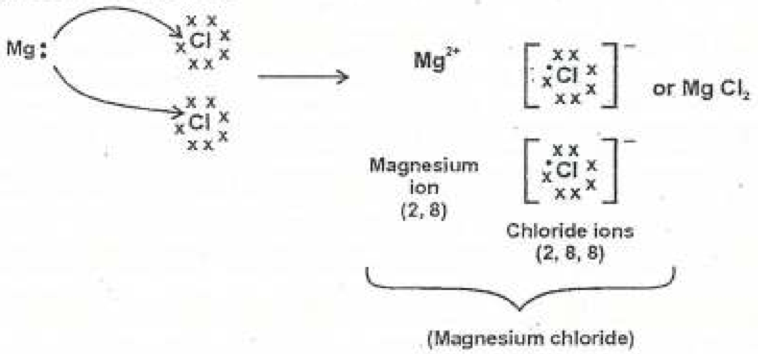


Formation of potassium chloride

Can also be represented in a similar manner.



Formation of magnesium chloride



Atomic number of magnesium (Mg) = 12

Its electronic configuration = 2, 8, 2

It loses 2 electrons from the valence shell to acquire the nearest noblegas configuration and form Mg^{2+} ion.

Atomic number of chlorine (Cl) = 17

Its electronic configuration = 2, 8, 7

It needs to gain only one electron in the valence shell to acquire the nearest noble gas configuration and form chloride ion (Cl^-). Therefore two chlorine atoms will be required to accept two electrons, one by each chlorine atom.

Properties of Ionic Compounds

1. **Physical state:** Most of the ionic compounds are crystalline solids. They are relatively hard because of strong electrostatic forces of attraction between the oppositely charged ions. They are brittle and break into pieces on applying force.
2. **Solubility:** They are soluble in water but insoluble in organic solvents like benzene, alcohol, ether, chloroform etc.
3. **Melting and boiling points:** They have high melting and boiling points. This is because a considerable amount of the energy is required to break to the strong inter-ionic attraction.
4. **Colour in the flame:** They import a characteristics colour to the flame.
5. **Electrical conductivity:** They conduct electricity in aqueous solution or in the molten state because free ions are present. In solid state ionic compounds do not conduct electricity.
6. **Ionic reactions:** They show ionic reactions which are very fast.

$$\underset{\text{Silver}}{Ag^+ + NO_3^-\,(aq)} + \underset{\text{(Sodium chloride)}}{Na^+Cl^-\,(aq)} \longrightarrow \underset{\substack{\text{Silver chloride}\\ \text{(ppt)}}}{AgCl\,(s)} + \underset{\text{Sodium nitrate}}{Na^+NO_3^-(aq)}$$

Occurrence of Metals

The major source of metals (whether in the free state or in the combined state) is the earth's curst. Some metals (Na, K) which form soluble salts like NaCl, $MgCl_2$ etc., are also found to occur in the sea water in the form of their soluble salts.

The most abundant metal on the earth's crust is aluminium followed by iron, calcium, sodium, potassium, magnesium and titanium. The remaining metals are present on the earth's crust in very small amounts.

The elementary state of the compounds in the form of which the metals occur in nature are called minerals. When they are mined from the earth's crust, they are always contaminated with earthy, sandy and rocky impurities. **These earth's sandy and rocky impurities associated with the mineral are called gangue or matrix.**

The mineral from which the metal can be extracted conveniently and economically is called an **ore.** Thus all **ores are minerals bult all minerals are not ores.**

Depending upon the reactivity, the occurrence of metals in the activity series may be represented as shown:

Metals above hydrogen	K, Ca, Na, Mg, Al	Highly reactive metals never found in the free state
Metals below hydrogen	Zn, Fe, Ni, Sn, Pb	Moderetaly reactive metals found int he combined state

$$\left.\begin{matrix} Cu \\ Ag \\ Pt \\ Au \end{matrix}\right\}$$ Less reactive metal
Found in the free state.

Occurrence of Metals in the Activity Series

The ores of some common metals are given below:

Metals	Name of the ore	Name of compound present in the ore	Formula of the ore
1. Sodium (Na)	Rock salt	Sodium chloride	$NaCl$
2. Calcium (Ca)	Dolomite	Calcium magnesium carbonate	$CaCO_3\ MgCO_3$
3. Aluminium (Al)	Bauxite	Aluminium oxide	$Al_3O_4\ 2H_2O$
4. Copper (Cu)	(i) Cuprite (Ruby copper)	Copper (I) oxide	Cu_2O
	(ii) Copper glance	Copper (I) sulphide	Cu_2S
	(iii) Copper pyrites	copper iron sulphide	$CuFeS_2$
5. Iron (Fe)	(i) Iron pyrites	Iron sulphide	FeS_2
	(ii) Haematite	Iron (III) oxide	Fe_2O_3
6. Zinc (Zn)	(i) Zinc blende	Zinc sulphide	ZnS
	(ii) Calamine	Zinc carbonate	$ZnCO_3$
7. Mercury (Hg)	Cinnabar	Mercury (II) sulphide	HgS
8. Silver (Ag)	Argentite (Silver glance)	Silver sulphide	Ag_2S
9. Lead (Pb)	Galena	Lead sulphide	PbS

Extraction of Metals (Metallurgy)

Getting metal out of the ore is called **extraction** of the metal.

'*The various steps involved in the extraction of the metal from its ores followed by refining of the metal is called metallurgy*'.

The three main steps involved in the extraction of any metal are:

1. Enrichment or concentration of the ore.
2. Extraction of the metal from the concentrated ore.
3. Refining of the impure metal.

Enrichment or Concentration of the Ore

The ore extracted from earth contains impurities like sand, stone, saw dust etc. Depending open the nature of ore and the impurities present any one of the following methods can be used.

(i) **Gravity separation or Hydraulic washing:** This method is used when the ore particles are heavier than the impurities. The powdered ore is placed over a wooden inclined table. It is then sprayed with a stream of water which carries away the lighter impurities with it. The heavier ores are left behind on the wooden table.

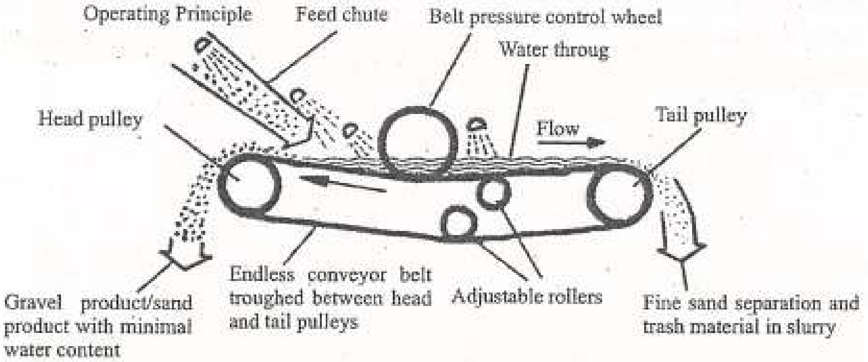


Fig. 8.1 Hydroulic washing system

(ii) **Froth floatation process:** This method is used for the concentration of sulphide ores. The powdered ore is mixed and agitated strongly and froth is produced. The sulphide ore particles are preferentially weted by the forth and ore carried to the surface while the impurities settles at the bottom. The forth is removed and washed and then the we get the concentrated ore.

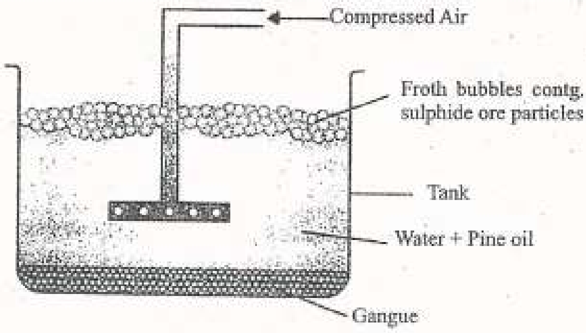


Fig: 8.2 Froth floatation process

(iii) **Electromagnetic separation:** This method is used when either ore or the impurity is magnetic. It is carried on a conveyor belt moving on two rollers one of which is magnetic. As the ores falls down from the magnetic roller, the magnetic particles of the ore and the non magnetic particles take up two different position and are collected in two heaps.

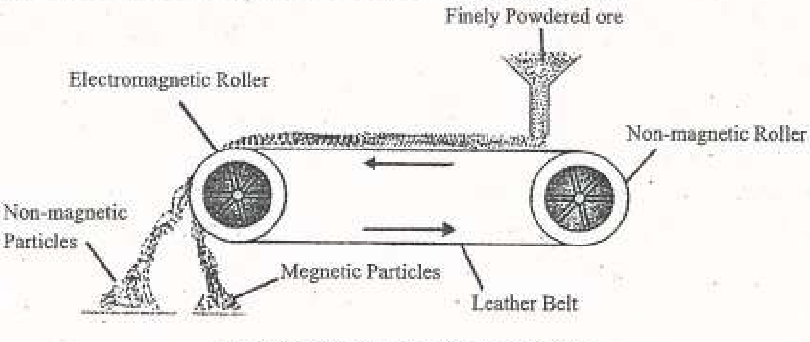


Fig: 8.3 Electromagnetic separation

(iv) Chemical separation: This method is based upon the difference in the chemical reactivity of the ore and the gangue towards a particular reagent. For example : bauxite ($Al_2.O_3.2\ H_2O$), an ore of aluminium, contains the impurities of iron (III) oxide $Fe_2\ O_3$ and sand, *i.e.*, silica (SiO_2). Pure alumina is obtained from the ore by **Baeyer's method** as follows :

For concentrating bauxite ore the powered ore is mixed with hot and concentrated solution of sodium hydroxide. The ore forms soluble sodium metal aluminate, while the impurities remains insoluble which is filtered and removed.

$$\underset{\substack{\text{Aluminium oxide}\\\text{(Present in the ore)}}}{Al_2O_3\,(s)} + 2NaOH\,(aq) \longrightarrow \underset{\substack{\text{Sodiummeta-aluminate}\\\text{(Water soluble)}}}{2NaIO_2\,(aq)} + H_2O\,(l)$$

$$\underset{\substack{\text{Silica}\\\text{(Present in the ore)}}}{SiO_2} + 2\,NaOH \longrightarrow \underset{\substack{\text{Sodium silicate}\\\text{(Water soluble)}}}{Na_2SiO_3} + H_2O$$

The filtrate is then hydrolysed to get aluminium hydroxide precipitate.

$$\underset{\text{Soldium aliminate}}{NaAlO_2\,(aq)} + 2\,H_2O\,(l) \longrightarrow \underset{\substack{\text{Aluminium hydroxide}\\\text{(ppt.)}}}{Al\,(OH)_3\,(S)} + NaOH\,(aq)$$

This precipitate is filtered and dried and then heated strongly to get alumina.

$$2\,Al(OH)_3 \xrightarrow{\text{Ignition}} \underset{\text{Alumina}}{Al_2O_3} + \underset{\text{Water vapour}}{3H_2O\,(g)}$$

Extraction of the Metal from the Concentrated Ore

The method used depends upon the nature of metal to be extracted. Based on their reactivity, the metals have been grouped into the following three categories:

1. Metals of low reactivity
2. Metals of middle reactivity
3. Metals of high reactivity

1. **Metals of low reactivity (Cu, Ag, Hg, Pt, Au):** The oxides are reduced to metals by heating alone. Thus, the only steps needed is roasting the sulphide ore, *i.e.*, heating the ore strongly in the presence of excess of air. As a result the sulphide is first converted sulphurdioxdide into and then reduced to the metal.

   For example:

$$\underset{\substack{\text{Mercuric sulphide}\\\text{(Cinnabar–ore of Hg)}}}{2\,HgS\,(s)} + 3\,O_2\,(g) \xrightarrow{\text{Heat}} \underset{\text{Mercuric oxide}}{2\,HgO\,(s)} + \underset{\text{Sulphurdioxide}}{2\,SO_2\,(g)}$$

$$2\,HgO\,(s) \xrightarrow{\text{Heat}} \underset{\text{Mercury}}{2\,Hg\,(l)} + \underset{\text{Oxygen}}{O_2\,(g)}$$

2. **Metals of middle reactivity (Fe, Zn, Pb, etc.):** These occur in nature as oxide, carbonates or sulphides. Thus the different steps involved for the extraction of the metal from the concentrated ore are as follows:

   (a) Conversion of the carbonate or sulphide ore into metal oxide: This is done by either of the following two methods:

   (i) Calcination (for carbonate ores): It is the process of heating the ore strongly in the absence of air. The metal carbonate decomposes to form metal oxide. For example:

$$\underset{\substack{\text{Zinc carbonate}\\\text{(Calamine–ore of Zn)}}}{ZnCO_3\,(s)} \xrightarrow[\text{(absence of air)}]{\text{Heat}} ZnO(s) + CO_2(g)$$

(ii) **Roasting (for sulphide ores):** It is the process of heating the ore strongly in the presence of excess of air. As a result, the sulphide ore is converted into metal oxide. For example,

$$\underset{\substack{\text{Zinc sulphide} \\ \text{(Zinc blende–ore of Zn)}}}{2\,ZnS\,(s)} + \underset{\text{From air}}{3\,O_2\,(g)} \xrightarrow[\text{Presence of excess of air}]{\text{Heat}} \underset{\text{(Zinc oxide)}}{2\,ZnO\,(s)} + \underset{\text{Sulphur dioxide}}{2\,SO_2\,(g)}$$

(b) **Reduction of the metal oxide to metal:** As these metals are moderately reactive, their oxides cannot be reduced by heating alone. Hence their oxides are reduced to metals by using a suitable reducing agent. Such as:

(i) **Reduction of heating with carbon:** Oxides of iron and zinc are reduced to their respective metals by heating with coke.

$$\underset{\text{Ferric oxide}}{Fe_2O_3\,(s)} + \underset{\text{Coke}}{3\,C\,(s)} \xrightarrow{\text{Heat}} \underset{\text{Iron}}{2\,Fe_2\,(s)} + \underset{\text{Carbon monoxide}}{3\,CO\,(g)}$$

$$\underset{\text{Zinc oxide}}{ZnO\,(s)} + \underset{\text{Coke}}{C\,(s)} \xrightarrow{\text{Heat}} \underset{\text{Zinc}}{Zn\,(s)} + \underset{\text{Carbon monoxide}}{CO\,(g)}$$

Carbon monoxide formed also act as reducing agent and further reduces the metal oxide to metal.

$$Fe_2O_3\,(s) + \underset{\text{Carbon monoxide}}{3\,CO\,(g)} \xrightarrow{\text{Heat}} \underset{\text{Iron}}{2\,Fe_2\,(s)} + \underset{\text{Carbon dioxide}}{3\,CO_2(g)}$$

$$ZnO\,(s) + CO\,(g) \xrightarrow{\text{Heat}} Zn\,(s) + \underset{\text{Carbon dioxide}}{CO_2}$$

Note: The reduction of metal oxides by heating with coke is called **smelting**.

(ii) **Reduction by heating with aluminium:** Reduction of MnO_2, Cr_2O_3 etc., is done by heating with more active metals like Na, K, Al. The reduction are displacement reactions and highly exothermic.

$$\underset{\text{Maganese dioxide}}{3\,MnO_2\,(s)} + \underset{\substack{\text{Aluminium} \\ \text{(powder)}}}{4\,Al\,(s)} \xrightarrow{\text{Heat}} \underset{\substack{\text{Magnese} \\ \text{(melt)}}}{3\,Mn\,(l)} + \underset{\text{Aluminium oxide}}{2\,Al_2O_3\,(s)}$$

$$\underset{\text{Chromium oxide}}{Cr_2O_3\,(s)} + \underset{\substack{\text{Aluminium} \\ \text{(powder)}}}{2\,Al} \xrightarrow{\text{Heat}} \underset{\substack{\text{Chromium} \\ \text{(melt)}}}{2\,Cr\,(l)} + \underset{\text{Aluminium oxide}}{Al_2O_3\,(s)}$$

Reduction of Fe_2O_3 with Al is called **thermite reaction,**

$$\underset{\text{Iron (III) oxide}}{Fe_2O_3\,(s)} + \underset{\text{Aluminium}}{2\,Al\,(s)} \xrightarrow{\text{Ignited}} \underset{\text{Iron (melt)}}{2\,Fe_2\,(e)} + Al_2O_3(s)$$

The reduction of metal oxides to metal using aluminium as the reducing agent is called aluminothermy.

Note: The above reactions are displacement reactions as the more active aluminium displaces the less active metals like Mn, Cr and Fe from their oxides.

3. **Extraction of metals present high up in the activity series (K, Ca, Na, Mg and Al):** The highly reactive metals cannot be obtained by reduction of their oxides by heating with carbon or aluminium. This is because these highly reactive metals have greater affinity for oxygen than for carbon or aluminum. Hence, these metals are obtained by the electrolysis of their molten or fused oxides or chlorides. The method is called **'electrolytic reduction'. For example:** Sodium,

magnesium and calcium are obtained by the electrolysis of their molten chlorides. The metals ore deposited at the cathode (the negatively charged electrode) whereas, chlorine is liberated at the anode (the positively charge electrode). The reactions are

At cathode: $\underset{\text{(sodium ions)}}{Na^+} + \underset{\text{(electron)}}{e^-} \xrightarrow{\text{Reduction}} \underset{\text{(Sodium metal)}}{Na\,(s)}$

At anode: $2\,Cl^- \xrightarrow{\text{Oxidation}} Cl_2 + 2\,e^-$

Similarly, aluminium is obtained by the electrolytic reduction of aluminium oxide:

At cathode: $Al^{3+}\,(l) + 3\,e^- \xrightarrow{\text{Reduction}} \underset{\text{Aluminium metal}}{Al\,(s)}$

At anode: $O^{2-}\,(l) \xrightarrow{\text{Oxidation}} \underset{\text{Oxygen atom}}{O\,(g)}$

$$\underbrace{O\,(g) + O\,(g)}_{\text{Oxygen atoms}} \longrightarrow \underset{\text{Oxygen gas}}{O_2\,(g)}$$

Refining of Impure Metals

The metal obtained above contains a number of impurities. It is called **crude metal.** The method of refining (purifying) depends upon the nature of the metal and the nature of impurities. The most common method is **electrolytic refining.** Impure metal is made the anode, pure metal sheet is made the cathode and water saluble salt of the metal is taken in the electrolytic tank (bath). Pure metal dissolve from the anode and deposited on the cathode impurities fall below the anode as **'anode mud'.**

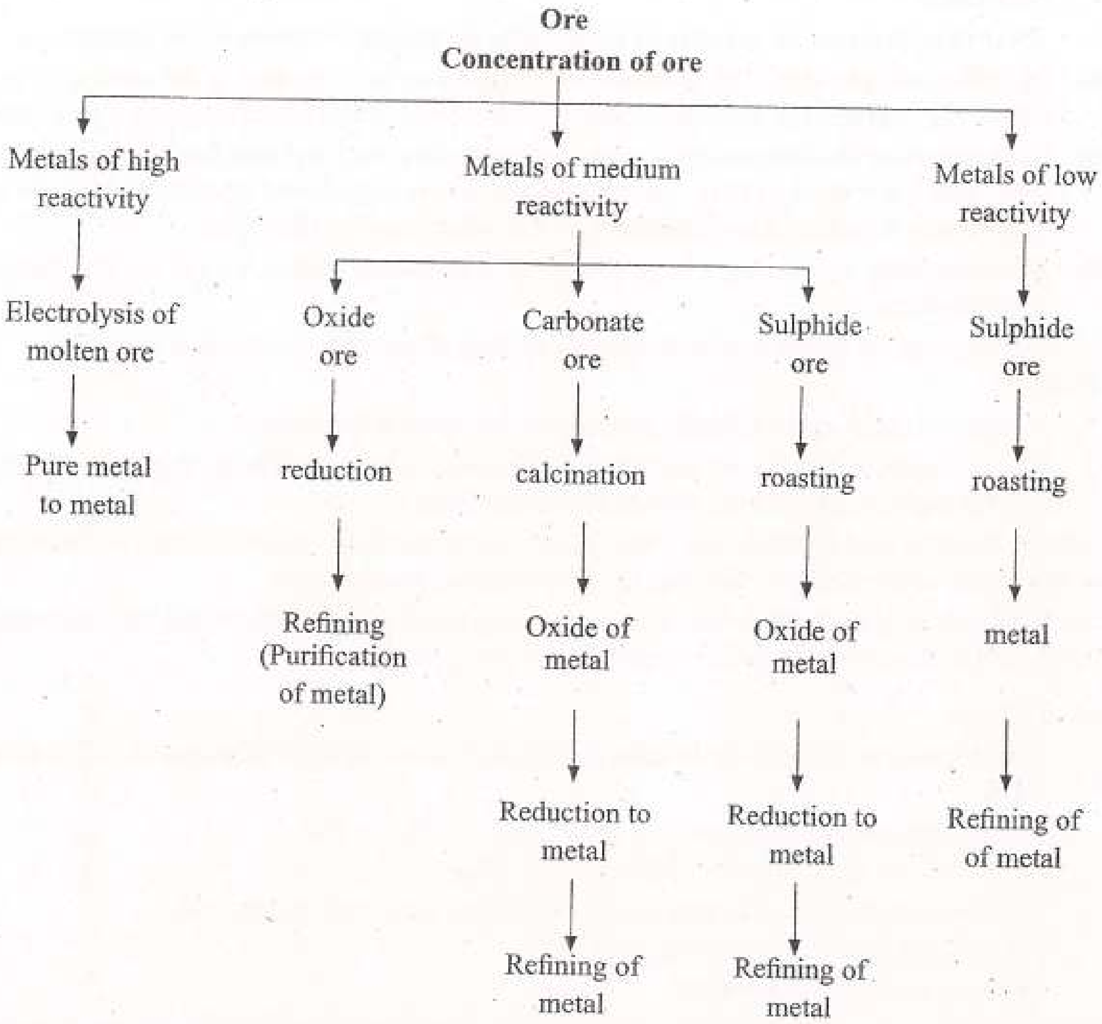
Electrolytic refining of copper: The black of the impure copper is made the anode. A thin plate of pure copper is made the cathode. A solution of copper sulphate acidified with dilute sulphuric acid is taken as the electrolyte in the electrolytic bath (or a tank). On passing electric current, pure copper from the anode passes into the solution as Cu^{2+} ions. An equivalent amount of Cu^{+2} ions from the solution are deposited on the cathode as pure copper.

At anode: $\underset{\text{(Copper atom)}}{Cu\,(s)} \longrightarrow \underset{\text{(Copper ions)}}{Cu^{2+}\,(aq)} + 2e^-$

At cathode: $\underset{\substack{\text{(Copper ions)}\\ \text{from slution}}}{Cu^{2+}(aq)} + 2e^- \longrightarrow \underset{\text{(Copper atom)}}{Cu}$

The soluble impurities go into the solution, whereas, the insoluble impurities settle down at the bottom of the anode are known as anode mud.

To sum up the method used and the steps applied for the extraction of different types of metals follow the chart given below:



Steps involved in the extraction of metals from ores

Corrosion: The process of slowly eating up of metals due to their conversion into oxides, carbonates, sulphides, sulphates, etc. by the action of atmospheric gases and moisture is called **corrosion.** When the corrosion takes place on iron then it is called **rusting.** Rusting occurs only in presence of air and moistures. It is an electrochemical process in which different parts of the iron surface acts as electrodes in a cell reaction. At the anode, iron atoms dissolve as Fe^{2+} ions. Rust is mainly hydrated ferric oxide ($Fe_2O_3.xH_2O$).

$$\underset{\text{Iron}}{2\,Fe\,(s)} + \underbrace{\underset{\text{Oxygen}}{3/2\,O_2\,(g)} + \underset{\text{moisture}}{xH_2O\,(l)}}_{\text{From moist air}} \longrightarrow \underset{\substack{\text{Hydrated ferric oxide}\\ \text{(Rust)}}}{Fe_2O_3.xH_2O\,(s)}$$

Conditions necessary for rusting of iron:

The two conditions which are necessary for rusting of iron are:

(i) Presence of air (or oxygen) and

(ii) Presence of water vapour (or moisture)

Prevention of rusting: The rusting of iron can be prevented by:

(i) By painting: Corrosion of metallic surface can be prevented by painting a layer of varnish and other paints.

These paint prevents the reaction of metals with the air and moistures in the atmosphere.

(ii) By oiling and greasing: When a thin film of grease or oil is applied to the surface of an iron object, the moisture and air cannot come in contact with it and hence resulting it prevented.

(iii) Galvanization: Galvanizaton is a method of protecting steel and iron from rusting by coating them with a thin layer of zinc. The galavanized article is protected against rusting even if the zinc corting is broken. **This is because zinc is more reactive than iron.**

(vi) Electroplating: By coating, a large amount of non reactive metals, we can prevent the metals from corrosion.

(v) By alloying: We can prevent corrosion by making alloys with non reactive metals.

Note:

1. A common metal which is highly resistant to corrosion is aluminium
2. Carbon constitutes the second most abundant element in the human body. Together with oxygen and hydrogen, it accounts for 93% of the body's mass.

Alloys: An alloy may be defined as a homogenous mixture of two or more metals, or a metal and a non metal. If one of the metals is mercury, the alloy is called an **amalgam.**

An alloy is usually prepared by first melting the main metal and then dissolving the other elements in it in a definite proportions. It is then cooled to room temperature.

Types of alloys:

1. **Ferrous alloys:** An alloys in which iron is present as one of the constituents is called a ferrous alloy.

   For example: Manganese steel (Fe = 86%; Mn = 13%,C = 1%)

   Nickel steel (Fe = 96 – 98%, Ni = 4 – 2%)

2. **Non ferrous alloys:** In which iron is not present as one of the constituents.

   For example: Brass (Cu = 80%), Zn = 20%)

   Bronze (Cu = 90%), Sn = 10%)

3. **Amalgams:** An alloy containing mercury as one of the constituent metal is known as amalgam.

   For example: Sodium amalgam, zinc amalgam etc.

Objective of alloy making: The main objectives of alloy making are:

(i) To increase hardness
(ii) To increase tensile strength
(iii) To increase resistance to corrosion
(iv) To lower melting point
(v) To modify chemical reactivity
(vi) To reduce electrical conductivity
(vii) To produce good costing and
(viii) To modify colour.

Note: Purity of gold is expressed in carats. Pure gold is 24 carat. It is very soft and is therefore, not suitable for making jewellery. To make it hard, it is alloyed either with copper or silver.

In India generally 22 carat gold is used for making ornaments. This means 22 parts by weight of pure gold is alloyed with 2 parts by weight of either copper or silver.

Some common alloys with their composition

1. Steel (Iron-99.–95%, Carbon – 0.05%)
2. Stainless (Iron-74%, Chromium – 18%, Nickel – 8%)
3. Brass (Copper – 80%, Zinc-20%)
4. Bronze (Copper-90%, Tin-10%)
5. German silver (does not contain silver) (Copper-60%, Zinc – 20%, Nickel-20%)
6. Duralumin (Al-95%, Cu-4%, Mg-0.5%, Mn-0.5%)
7. Magnalium [Al-95%, Mg – 5%]
8. Aluminium Bronze [Al-95%, Cu – 5%]
9. Bronze Solder [Lead-5%, Tin – 50%]

Key Points

- ✓ Elements can be classified as metals and non-metals
- ✓ Metals are lustrous, ductile and are good conductors of heat and electricity. They are solids at room temperature, except mercury which is a liquid.
- ✓ Non-metals have properties opposite to that of metals.
- ✓ Metals can form positive ions by losing electrons to non-metals
- ✓ No metals form negatively charged ions by gaining electrons.
- ✓ Metals forms oxide which are basic in nature. Aluminium oxide and zinc oxide show the properties of both basic as well as acidic oxides. These oxides are known as amphoteric oxides.
- ✓ Non-metals form oxides which are either acidic or neutral.
- ✓ A list of common metals arranged in order of their decreasing reactivity is known as an activity series.
- ✓ A more reactive metal displaces a less reactive metal from its salt solution
- ✓ The extraction of metals from their ores and then refining them for use is known as metallurgy.
- ✓ The slow decomposition of metallic surface when left exposed to air and moistures is called corrosion.
- ✓ An alloy is a homogeneous mixture of two or more metals or a metal and a non-metal

Multiple Choice Questions

1. Which of the following property is generally not shown by metals ?
   (a) Electrical conduction (b) Dullness
   (c) Sonorous in nature (d) Ductility
2. Which of the following statement is not correct?
   (a) All metals are solids at room temperature
   (b) All metals passes lusture when freshly prepared
   (c) All metals from basic oxides
   (d) All metals are good conductor of heat and electricity
3. The best conductor of electricity is
   (a) Copper (b) Silver
   (c) Aluminium (d) All one equal
4. Which of the following ore cannot be concentrated by electromagnetic separation ?
   (a) Chromite (b) Cuprite
   (c) Magnetite (d) Pyrolusite
5. Aluminium is used for making cooking utensils Which of the following properties of aluminium are responsible for the same ?
   (i) Good thermal conductivity
   (ii) Good electrical conductivity
   (iii) Ductility
   (iv) High melting point
   (a) (i) and (ii) (b) (i) and (iii)
   (c) (i) and (iv) (d) (ii) and (iv)
6. Cinnabar is an ore of
   (a) Calcium (b) Zinc
   (c) Mercury (d) Copper
7. Safety fuse wire is made of
   (a) Platinum (b) Silver
   (c) Copper (d) Alloy of tin and lead
8. All ores are minerals but all mineral are not
   (a) Compounds (b) Suspensions
   (c) Ores (d) Mixtures
9. When aluminium is added to sodium hydroxide solution
   (a) Oxygen is evolved (b) Hydrogen is produced
   (c) Water is produced (d) No reaction takes place
10. The correct order of electrical conductivity is
    (a) Al > Cu > Au > Ag (b) Ag > Cu > Au > Al
    (c) Cu > Ag > Al > Au (d) Au > Ag > Al > Cu

11. Which of the following metal forms amphateric oxide?
(a) Copper
(b) Silver
(c) Aluminium
(d) Iron

12. Beakers A, B and C contain zinc sulphate, silver nitrate and iron (II) sulphate solutions, respectively, copper pieces are added to each beaker. Blue colour will appear in case of
(a) Beaker A
(b) Beaker B
(c) Beaker C
(d) All the beakers

13. Match the entries of column I with appropriate entries of column II

Column I (metal)	Column II (Ore of the metal)
(i) Aluminium	(A) Calamine
(ii) Iron	(B) Dolimite
(iii) Lead	(C) Cinnabar
(iv) Mercury	(D) Haematite
(v) Zinc	(E) Galena
(vi) Calcium	(F) Bouxite

(a) (i) $\rightarrow$ F, (ii) $\rightarrow$ D, (iii) $\rightarrow$ (E) (iv) $\rightarrow$ (C), (v) $\rightarrow$ A, (vi) $\rightarrow$ (B)
(b) (i) $\rightarrow$ D, (ii) $\rightarrow$ A, (iii) $\rightarrow$ (B) (iv) $\rightarrow$ (E), (v) $\rightarrow$ F, (vi) $\rightarrow$ (C)
(c) (i) $\rightarrow$ B, (ii) $\rightarrow$ C, (iii) $\rightarrow$ (E) (iv) $\rightarrow$ (A), (v) $\rightarrow$ D, (vi) $\rightarrow$ (F)
(d) (i) $\rightarrow$ C, (ii) $\rightarrow$ D, (iii) $\rightarrow$ (A) (iv) $\rightarrow$ (B), (v) $\rightarrow$ F, (vi) $\rightarrow$ (E)

14. Which of the following oxide cannot be reduced with carbon to obtain the metal ?
(a) MnO_2
(b) Al_2O_3
(c) Cr_2O_3
(d) All of these

15. 18 carat gold contains
(a) 5% gold
(b) 75% gold
(c) 18% gold
(d) 60% gold

16. Which of the following are not ionic compounds ?
(i) KCl
(ii) HCl
(iii) CCl_4
(iv) NaCl
(a) (i) and (ii)
(b) (ii) and (iii)
(c) (iii) and (iv)
(d) (i) and (iii)

17. The composition of aqua regia is
(a) Dil HCl : Conc HNO_3
3 1
(b) Conc HCl : Dil HNO_3
3 : 1
(c) Conc HCl : Conc HNO_3
3 : 1
(d) Dil HCl : Dil HNO_3
3 : 1

18. What happens when calcium is treated with water ?
    (i) It does not react with water
    (ii) It reacts violently with water
    (iii) It reacts less violently with water
    (iv) Bubbles of hydrogen gas formed stick to the surface of calcium
    (a) (i) and (iv) (b) (ii) and (iii)
    (c) (iii) and (iv) (d) (i) and (ii)
19. Which one of the following metals does not react with cold as well as hot water ?
    (a) Na (b) Mg
    (c) Ca (d) Fe
20. Generally metals react with acids to give salt and hydrogen gas. Which of the following acids does not give hydrogen gas on reacting with metals (except Mn and Mg) ?
    (a) HCl (b) H_2SO_4
    (c) HNO_3 (d) All of these
21. Which one of the following four metals would be displaced from the solution of its salts by other three metals ?
    (a) Ag (b) Cu
    (c) Mg (d) Zn
22. An alloy is
    (a) An element (b) A compound
    (c) A homogeneous mixture (d) A heterogeneous mixture
23. Which of the following oxide(s) of iron would be obtained on prolonged reaction of iron with steam ?
    (a) FeO (b) Fe_2O_3
    (c) Fe_3O_4 (d) Fe_2O_3 and Fe_3O_4
24. The most abundant metal on the earth's crust is
    (a) Copper (b) Zinc
    (c) Aluminium (d) Iron
25. When a sample of copper containing iron as impurity is purified by electrolysis, the appropriate electrodes are cathode Anode:
    (a) Pure iron pure copper (b) Impure sample pure copper
    (c) Impure iron impure sample (d) Pure copper impure sample
26. Which of the following metals exist in their native state
    (i) Cu (ii) Au
    (iii) Zn (iv) Ag
    (a) (ii) and (iv) (b) (i) and (iii)
    (c) (iii) and (iv) (d) (ii) and (ii)

27. Match the entries of column I with entries of column II

Column-I (Metal and its ore)	Column-II (Method of concentration)
(i) Iron from haematite	(A) Froth floation
(ii) Copper from copper glance	(B) Gravity separation
(iii) Aluminium from bauxite	(C) Chemical separation
(iv) Chromium from chromite ore	(D) Hydraulic washing

(a) (i) → (B), (ii) → (A), (iii) → (D) (iv) → (C)
(b) (i) → (C), (ii) → (D), (iii) → (A) (iv) → (B)
(c) (i) → (D), (ii) → (A), (iii) → (C) (iv) → (B)
(d) (i) → (B), (ii) → (C), (iii) → (D) (iv) → (A)

28. Silver articles become black on prolonged exposure to air. This is due to the formation
(a) Ag_3N
(b) Ag_2S
(c) Ag_2O
(d) Ag_2S and Ag_3N

29. Galvanization is a method of protecting iron from rusting by coating with thin layer of
(a) Zinc
(b) Silver
(c) Galium
(d) Aluminium

30. If copper is kept open in air, it slowly losses its shining brown surface and gains a green coating. It is due to the formation of
(a) CuO
(b) $CuSO_4$
(c) $CuCO_3$
(d) $Cu(NO_3)_2$

31. Which of the following metals are obtained by electrolysis of their chloride in moeten state?
(a) Na
(b) Ca
(c) Fe
(d) Cu
(a) (i) and (iv)
(b) (i) and (ii)
(c) (i) and (iii)
(d) (iii) and (iv)

32. During electrolytic refining of zinc, it gets
(a) Deposited on anode
(b) Deposited on cathode
(c) Deposited on cathode as well as anode
(d) Remains in the solution

33. An element A is soft and can be cut with a knife. This is very reactive to air and cannot to kept open in air. It reacts vigorously with water. Identify the element from the following
(a) Ca
(b) P
(c) Na
(d) Mg
(e) Fe

34. An electrolytic cell consists of
(i) Positively charged cathode
(ii) Negatively charged anode
(iii) Positively charged anode
(iv) Negatively charged cathode

(a) (i) and (ii)
(b) (i) and (iii)
(c) (ii) and (iii)
(d) (iii) and (iv)

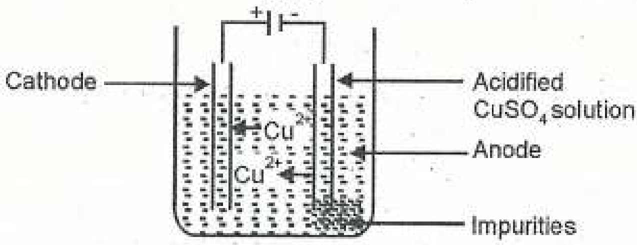
35. Generally, metals are solid in nature. Which one of the following metals is found in liquid state at room temperature ?
(a) Na
(b) Cr
(c) Hg
(d) Fe

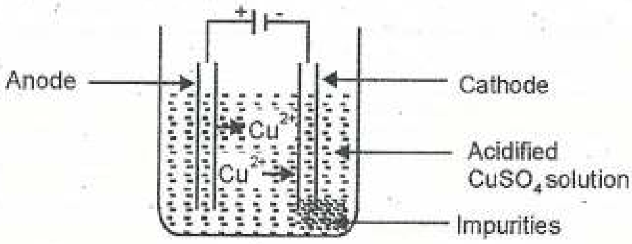
36. Alloys are homogeneous mixtures of a metal with a metal or non-metal, which among the following alloys contain non-metal as one of its constituents ?
(a) Bronze
(b) Brass
(c) Steel
(d) Amalgam

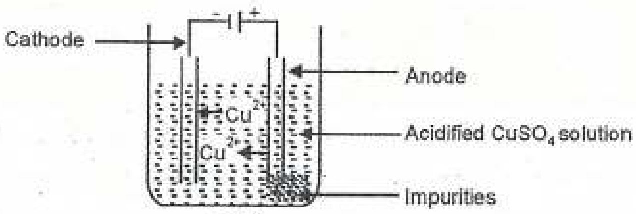
37. Electrical wires have a coating of an insulating material. The material generally used is
(a) Sulphur
(b) PVC
(c) Graphite
(d) All can be used

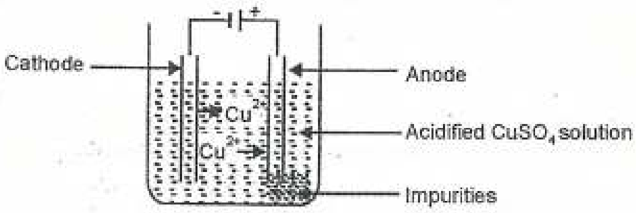
38. Which of the following can undergo a chemical reaction ?
(a) $MgSO_4 + Fe$
(b) $MgSO_4 + Pb$
(c) $ZnSO_4 + Fe$
(d) $CuSO_4 + Fe$

39. Which one of the following figures correctly describes the process of electrolytic refining ?

(a)


(b)


(c)


(d)


40. Which among the following statements is incorrect for magnesium metal ?
   (a) It burns in oxygen with dazzling white flame.
   (b) it reacts with cold water to form magnesium oxide and evolves hydrogen gas.
   (c) It reacts with steam to form magnesium hydroxide and evolves hydrogen gas.
   (d) It reacts with hot water to form magnesium hydroxide and evolves hydrogen gas.

41. Two ml each of concentrated HCl, HNO_3 and mixture of concentrated HCl and concentrated HNO_3 in the ratio of 3 : 1 were taken in test tubes labelled as A, B and C. A small piece of metal was put in each test tube. No change occurred in test tubes A and B but the metal got dissolved in test tube C. The metal could be.
   (a) Au (b) Al
   (c) Pt (d) Cu

42. Reaction between X and Y forms compound Z. X loses electron and Y gains electron. Which of the following properties is not shown by Z ?
   (a) Has low melting point
   (b) Has high melting point
   (c) Occurs as solid
   (d) Conducts electricity in molten state

43. The electronic configuration of three elements X, Y and Z are X—2, 8; Y—2, 8, 7 and Z—2, 8, 2 which of the following is correct ?
   (a) X is metal
   (b) Y is a metal
   (c) Z is a non-metal
   (d) Y is a non-metal and Z is a metal

44. Although metals forms basic oxides, which of the following metals form an amphoteric oxide ?
   (a) Na (b) Cu
   (c) Ca (d) Al

Answer Key

1. (b)	2. (a)	3. (b)	4. (b)	5. (c)	6. (c)	7. (d)	8. (c)	9. (b)	10. (b)
11. (c)	12. (b)	13. (a)	14. (d)	15. (b)	16. (b)	17. (c)	18. (c)	19. (d)	20. (c)
21. (b)	22. (c)	23. (c)	24. (c)	25. (d)	26. (a)	27. (c)	28. (b)	29. (a)	30. (c)
31. (b)	32. (b)	33. (c)	34. (d)	35. (c)	36. (c)	37. (b)	38. (d)	39. (c)	40. (b)
41. (c)	42. (a)	43. (d)	44. (d)						

Hints and Solutions

16. (b)

HCl and CCl_4 are covalent compounds.

19. (d)

Fe does not react with cold as well as hot water. It reacts only with steam.

20. (c)

HON_3 is oxidising agent. It oxidzes metal to metal oxide which further dissolves in HNO_3 to form metal nitrate and HNO_3 itself is reduced to NO_2 or NO or N_2O depending upon the nature of the metal and concentration of acid. Mn and Mg are the only metals which react with dilute of HNO_3 to produce H_2 gas.

21. (b)

Out of the given metals, copper is least reactive and hence will be displaced from its salt solution by other metals.

26. (a)

Being least reactive, gold (Au) and silver (Ag) are found in the native state

28. (b)

H_2S gas of the air attacks silver to form a layer of black Ag_2S.

30. (c)

The green coating is due to the formation of basic copper carbonate $CuCO_3.Cu(OH)_2$.

38. (d)

Fe is more reactive than Cu and hence can displace Cu from $CuSO_4$ solution.

39. (c)

Cathode is the electrode connected to the negative (–) terminal of the battery while anode is the electrode connected to the positive (+) terminal of the battery. Cu^{2+} ions from the solution are deposited on the cathode while Cu from impure anode dissolves into the solution and the impurities fall below anode as anode mud.

40. (b)

Mg does not react with cold water.

41. (a, c)

Au and Pt do not react with conc HCl or conc HNO_3 but dissolves in a mixture of conc. HCl and corc. HNO_3 in the ratio 3 :1 called aqua-regia)

42. (a)

As X loses electron and Y gains electron to form Z. Hence, Z is an ionic compound Ionic compounds have high melting points.

44. (d)

Al forms an amphoteric oxide with formula Al_2O_3. It can react with acid as well as base.

9. Carbon and Its Compounds

Learning Objectives

- * Covalent Bonding in Carbon Compounds
- * Carbon always forms covalent bonds
- * Carbon is tetravalent
- * Carbon tetrachedral
- * Types of covalent bonds and its examples
- * Properties of covalent compounds
- * Allotropic Forms of Carbon
  - * Diamond, Graphite and Fullerenes
- * Versatile Nature of Carbon
- * Organic Compounds
  - * vital force theory
  - * Wohler's systhesis
- * Saturared and Unsaturated Carbon Compounds
  - * Reactivity of satured and unsatured carbon compounds
  - * Chain, branches and rings compounds
- * Functional Groups
- * Homologus Series and its Characteristics
- * Nomenclature of Organic Compounds
- * Chemical Properties of Organic Compound
- * Ethanol and its Properties and Uses
- * Ethanoic Acid and its Chemical Properties
- * Soaps and Detergents

One of the most important non-metal is carbon having the symbol C. It is very important for us both in the element form and in the combined form.

The amount of carbon present in the earth's crust and in the atmosphere is quite meager. The earth's crust has only 0.02% carbon in the form of minerals (such as carbonate, hydrogen carbonates, coal and petroleum) and atmosphere has 0.03% carbon dioxide. In spite of this small amount of carbon available in nature, carbon compounds play an extremely important role in our lives.

Covalent Bonding in Carbon Compounds

In the previous chapter, we have studied some properties of the ionic compounds. There we have stated that **ionic compounds have high melting and boiling points and conduct electricity in aqueous solutions as well as in the molten (or fused) state.** All these properties were explained on the basis of nature of bonding in ionic compounds.

Properties of some carbon compounds:

Melting points and boiling points of some compounds of carbon

Compounds	Molecular formula	Melting point	Boiling point
Ethanol	CH_3CH_2OH	156 k	351 k
Chloroform	$CHCl_3$	209 k	334 k
Methane	CH_4	90 k	111 k
Acetic acid	CH_3COOH	290 k	391 k

From the above table, it is clear that the melting and boiling point of carbon compounds are very low.

This is due to the reason that the force of attraction between the molecules of these compounds are not strong. Further, most of the carbon compounds are poor or non conductor of electricity. This means that the bonding in these compounds is such that it does not lead to the formation of ions.

Carbon Always forms Covalent Bonds

Valency or the combined capacity of an element depends upon the number of valence (*i.e.*, electrons present in the outer–most shell). The atomic number of the carbon is 6. So, its electronic configuration is $\overset{k}{2}\ \overset{L}{4}$.

Reactivity of any element depends upon how easily it can completely fill its outermost shell and thus attain the stable electronic configuration of the nearest noble or inert gas. Elements forming ionic compounds achieve the noble gas configuration either by (outermost shell) losing or gaining electrons from the outermost shell. Now carbon has four electrons in its valence shell *i.e.*, L shell. Therefore, it should either lose or gain 4 electrons to achieve the noble gas configuration and become stable. However, it is difficult for carbon to gain or loose four electrons because of the following reasons:

(a) It cannot gain 4 electrons to form C^{4+} ions having neon gas (2, 8) configuration because this cation would be highly unstable due to the large amount of energy required to overcome the force of repulsion between the four electrons being added and the six electrons already present in the carbon atom.

(b) It cannot lose 4 electrons to form C^{4-} ions having helium gas (2) configuration because this anion would be highly unstable due to the large amount of energy required to remove four electrons from the carbon atom.

Thus, carbon can neither gain nor lose 4 electrons to acquire the nearest noble gas configuration. To overcome this problem carbon can acquire the nearest noble gas configuration is by sharing of its valence electrons with electrons of other carbon atoms or atoms of other elements.

Such bonds which are formed by mutual sharing of electrons between two atoms are called covalent bonds. Thus, covalent bond can be explained as below:

'A chemical bond formed between two atoms by mutual sharing of valence electrons between these two atoms so that each atom acquires the stable electronic configuration of the nearest noble gas is called a **covalent bond** and the number of electrons contributed by each atom for sharing is known as its **covalency** and the compounds formed by sharing of electrons are called **covalent compounds.**'

Carbon is Tetrahedral

Dutch scientist, **J. Van't Hoff** and French scientist **C. Le Bell** both are directed towards the four corners of a regular tetrahedran Independently in 1874 pointed out that the four valencies of carbon do not lie in a plane, but are directed towards the four corners of a regular tetrahedran. 'In other words, carbon is **Tetrahedral.** The angle between any two adjacent valencies is **109°–28'** which is also called the **tetrahedral angle.**

Here, the thick solid line represent the bond above the plane of the paper and towards the observer, the dotted line represents the bond below the plane of the paper and away from the observer while the normal or ordinary solid lines represent the bonds in the plane of the paper.

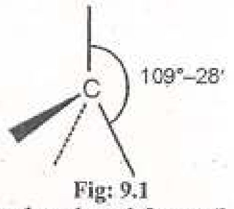


Fig: 9.1

Types of Covalent Bonds

The covalent bonds are of three types. If each atom contributes one electron, the covalent bond formed is called a **single covalent bond** and is represented by a single line (–), if each contributes two electrons, the covalent bond formed is called a **double bond** and is represented by a double line = and if atom contributes three electrons called a triple bond the covalent bond is called a triple bond is represnted by triple line (≡)

Examples of Formation of Covalent Bonds

(i) **Formation of hydrogen (H_2) molecule:** The atomic number of hydrogen is 1. Hence, hydrogen has one electron in its k-shell and thus requires one more electron to complete the k-shell. So two hydrogen atoms share one electron each to form a molecule of hydrogen. H_2. By doing same each hydrogen atom attains the stable electronic configuration of the nearest noble gas, helium, which has two electrons in its k shell. We can depict this using dots or crosses to represent valence electrons, involved in sharing. Such structures of molecules called **electron dot structures.** The electrons dot structure of H_2 molecule is shown as :

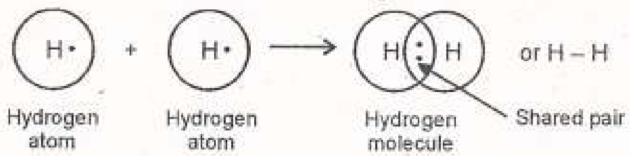


Fig: 9.2 Electron dot structure of chlorine molecule

Thus, **valency of hydrogen is one.** In other words, **hydrogen is monovalent.**

(ii) **Formation of chlorine (Cl_2) molecule:** The atomic number of chlorine is 17. So, its electronic configuration is:

K	L	M
2	8	7

Thus, chlorine has 7 electrons in its valence shell *i.e.*, M-shell. Therefore, to complete the M-shell it needs one more electron. So, two chlorine atoms share one electron each to form a diatomic molecule of chlorine Cl_2 and attain a stable electronic configuration of the nearest noble gas, argon. The electron dot structure of chlorine molecule is shown as:

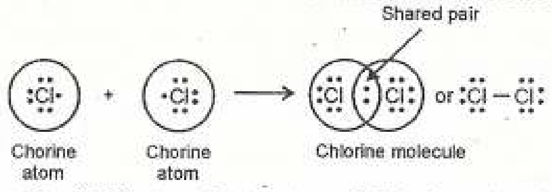


Fig: 9.3 Electron dot structure of Chlorine molecule

Since each chlorine atom shares one electrons to form Cl_2 molecule, therefore the **valency of chlorine is one.** In other words, **chlorine is monovalent.**

Note : Electrons which are not involved in bond formation are called **unshared pairs or lone pairs.**

(iii) Formation of ammonia (NH_3) molecule: The atomic number of nitrogen is 7. Its electronic configuration is

K	L
2	5

To acquire the stable electronic configuration of the nearest noble gas, neon, it needs three more electrons.

On the other hand, atomic number of hydrogen is 1 and to acquire the stable electronic configuration it needs one more electron.

In order to complete its octect, nitrogen shares three of its valence electrons, with one electron each of three hydrogen atoms to form a molecule of ammonia.

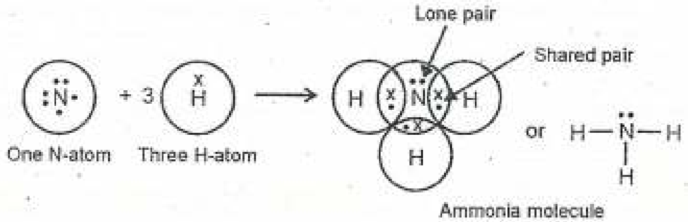


Fig: 9.4 Electron dot structure of NH_3 molecule

- The **valency of nitrogen is three** *i.e.*, it **is trivalent.**
- Nitrogen has **one lone pair of electrons**

(iv) Formation of methane (CH_4) molecule: The electrons configuration of carbon is $\begin{smallmatrix} k & L \\ 2 & 4 \end{smallmatrix}$

Carbon needs four more electrons to complete, its octet. Carbon shares its four valence electrons, with one electron each of four hydrogen atom to form a molecule. In methane the four shared pairs of electrons form C—H Single covalent bonds.

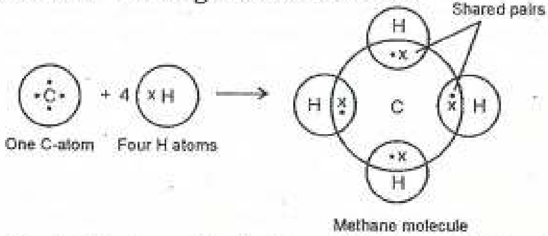


Fig: 9.5 Electron dot structure of Methane (CH_4) molecule

The four C–H bonds do not lie in a plane but are directed towards the four corners of regular tetrahedaron. The angle between any two adjacent C–H bond is 109°–28'. Thus **methane is not planar but is tetrahedral.**

Note: Methane is the simplest carbon compound. It is widely used as a fuel and is the major component of Biogas and Compressed Natural Gas (CNG).

(v) Formation of oxygen (O_2) molecule: The atomic number of oxygen is 8 and its electronic configuration is $\overset{k}{2}\ \overset{L}{6}$.

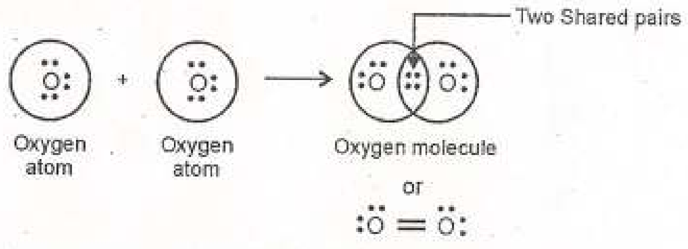


Fig: 9.6 The electron dot structure of oxygen molecule

Note: Two atoms cannot mutually share more than three electron pairs because the electron-electron repulsions between four and more shared pairs make the molecules unstable

Homoatomic and Heteroatomic Molecules

Molecules which are made up of only one kind of atoms such H_2, O_2, N_2 etc. are called homoatomic molecules while those which are made up of more than one type of atoms such as CH_4, NH_3 etc. are called heteroatomic molecules.

Properties of covalent compounds

The covalently bonded molecules have strong bond within the molecules, but their intermolecular forces of attraction are weak. As a result, the melting points and boiling points of covalent compounds are low.

Covalent compounds are generally poor conductors of electricity because during the formation of covalent bonds, only electrons are shared between atoms and no charged particles are formed.

Allotropic Forms of Carbon

'The phenomenon of existence of an element in two or more forms which have different physical properties but identical chemical properties is called **allotropy.**

Carbon occurs in three crystalline allotropic forms. These are:

1. Diamond 2. Graphite 3. Fullerenes.

Diamond

Diamond has a three-dimensional network structure.

It is the hardest natural substance known. It is a bad conductor of electricity but is a very good conductor of heat. Because of hardness and high thermal conductivity, diamond tipped tools do not overheat and hence are extensively used for cutting and drilling purposes.

It is a transparent substance with high refractive index. Therefore, it is used for making gemstones and jewellery. Chemically diamond is extremely unreactive.

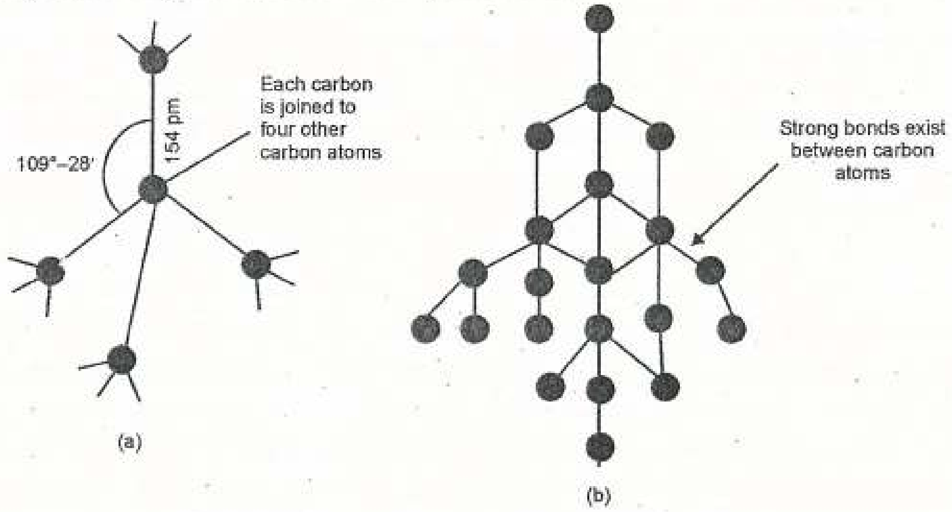


Fig: 9.7 (a) Tetrahedral arrangement of carbon atoms in diamond
(b) Three-dimensional network structure of diamond

Graphite

Graphite has two dimensional sheet like structure consisting of a number of benzene rings fused together.

Graphite is soft and greasy and is used as solid lubricant for heavy machinery operating at high temperatures. It is a good conductor of both heat and electricity. Because of high electrical conductivity graphite is used for making electrodes of battery and arcs.

Graphite is an opaque greyish black substance. It is reactive.

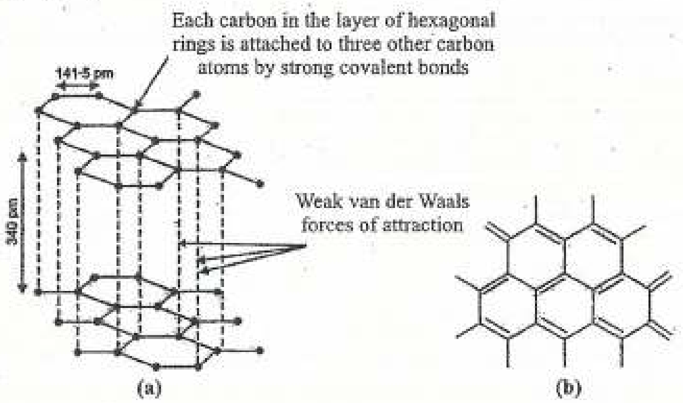
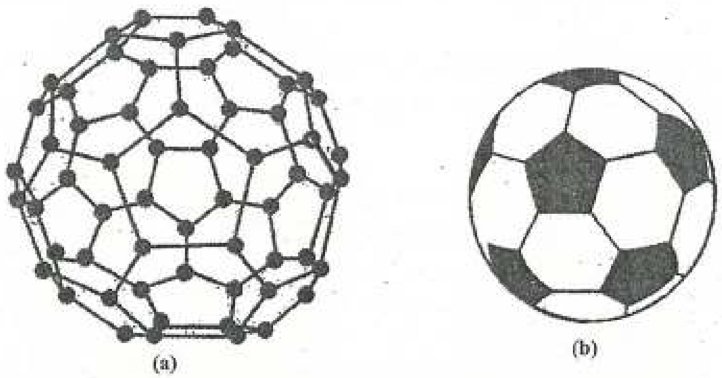


Fig: 9.8 Structure of graphite: (a) Consisting of two-dimensional layers
(b) Each layer consisting of fused benzene rings

Fullerenes

Fullerenes are a new class of carbon allotropes. They are spheroidal in shape and contain even number of carbon atoms ranging from 60–350 or above. The C_{60} fullerene is the most stable and was the first to be identified. It contains 60 carbon atoms which are arranged in the shape of a football or a soccer ball. Therefore it is also called bucky ball.

Further because these allotropes look like geodesic domes designed by the US architect Buck minster Fuller, they are called **Buckminster fullerenes** or simply **fullerenes.**



(a) (b)

Fig: 9.9 (a) Structure of Buckminster fullerenes (C_{60}) **(b) Comparison with a football consisting of five and six membered rings**

Versatile Nature of Carbon

Many of things we use in our day to day life are made up of carbon compounds. Before we start the study of carbon compounds we must understand as to why carbon forms so many compounds. The four main reasons for this are discussed below:

Catenation

'The unique property of self linking of carbon atoms through covalent bonds to form long straight or branched chains and rings of different sizes is called catenation.'

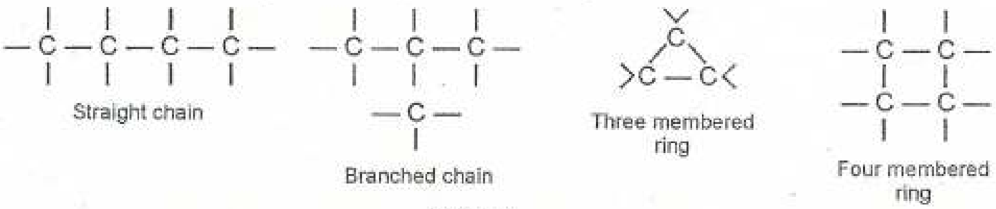


Fig: 9.10

The property of catenation is probably due to (i) small size (ii) unique electronic configuration (iii) great strength of carbon-carbon bonds.

Notes : Both carbon and silicon have similar valence electronic configuration (*i.e.*, have four electrons in the valence shell) but carbon shows catenation to a much greater extent than silicon.

Tetracovalency of carbon

Carbon has a valency of four. Therefore, it is capable of bonding four other atoms of carbon or atoms of some other monovalent elements. Further due to small size, the nucleus of carbon atom can hold its shared pairs of electrons strongly. As a result the bonds that carbon forms with most of the other elements such as hydrogen, oxygen, nitrogen etc., are very strong thereby making these compounds exceptionally stable. This further increases the number of carbon compounds.

Tendency to form multiple bonds

Due to small size, carbon also forms multiple (double and triple) bonds with other carbon atoms, oxygen, sulphur and nitrogen.

Isomerism

Another reason for huge number of carbon compounds is the phenomenon of isomerism. Isomerism is defined as follows:

'If a given molecule formula represents two or more structures having different properties, the phenomenon is called isomerism and the different structures are called isomers'.

Organic Compounds

Compounds are divided into two classes namely, organic and inorganic. Compounds which are associated directly or indirectly from living organism, such as animals and plants, were called organic compounds for example urea, oils fats, dyes etc., On the other hand compounds which were isolated from non living sources, such as rocks and minerals, were called inorganic compounds *e.g.*, common salt, marble, alum etc.

Vital force theory

Berzelius a Swedish chemist in 1815 proposed a vital force theory. According to this theory, 'Organic compounds are produced only under the influence of some mysterious force existing in the living organisms. This mysterious force was called the vital force.'

Wohler's synthesis

In 1828, Friedrich Wohler, a German chemist accidently prepared urea. He prepared urea by a heating an aqueous solution of two inorganic compounds, *i.e.*, ammonium chloride and potassium cynate.

$$\underset{\text{Ammonium chloride}}{NH_4Cl} + \underset{\text{Potassium cynate}}{KNCO} \xrightarrow[\text{Rearrangement}]{\text{Heat}} \underset{\text{Ammonium Cyanate}}{NH_4CNO} + \underset{\text{Potassium cynate}}{KCl}$$

$$\underset{\substack{\text{Ammonium Cyanate}\\ \text{(Inorganic compound)}}}{NH_4CNO} \xrightarrow[\text{Rearragnement}]{\text{Heat}} \underset{\substack{\text{Urea}\\ \text{(Organic compound)}}}{H_2N-\overset{\overset{\displaystyle O}{\|}}{C}-NH_2}$$

This synthesis gave a death blow to vital force theory and clearly demonstrated that **no mysterious force was required in the formation of organic compounds in the laboratory.**

Note: The first organic compound synthesized in the laboratory was urea. It is extensively use as nitrogen fertilizer.

Modern definition of organic compounds: 'Compounds of carbon containing, usually hydrogen and one and more other elements such as a oxygen, nitrogen, sulphur etc. are called **Organic compounds** and the branch which deals with the study of organic compounds is called **organic chemistry.**'

Organic compounds of carbon and hydrogen are called **hydrocarbon.**

Saturated and Unsaturated Carbon Compounds

Compounds of carbon which are linked by only single bonds between the carbon atoms are called **saturated compounds.** For example, ethane, propane, butane etc.

Compounds of carbon having double or triple bonds between their carbon atoms are called **unsaturated compounds.** For example, ethene (ethylene) and ethyne (acetylene) etc.

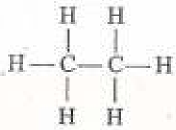
Structure of ethane (C_2H_6)

To derive the structure of ethane, the following steps are followed:

Step 1: Link the two carbon atoms through a single bond:

C — C

Step 2: Three valencies of each carbon atom remain unsatisfied, so each is bonded to three hydrogen atoms :



Note: Such structures in which the bonds between different atoms are shown by dashes are called **compounds structural formulae** or simply **structural formulae.** Ethane may also be written as : CH_3— CH_3 or CH_3CH_3. These are called **condensed structural formulae.**

The electron dot structure of ethane is shown as:

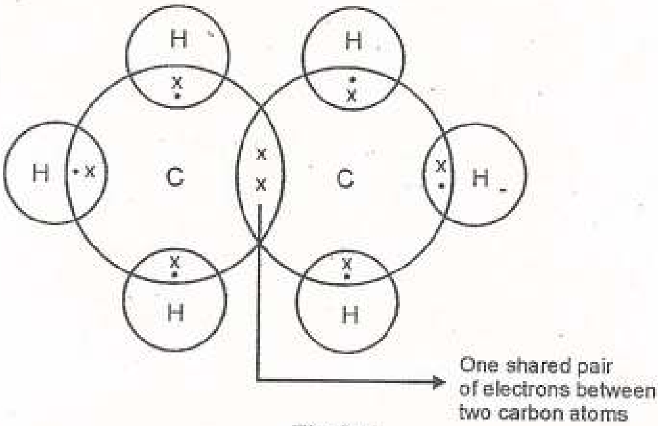


Fig: 9.11

Electron dot structure of propane with molecular formula (C_3H_8)

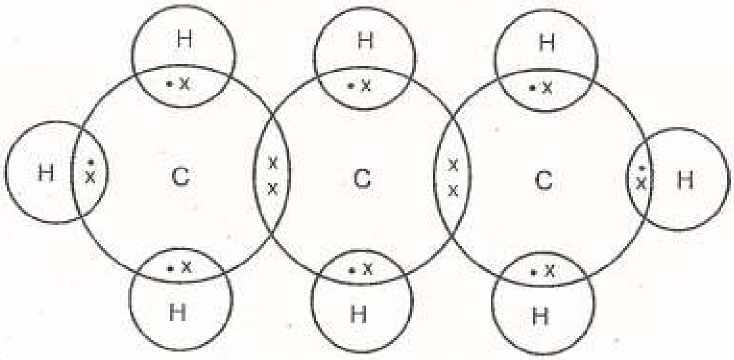


Fig: 9.12

Structure of ethene (C_2H_4)

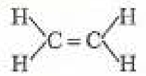
The structure of ethene can be derived by the following steps :

Step 1: Link the two carbon atoms together by a single bond.

$$C - C$$

Step 2 : Since there are total four hydrogens, attach two hydrogen atoms to each cabon:

Step 3: In the above formula, one valency of each carbon is free or unsatisfied. This can be satisfied if there is a double bond between the two carbon atoms. Thus the structural formula of ethene is:



The electrons dot structure of ethene is:

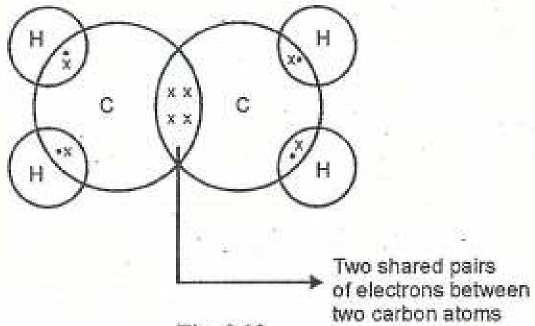


Fig: 9.13

Structure of ethyne (C_2H_2)

It is also called acetylene. Its structure can be derived following the steps:

Step 1: Link two carbon atoms by a single bond :

$$C - C$$

Step 2 : Since there are two hydrogens, attach one hydrogen to each carbon,

$$H - C - C - H$$

Step 3 : To satisfy the remaining two valencies of each carbon, connect the two carbon atoms by a triple bond. Thus, the structural formula of ethyne is:

$$H - C \equiv C - H$$

The electron dot structure of ethyne is:

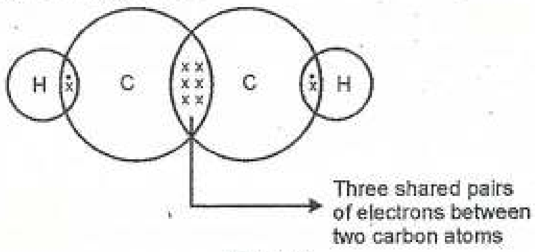
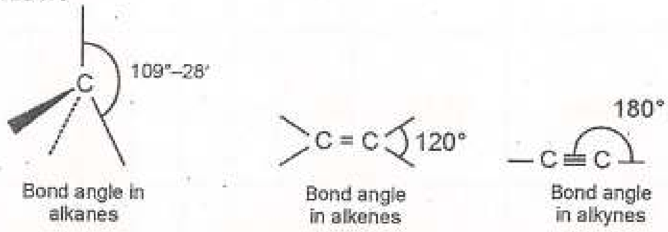


Fig: 9.14

Reactivity of saturated and unsaturated carbon compounds

Unsaturated compounds are more reactive than saturated compounds. This is due to the angle strain as discussed below:



In alkanes, carbon has its usual tetrahedral angle (109° - 28′). That is why they are relatively unreactive, But in alkenes and alkynes bond angles are higher than 109°–28′. In other words, these molecules are under strain and hence more reactive. Therefore, alkenes and alkynes add hydrogen in the presence of catalysts such as palladium or nickel to give saturated compounds *i.e.*, alkanes. For example

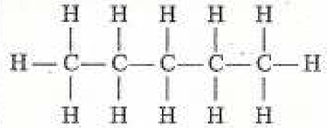
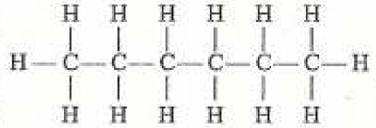
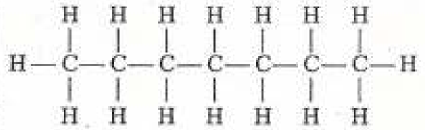
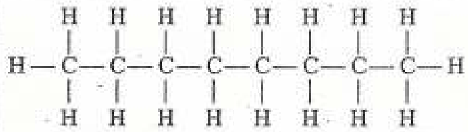
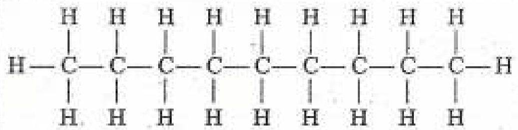
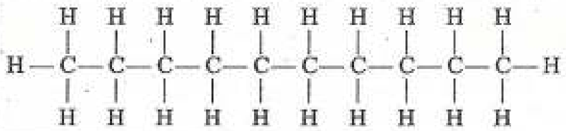
$$\underset{\text{Ethene}}{CH_2=CH_2} + H_2 \xrightarrow[472\text{ k}]{\text{Ni}} \underset{\text{Ethane}}{CH_3-CH_3} \xleftarrow[373\text{ k}]{\text{Ni}} \underset{\text{Ethyne}}{HC\equiv CH} + 2H_2$$

Note: Alkanes have the general formula $\mathbf{C_nH_{2n+2}}$ where n = 1, 2, 3, ... etc. The general formula of alkenes is $\mathbf{C_nH_{2n}}$ and the general formula of alkynes of $\mathbf{C_nH_{2n-2}}$ where n = 2, 3, 4 .... etc.

Chains, Branches and Rings Compounds

(a) Straight chain compounds: There is a restriction on the number of carbon in a chain, therefore we can have chains containing tens or even hundreds of carbon atoms. The names and structure of first of these carbon compounds are given in table below:

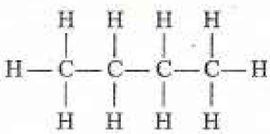
<table>
<tr><th>No. of carbon atoms in the chain</th><th>Name</th><th>Formula</th><th>Structure</th></tr>
<tr><td>1</td><td>Methane</td><td>CH_4</td><td>H
|
H—C—H
|
H</td></tr>
<tr><td>2</td><td>Ethane</td><td>C_2H_6</td><td>H H
| |
H—C—C—H
| |
H H</td></tr>
<tr><td>3</td><td>Propane</td><td>C_3H_8</td><td>H H H
| | |
H—C—C—C—H
| | |
H H H</td></tr>
<tr><td>4</td><td>Butane</td><td>C_4H_{10}</td><td>H H H H
| | | |
H—C—C—C—C—H
| | | |
H H H H</td></tr>
</table>

5	Pentane	C_5H_{12}	
6	Hexane	H_6H_{14}	
7	Heptane	C_7H_6	
8	Octane	C_8H_{18}	
9	Nonane	C_9H_{20}	
10	Decane	$C_{10}H_{22}$	

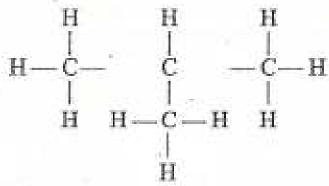
(b) Branched chain compounds: Butane has four carbon atoms. We can arrange these four carbon two difference ways. The two possible carbon chains or skeletons are shown as:

(a) **Straight** (b) **Branched chain**

Satisfying the remaining valencies of each carbon with hydrogen atoms, we get the following two structures having the same molecular formula C_4H_{10}



(a) **Butane**



(b) Isobutane

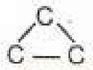
Thus, '**Compounds having the same molecular formula but different structures are called structural isomers and the phenomenon is called structural isomerism.**'

Further since the isomers, butane and isobutane, have different arrangement of the carbon, they are also called **chain isomers.**

(c) **Cyclic compounds:** Compounds of carbon in which carbon atoms are arranged in a ring are called cyclic compounds. Cyclic compounds are also of the following types:

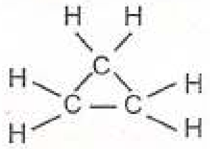
(i) **Saturated cyclic compounds:** Saturated cyclic compounds of carbon are called **cycloalkanes.** Their general formula is C_nH_{2n} where n = 3, 4, 5, 6 .... etc. cycloalkanes can also be represented by polygon formulae in which each corner represents a CH_2 group while each line represents a carbon-carbon single bond. For example

C_3H_6 : → Cyclopropane



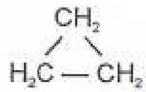
Cyclopropane
(Carbon skeleton)

or



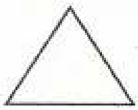
Cyclopropane
(Structural formula)

or



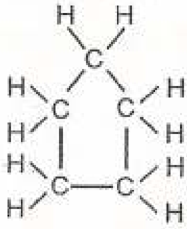
(Condensed formula)

or



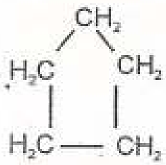
(Polygon formula)

C5C10 : → Cyclopentane



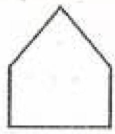
(Structural formula)

or



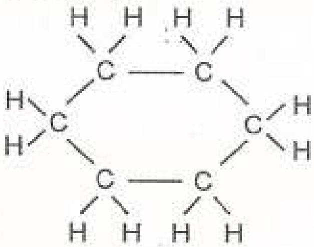
(Condensed formula)

or



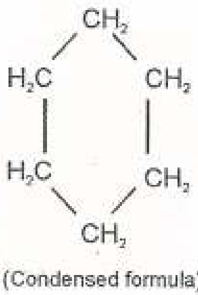
(Polygon formula)

C6H12 : →Cyclo hexane



(Structural formula)

or



(Condensed formula)

or

(Polygon formula)

Note: All the cycloaloanes are collectively called as alicyclic compounds because they behave like alkanes but possess cyclic structures.

(ii) **Unsaturated cyclic compounds:** Benzene is an unsaturated cyclic carbon compound. Its molecular formula is C_6H_6. It has three alternate single and double bonds between carbon atoms. Its structure was proposed by **August Kekule.** Both *(a)* and *(b)* represents Kekule's structures which differ only in the position of double bonds.

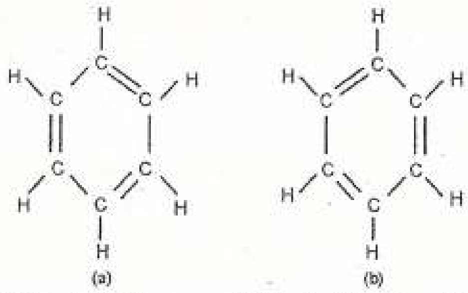
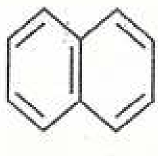


Fig: 9.15 (*a*) and (*b*) Represents Kekule: Sturcture of benzene



(Naphthalene)

Fig: 9.16

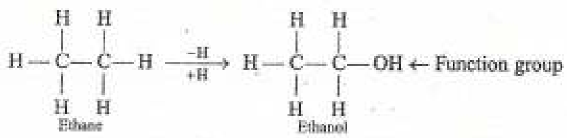
Note: Compounds which contain one or more isolated or fused benzenerings are called **aromatic compounds.** The parent member of aromatic compounds is benzene. Another common aromatic compound is naphthelene which is used in the form of balls to protect warm clothes from moth and insects.

Functional Groups

Carbon is a very friendly element because it also forms bonds with other elements. These elements may replace one or more hydrogens of a hydrocarbon chain in such a way that the valency of carbon remains satisfied. As a result of this replacement, new compounds are formed. In these new compounds, the element replacing hydrogens of the parent hydrocarbon chain is referered to as a hetero atoms. These hetero atoms, give specific chemical properties to the new compounds regardless of the nature and length of the carbon chain and hence are called functional groups.

Thus, **'A functional group may be defined as an atom or a group of atoms present in a molecule which largely determines its chemical properties'.**

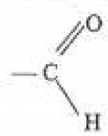
For example: Ethane (C_2H_6) and ethanol or ethyl alcohol (C_2H_5OH)



Both ethane and ethanol have different physical and chemical properties. Properties of ethanol depend upon the hydroxyl group.

Thus, hydroxyl (–OH) group is the functional group of ethanol.

Some common functional groups in carbon compounds

Hetero atom	Formula of the functional group	Name of the functional group
Cl	—Cl	Chloro
Br	—Br	Bromo
O	—OH	Hydroxyl
		Aldehydic

	$-\underset{\underset{O}{\|}}{C}-$	Ketonic
	$-\underset{\|}{C}-OH$	Carboxyl

Note: Functional groups which are always present at the end of a carbon chain are called **terminal functional groups.** For example, $-\overset{\overset{O}{\|}}{C}-H$ (aldehyde) and $-\overset{\overset{O}{\|}}{C}-OH$ (carboxyl) group. Functional groups which are always present in between the carbon chain are called **non-terminal functional groups.**

For example $>C=O$ (ketogroup)

$$\overset{4}{C}H_3-\overset{3}{C}H_2-\overset{2}{C}H=\overset{1}{C}H_2$$
1–Butene
(Terminal alkene)

$$\overset{1}{C}H_3-\overset{2}{C}H=\overset{3}{C}H-\overset{4}{C}H_3$$
2–Butene
(Non–terminal alkene)

$$\overset{4}{C}H_3-\overset{3}{C}H_2-\overset{2}{C}H\equiv\overset{1}{C}H$$
1–Butyne
(Terminal alkyne)

$$\underset{\text{Copper}}{Cu\,(s)}+\underset{\substack{\text{Silver nitrate}\\ \text{(Colourless)}}}{Ag\,NO_3\,(aq)}\longrightarrow\underset{\substack{\text{Coppernitrate}\\ \text{(Blue)}}}{Cu\,(NO)_2\,(aq)}+\underset{\text{Silver}}{2\,Ag\,(s)}$$

Homologus Series and its Characteristics

"A homologus series may be defined as a family of organic compounds having the same functional group, similar chemical properties and the successive (adjacent) members of which differ by a CH_2 unit or 14 mass units.'

The individual members of a homologus series are called **homologues** and the phenomenon is called **homology.**

Characteristics of Homologus Series

1. The molecular formulae of any two successive (adjacent) of a homologus series is differ by CH_2 unit. For example,

   CH_4 and C_2H_6 – the first and the second member differ by a CH_2 unit

   C_2H_6 and C_3H_8 – the second and the third member differ by a CH_2 unit

   C_3H_8 and C_4H_{10} – the third and the fourth member differ by a CH_2 unit

   In similar way, we can explain that any other two successive members of homologus series of alkanes differ by a CH_2 unit.
2. The molecular masses of any two successive members of a homologus series differ by 14 u.
3. All the members of a given homologus series have the same functional group.
4. All the members of a homologus series have similar chemical properties.
5. The members of a homologus series show a gradation in physical properties as the molecular mass increases. For example, the melting points and boiling points increases with increasing molecular mass. Other physical properties like solubility in a particular solvent also show a similar gradation.

Nomenclature of Carbon Compounds

International Union of Pure and Applied Chemistry (IUPAC) have given certain rules to systematize of the nomenclature of organic compounds. IUPAC name of any organic compound can be derived by using the following rules :

1. Identify the number of carbon atoms in the compound.

   A compound containing one carbon atom will be named after **methane.**

   A compound containing two carbon atoms will be named after **ethane.**

2. The functional group present in the organic compound is indicated either by a prefix or by a suffix.

   A prefix is a word which is added before the name of the compound and a suffix is a word which is added after the name of the compound.

The prefixes and suffixes of the common functional groups are:

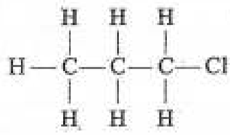
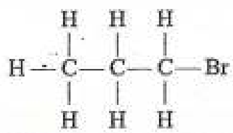
Functional group	Prefix	Suffix
1. Chlorine	Chloro	–
2. Bromine	Bromo	–
3. Alcohol	–	ol
4. Aldehyde	–	al
5. Ketone	–	one
6. Carboxylic acid	–	oic acid
7. Double bond (alkenes)	–	ene
8. Triple bond (alkynes)	–	yne

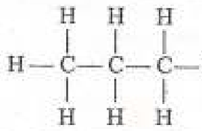
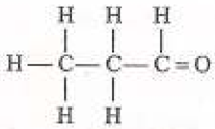
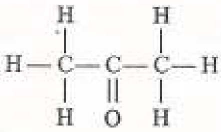
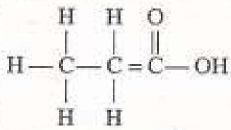
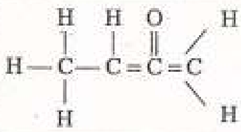
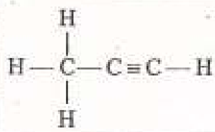
3. If a suffix is to be added, the final 'e' from the name of the carbon chain is deleted. For example, a three carbon chain with a ketone group would be named in the following manner:

   Propane – 'e' = Propan + 'one' = propanone

4. If the carbon chain is unsaturated, the final 'ane' from the name of the carbon chain is replaced by either ene if the carbon chain contains one double bond or by yne if the carbon chain contains a triple bond.

Nomenclature of functional groups:

Functional group	Prefix/Suffix	Example
1. Halogen	Prefix-chloro bromo etc,	 Chloropropane  Bromopropane

2. Alcohol	Suffix-ol	 Propanol
3. Aldehyde	Suffix-al	 Propanal
4. Ketone	Suffix-one	 Propan one
5. Carboxylic acid	Suffix-oic acid	 Propanoic acid
6. Doubl bond (calkenes)	Suffix-ene	 Propene
7. Triple bond (alkynes)	Suffix-yne	 Propyne

Chemical Properties of Carbon Compounds

(i) **Combustion:** Combustion means heating a substance strongly in presence of excess of oxygen or air. During combustion, all the allotropic form of carbon are oxidised to form carbon dioxide with release of large amount of heat and light.

In a similar way, during combustion, carbon of the organic compounds is oxidised to carbon dioxide and hydrogen to water with release of a large amount of heat and light. **Therefore combustion may be regarded as an oxidation reaction.**

(i) $\underset{\text{Carbon}}{C} + \underset{\text{Oxygen}}{O_2} \longrightarrow \underset{\text{Carbondioxide}}{CO_2}$ heat and light

(ii) $\underset{\text{Methane}}{CH_4} + 2O_2 \longrightarrow CO_2 + 2H_2O$ + heat + light

(iii) $\underset{\substack{\text{Copper Sulphide}\\ \text{(Black ppt.)}}}{CuS\downarrow} + \underset{\text{Sulphuric acid}}{H_2SO_{4(aq)}} + 3O_2 \longrightarrow 2\,CO_2 + 2H_2O$ + heat + light

(iv) $\underset{\text{Ethyne}}{HC \equiv CH} + \frac{5}{2}O_2 \longrightarrow 2\,CO_2 + H_2O$ + heat + light

(v) $CH_3CH_2OH + 3O_2 \longrightarrow 2\,CO_2 + 3\,H_2O$ + heat + light

Saturated hydrocarbons will generally burn with a yellow flame but unsaturated hydrocarbons burn with a yellow flame with lots of black smoke. This yellow flame results in a sooty deposit on the metal plate. This **sooty deposit is actually unburnt carbon which is produced due to incomplete combustion. The reason being that the carbon content of unsaturated compounds is more than the hydrogen content and hence carbon is not completely burnt and the unburnt carbon deposit as a root.**

The gas/kerosene stove used at home have holes for air so that sufficient amount of oxygen is available for complete combustion of fuel to produce a blue flame. Sometimes bottom of cooking vessels getting blackened, it means air holes are blocked and the fuel is getting wasted.

Fuel like coal and petroleum also contain some amounts of nitrogen and sulphur containing compounds. Their combustion results in the formation of oxides of nitrogen (*i.e.*, nitrogen dioxide, nitric oxide etc.) and sulphur (*i.e.*, sulphur dioxide, sulphur trioxide etc.,) which are the major *pollutants* in the environment.

Why do substances burn with or without a flame?

When coal or wood is ignited, it burns with a flame in the beginning. Similarly, a candle or the LPG in the gas stove always burns with a flame. However, you must have observed that the wood or charcoal in an **angithi** just glows red and gives lot of heat without producing a flame **The reason being that a flame is produced only when gaseous substances burn.** When wood or charcoal is ignited, the volatile substances present (in wood or charcoal), vapourise and burn with a flame in the beginning.

A luminous flame is produced when the atoms of a gaseous substances are heated and begin to glow. **The colour produced by each element is a characteristic property of that element.** For example, a greenish blue flame is produced when a copper wire is heated in the flame of a gas stove.

Origin of coal and petroleum: Coal and Petroleum have been formed from biomass. **Coal is the remains of trees, ferns, and other plants that lived millions of years ago.** As a result of earthquakes or volcanic eruptions, these got buried under the surface of the earth. Under the influence of moisture, high temperature and pressure of the layers of earth and rocks, the plants slowly decayed to form coal.

On the other hand **Petroleum and natural gas are the remains of tiny plants and animals that lived in the sea.**

Fossils are the remains of former living things (plants, animals) preserved under the rocks, therefore, coal and petroleum are called **fossil fules.**

(ii) Oxidation: "Addition of oxygen to any substances is called **oxidation** and the substances which are capable of adding oxygen to other substances are called **oxidising agents.**"

Alkaline potassium permanganate and acidified potassium dichromate are good oxidising agents. These can easily oxidise alcohols to carboxylic acids. For example,

$$\underset{\text{Potassium permagnate}}{2\,kMnO_4} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Potassium hydroxide}}{2\,KOH} + \underset{\text{Maganese dioxide}}{2\,MnO_2} + 3[O]$$

$$\underset{\text{Potassium deichromate}}{K_2Cr_2O_7} + \underset{\text{Sulphuric acid}}{4\,H_2SO_4} \longrightarrow \underset{\text{Potassium sulphate}}{K_2SO_4} + \underset{\text{Chromium sulphate}}{Cr_2(SO_4)_3} + 4\,H_2O + 3[O]$$

(iii) Additional Reaction: Due to the presence of double and triple bonds, unsaturated hydrocarbons add hydrogen in presence of a catalyst such as nickel, platinum or palladium to form saturated hydrocarbons. This process is called **catalytic hydrogenation. For example**

$$\underset{\text{Ethene}}{CH_2=CH_2} + H_2 \xrightarrow{\text{Ni, 473 K}} \underset{\text{Ethane}}{CH_3-CH_3}$$

$$CH\equiv CH + 2H_2 \xrightarrow{\text{Ni, 473 K}} \underset{\text{Ethane}}{CH_3-CH_3}$$

Catalysts are substances which can change or usually increase the speed of a chemical reaction without being used up in that reaction.

This additional reaction is commonly used in hydrogenation of vegetable oils in presence of nickel as catalyst to form fats. **Vegetable oils generally have long unsaturated carbon chains while animal fats have saturated carbon chains.**

$$\underset{\text{(liquid)}}{\text{Vegetable oil} + H_2} \xrightarrow{\text{Ni, 473 K}} \underset{\text{(solid)}}{\text{Vanaspati ghee}}$$

Notes:

1. When vegetable oils are exposed to hot and humid weather for a long time they turn rancid *i.e.*, they develop unpleasent smell and taste due to formation of carboxylic acids and aldehydes. Hydrogenation reduces the number of such unsaturated carbon chains and hence slows down the development of rancidity.
2. Saturated carbon chains present in saturated fats increase the level of the bad cholesterol in blood. On the other hand, animal fats like 'ghee' and 'butter' contain saturated fatty acids which are said to be bad for health. Therefore, oils containing unsaturated fatty acids should be used for cooking.

(iv) Substitution Reaction: Due to the presence of strong (C—C) and (C—H) single bonds saturated hydrocarbons (*i.e.*, alkanes) are quite unreactive and are inert to the action of most of the reagents. Thus alkanes are also called **paraffins.**

However in presence of heat or light, chlorine reacts very rapidly with alkanes to form substitution products. For example:

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Chlorine}}{Cl_2} \longrightarrow \underset{\substack{\text{Chloromethane} \\ \text{(Substitution product)}}}{CH_3Cl} + HCl$$

However with excess of chlorine all the hydrogen atoms of methane are replaced one by one to form a number of products as shown below :

$$\underset{\text{(Chloromethane)}}{CH_3Cl} + Cl_2 \xrightarrow[\text{or 520–670 K}]{\text{Sunlight}} \underset{\substack{\text{(Dichloromethane)} \\ \text{(Methylene chloride)}}}{CH_2Cl_2} + HCl$$

$$CH_2Cl_2 + Cl_2 \xrightarrow[\text{or 520–670 K}]{\text{Sunlight}} \underset{\text{(Chloroform)}}{CHCl_3} + HCl$$

$$\underset{\text{(Trichloromethane)}}{CHCl_3} + Cl_2 \xrightarrow[\text{or 520–670 K}]{\text{Sunlight}} \underset{\text{(Carbon tetrachloride)}}{CCl_4} + HCl$$

However, with higher homologues of alkanes, a number of products containing even one chlorine atom are formed. For example,

$$\underset{\text{Propane}}{CH_3-CH_2-CH_3} + Cl_2 \xrightarrow[\text{or 520–670 K}]{\text{Sunlight}} \underset{\text{1-Chloropropane}}{\overset{3}{C}H_3-\overset{2}{C}H_2-\overset{1}{C}H_2-Cl} + \underset{\text{2-Chloropropane}}{\overset{3}{C}H_3-\overset{2}{C}H(Cl)-\overset{1}{C}H_3}$$

Ethanol (C_2H_5OH) and its Properties and Uses

The most commonly used alcohol is ethanol. It is the second member of the homologous series of alcohols. Some important physical properties of ethanol are described below:

Physical properties

1. Ethanol is colourless liquid at room temperature. Its freezing points is 156 K while its boiling point is 251 K.
2. It has a distinct smell and burning taste.

3. It is soluble in water in all proportions.
4. It is an active ingredient of all alcoholic drinks such as bear, rum, whisky, brandy etc. Consumption of small quantities of dilute ethanol causes **drunkenness.** However intake of even a small quantity of pure alcohol can be lethal.

Note: Unlike ethanol, intake of methanol in very small quantities can cause death. Methanol also affects the optic nerve, causing blindness.

Chemical properties of ethanol:

1. **Reaction with sodium:** Ethanol reacts with sodium in the cold to form sodium ethaoxide with evolution of hydrogen gas.

$$2H_3CH_2OH + 2\,Na \xrightarrow{\text{Cold}} \underset{\text{Sodium ethoxide}}{2H_3CH_2ONa} + H_2$$

Hydrogen is a combustible gas. When a burning matchstick is brought near the mouth of the test tube. It burns with a **'pop'** sound which a characteristic property of hydrogen gas.

2. **Reaction with concentrated sulphuric acid:** When ethanol is heated with excess of concentrated sulphuric acid at 443 K an unsaturated hydrocarbon ethane is produced.

$$\underset{\text{Ethanol}}{CH_3-CH_2OH} \xrightarrow[443\text{ K}]{\text{Conc } H_2SO_4} \underset{\text{Ethane}}{\overset{H}{\underset{H}{}}\rangle C = C\langle\overset{H}{\underset{H}{}}} + \underset{\text{Water}}{H_2O}$$

Note: This reaction is called dehydration because it involves the removal of a molecule of water from ethanol and concentrated sulphuric acid which removes water from ethanol is called the dehydrating agent.

Uses of ethanol

1. Ethanol in form of rectified spirit (95% alcohol + 5% water) is used as an **antiseptic for wounds.**
2. It is also used for sterilising skin before giving an injection.
3. Alcohol is used as preservative for specimens.
4. Alcohol gels have become common as hand sanitizers.
5. Ethanol is used as a fuel in internal combustion engines in form of power alcohol.
6. It is used in alcoholic beverages *i.e.*, bear, rum etc.
7. It is used in preparation of dyes, cosmetics and transparent soaps.
8. It cold countries, ethanol is used as an antifreeze in the radiators of automobiles.

Ethanoic Acid (CH_3COOH) and its Chemical Properties

The common name of ethanoic acid is **acetic acid.** A 5–8% solution of acetic acid in water is called **vinegar** and used widely as a preservative for sausaces, pickles etc.

Some important physical properties are:

1. Ethanoic acid is a colourless, pungent smelling liquid
2. When pure ethanoic acid is cooled, it freezes (mp 290 K) forming glacier like crystals. Therefore, 100% acetic acid, obtained by melting their crystals,, is called **glacial acetic acid.** It boils at 391K.
3. Ethanoic acid is miscible with water in all proportions.

Chemical Properties of Ethanoic Acid

The group of organic compounds called carboxylic acids are obviously characterised by a special acidity. However unlike mineral acids like HCl, which are completely ionised, carboxylic acids are weak acids.

Reaction with active metals

$$\underset{}{2\,CH_3COOH} + \underset{\text{Sodium}}{2\,Na} \longrightarrow \underset{\text{Sodium ethanoate}}{2\,CH_3COONa} + H_2$$

$$2\,CH_3COOH + \underset{\text{Calcium}}{Ca} \longrightarrow$$

Reaction with alkalis or bases

$$CH_3COOH + \underset{\substack{\text{Sodium hydroxide}\\ \text{(base)}}}{NaOH} \longrightarrow \underset{\substack{\text{Sodium ethanoate}\\ \text{or Sodium acetate}\\ \text{(Salt)}}}{CH_3COONa} + \underset{\text{Water}}{H_2O}$$

Reaction with sodium carbonate and sodium hydrogen carbonate

$$2\,CH_3COOH + \underset{\text{Sodium carbonate}}{Na_2CO_3} \longrightarrow 2CH_3COONa + \underset{\text{Carbon dioxide}}{CO_2} + H_2O$$

$$CH_3COOH + \underset{\text{Sodium hydrogen carbonate}}{NaHCO_3} \longrightarrow CH_3COONa + CO_2 + H_2O$$

The carbon dioxide gas thus evolved can be easily identified by passing it from lime water which turns milky due to the formation of insoluble calcium carbonate. Thus,

$$\underset{\text{Lime water}}{Ca\,(OH)_2} + CO_2 \longrightarrow \underset{\substack{\text{Calcium carbonate}\\ \text{(Milkiness)}}}{CaCO_3} + H_2O$$

Thus, when sodium hydrogen carbonate is added to an aqueous solution of ethanoic acid, a brisk effervescence due to the evolution of CO_2 is produced. **This reaction is used as a test of carboxylic acids.**

Esterification

Carboxylic acids react with alcohols to form esters.

$$\underset{\text{Ethanoic}}{CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-OH} + \underset{\text{Ethanol}}{H-OCH_2CH_3} \xrightarrow[\text{Heat}]{\text{Conc. }H_2SO_4} \underset{\substack{\text{Ethyl ethanoate}\\ \text{(An ester)}}}{CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-OCH_2CH_3} + H_2O$$

The reaction between a carboxylic acid and an alcohol to form an ester is called the **esterfication recation.**

Saponification

Easter are sweet smelling substances. These are used in making perfumes and as flavouring agents. On treating with sodium hydroxide, which is an alkali, the ester is converted back to alcohol and sodium salt of carboxylic acid. This reaction is known as saponification because it is used in the preparation of soap.

$$\underset{\text{Ethyl ehanoate}}{CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-OCH_3CH_3} + \underset{\substack{\text{Sodium}\\ \text{hydroxide}}}{NaOH} \xrightarrow{\text{Heat}} \underset{\text{Sodium ethanoate}}{CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-ONa} + \underset{\text{Ethanol}}{CH_3CH_2OH}$$

Soaps and Detergents

"Sodium and potassium salts of higher fatty acids such as palmitic acid ($C_{15}H_{31}COOH$), stearic acid ($C_{17}H_{35}COOH$) and oleic acid ($C_{17}H_{33}COOH$) etc. are called soaps while detergents are ammonium or Sulphonate or sulphate salts of long chain hydrocarbons contains 12–18 carbon atoms."

For example:

- COO^-Na^+ Soap molecule
- $Na^+ (CH_3)_3Cl^-$ Detergent molecule
- $SO_3^- Na^+$ Detergent molecule
- $OSO_3^- Na^+$ Detergent molecule

Synthetic detergent are also called soapless soaps because they have cleansing action like that soaps but chemically they are not soaps *i.e.*, sodium salts of higher fatty acids.

Notes:

(i) Water that produce lather (foam) with soap readily is called soft water for example, rain water, distilled water, demineralised water etc.

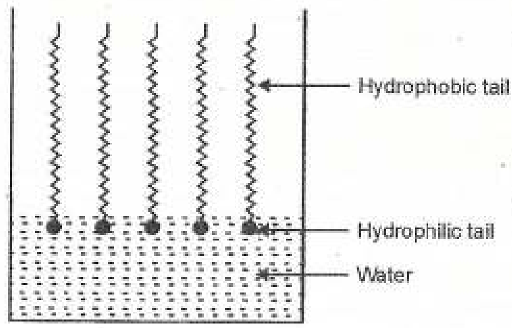
(ii) Water that does not produce lather (foam) with soap readily is called hard water for example sea water, tube well water, hand pump water etc.,

(iii) The hardness of water is due to the presence of bicarbonates, chlorides and sulphates of calcium and magnesium.

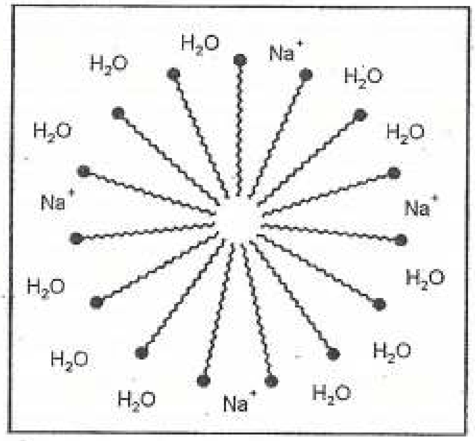
(iv) Soaps cannot be used in hard water even detergents can't be used in hard water.

The cleansing action of soaps and detergent is due to the reason that they consist of two parts–the long hydrocarbon tails which dissolve in oily dirt or grease **(hydrophobic)** and the negatively charged heads which dissolve in water **(hydrophilic)**. When a dirty cloth is treated with soap or detergent solution. The **soap or detergent ionic micelles** is formed with dirt laying at their centres. This lowers the surface tension of water and the oily dirt or grease is easily removed from the surface of clothes. Since detergents lower the surface tension of water to a greater extent than soaps, therefore, the **cleaning power of detergents is much higher than those of soaps.**

Key Note: Soaps are 100% biodegradable and hence do not cause water pollution in lakes, rivers and other water bodies. In contrast, detergents are non biodegradable and cause water pollution.



(a) Soap molecules at the surface of water



(b) Micelle formed by soap molecules in water

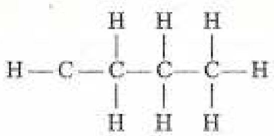
Fig: 9.17

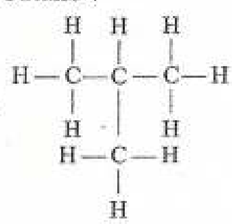
Key Points

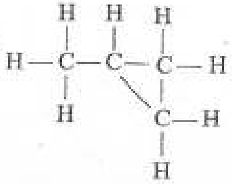
- ✓ Carbon is a versatile element that forms the basis for all living organism and many of the thing we use.
- ✓ This large variety of compounds is formed by carbon because of its tetravelency and the property of catenation that it exhibits.
- ✓ Carbon forms covalent bonds with itself and other elements such or hydrogen, oxygen, sulphur, nitrogen, and chlorine.
- ✓ Covalent bonds are formed by the sharing of electrons between two atoms so that both can achieve a completely filled outermost shell.
- ✓ Carbon also forms compounds containing double and triple bonds between carbon atoms.
- ✓ The ability of carbon to form chains gives rise to a homologous series of compounds.
- ✓ A functional group is an atom or a group of atoms present in a molecule which determines its properties.
- ✓ Saturated hydrocarbons burn with a blue flame while unsaturated hydrocarbons burn with a yellow flame with lots of black smoke.
- ✓ Ethanol and ethanoic acid are carbon compounds of importance in our daily lives.
- ✓ The action of soaps and detergents is based on the presence of both hydrophobic and hydrophilic groups in the molecule and this helps to emulsify the oily dirt and hence its removal.

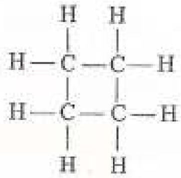
Multiple Choice Questions

1. A covalent bond is formed by
   (a) One sided sharing of electrons
   (b) Mutual sharing of electrons
   (c) Complete transfer of electrons
   (d) Any of the three above
2. Carbon exists in the atmosphere in the form of
   (a) Carbon monoxide
   (b) Carbon dioxide
   (c) Carbon monoxide in traces and carbon dioxide
   (d) Coal
3. Characteristics given in of the following statements are usually correct for carbon compounds ? These
   (i) Are good conductors of electricity
   (ii) Are poor conductors of electricity
   (iii) Have strong forces of attraction between their molecules
   (iv) Do not have strong force of attraction between their molecules
   (a) (i) and (ii)
   (b) (iii) and (iv)
   (c) (ii) and (iv)
   (d) (i) and (iv)
4. The general formula for alkyne is:
   (a) C_nH_{2n+1}
   (b) C_nH_{2n-1}
   (c) C_nH_{2n}
   (d) C_nH_{2n+2}
5. Carbon forms a large member of organic compounds due to
   (a) Catenation
   (b) Tendency to form multiple bonds
   (c) Phenomenon of isomerism
   (d) All the three above
6. Which of the following is not a saturated hydrocarbon
   (a) Cyclohexane
   (b) Butane
   (c) Isobutane
   (d) Benzene
7. Ethane, with molecular formula C_2H_6 has
   (a) 4 covalent bonds
   (b) 5 covalent bonds
   (c) 6 covalent bonds
   (d) 7 covalent bonds
8. Which one of the following is a denatured alcohol ?
   (a) Ethanol
   (b) Methanol
   (c) Propanol
   (d) Butanol
9. Which of the following are correct structural isomers of butane ?

(i) 

(ii) 

(iii) 

(iv) 

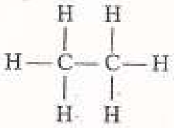
(a) (i) and (ii)

(b) (ii) and (iii)

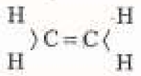
(c) (i) and (iii)

(d) (ii) and (iv)

10. Structural formula of alkene is

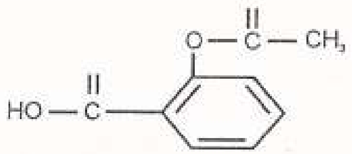
(a) 

(b) $\underset{\text{Potassium Chloride}}{2\,KCl\,(aq)} + \underset{\text{Iodine}}{I_2(s)}$

(c) 

(d) All of these

11. Functional groups present in aspirin



(a) Ester and aldehyde

(b) Ester and carboxylic acid

(c) Easter and ketone

(d) Carboxylic acid and ether

12. Which one of the following is a functional group of alcohol ?

(a) R — OH

(b) R — COOH

(c) R — CO — R

(d) R — CHO

13. The reaction $2C_2H_5OH + 2\,Na \longrightarrow 2C_2H_5ONa + H_2$ suggests that ethanol is

(a) Acidic in nature

(b) Amphoteric

(c) Neutral

(d) Basic in nature

14. $CH_3-CH_2-OH \xrightarrow[\text{Heat}]{\text{Alkaline kMnO}_4} CH_3-COOH$

In the above reaction, alkaline $kMnO_4$ acts as

(a) Catalyst

(b) Reducing agent

(c) Oxidising agent

(d) Dehydrating agent

15. Buckminster fullerene is an allotropic form of

(a) Phosphorus

(b) Sulphur

(c) Carbon

(d) Tin

16. Which of the following is the correct representation of electron dot structures of nitrogen ?

(a) $:\dot{N}::\dot{N}:$

(b) $:N::N:$

(c) $:\ddot{N}:\ddot{N}:$

(d) $:\ddot{N}\vdots N:$

17. Which of the following represents an esterfication reaction ?

(a) $CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$

(b) $CH_3COOC_2H_5 + NaOH \xrightarrow{Heat} CH_3COONa + C_2H_5OH$

(c) $CH_3COONa + NaOH \xrightarrow{CaO633\,K} CH_4 + Na_2\,CO3$

(d) $CH_3COOH + C_2H_5OH \xrightarrow{Conc.\,H_2SO_4} CH_3\,COOC_2\,H_5 + H_2O$

18. Which of the following substances is added to denature ethanol ?

(a) Methanol
(b) Copper sulphate
(c) Pyridine
(d) All the three above

19. Oils on treating with hydrogen in the presence of palladium or nickel catalyst from fats. This is an example of

(a) Oxidation reaction
(b) Displacement reaction
(c) Addition reaction
(d) Substitution reaction

20. A molecule of ammonia (NH_3) has

(a) Only single bond
(b) Only double bonds
(c) Only triple bonds
(d) Two double bonds and one single bond

21. The first member of alkyne homologus series is

(a) Ethyne
(b) Ethene
(c) methane
(d) ethane

22. Carbon forms four covalent bonds by sharing its four valence electrons with four univalent atoms, *e.g.*, hydrogen. After the formation of four bonds, carbon attains the electronic configuration of

(a) Helium
(b)Neon
(c) Krypton
(d) Argon

23. Match the reactions given in column (A) with the names given in column (B).

Column (A)	Column (B)
(A) $CH_3OH + CH_3COOH \xrightarrow{H^+} CH_3COOCH_3 + H_2O$	(i) Addition reaction
(B) $CH_2 = CH_2 + H_2 \xrightarrow{Ni} CH_3 - CH_3$	(ii) Substitution reaction
(C) $CH_4 + Cl_2 \xrightarrow{Sunlight} CH_3Cl + HCl$	(iii) Neutralisation reaction
(D) $CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$	(iv) Esterification reaction

(a) a – (ii), b – (i), c – (iv), d – (iii)
(b) a – (v), b – (i), c – (ii), d – (iii)
(c) a – (iii), b – (ii), c – (i), d – (ii)
(d) a – (iv), b – (iii), c – (iv), d – (i)

24. Which of the following set of compounds have the same molecular formula ?

(a) Butane and isobutane
(b) Cyclohexane and 1-hexen
(c) Both of these
(d) None of these

25. While cooking if the bottom of the vessel is getting blackened on the outside. It means that

(a) The food is not cooked completely
(b) The fuel is wet
(c) The fuel is burning completely
(d) The fuel is not burning completely

26. Which of the following substance cannot be used to distinguish ethanol from ethanoic acid ?
   (a) $NaHCO_3$
   (b) Hot alkaline $KMnO_4$ solution
   (c) Na metal
   (d) Hot acidified $K_2Cr_2O_7$ solution

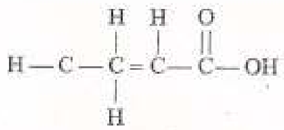
27. Vinegar is solution of
   (a) 50%–60% acetic acid and in water
   (b) 50%–60% acetic acid in alcohol
   (c) 5%–8% acetic acid in water
   (d) 5%–8% acetic acid in alcohol

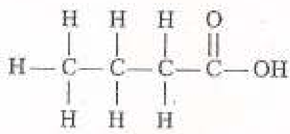
28. Rubbing alcohol is
   (a) CH_3OH
   (b) C_2H_5OH
   (c) C_3H_7OH
   (d) $C_5H_{11}OH$

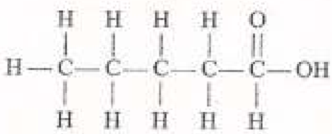
29. The correct electron dot structure of a water molecule is
   (a) $H\cdot\underset{..}{\ddot{O}}\cdot H$
   (b) $H:\underset{..}{\ddot{O}}\cdot H$
   (c) $H:\underset{..}{\ddot{O}}:H$
   (d) $H:\underset{..}{\ddot{O}}:H$

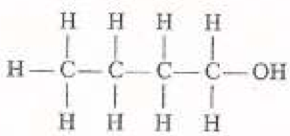
30. The soap molecule has a
   (a) Hydrophilic head and a hydrophilic tail
   (b) Hydrophilic head and a hydrophobic tail
   (c) Hydrophobic head and a hydrophobic tail
   (d) Hydrophobic head and a hydrophilic tail

31. The correct structural formula of butanoic acid is

(a) 

(b) 

(c) 

(d) 

32. Wood alcohol is
   (a) CH_3OH
   (b) C_3H_7OH
   (c) C_2H_5OH
   (d) CH_3COCH_3

33. The hetero atoms present in
   $CH_3—CH_2—O—CH_2—CH_2Cl$ are
   (i) Oxygen
   (ii) Chlorine
   (iii) Carbon
   (iv) Hydrogen
   (a) (i) and (ii)
   (b) (i) and (iii)
   (c) (ii) and (iv)
   (d) (i) and (iv)

34. In the soap micelles
    (a) The ionic end of soap is on the surface of the cluster while the carbon chain is in the interior of the cluster.
    (b) The ionic end of soap is in the interior of the cluster.
    (c) Both ionic end and carbon chain are the exterior of the cluster.
    (d) Both ionic end and carbon chain are in the interior of the cluster.
35. Ethanol reacts with sodium and forms two products. These are
    (a) Sodium ethoxide and oxygen.
    (b) Sodium ethoxide and hydrogen.
    (c) Sodium ethanoate and oxygen.
    (d) Sodium ethanoate and hydrogen.

Answer Key

1. (b)	2. (b)	3. (c)	4. (b)	5. (d)	6. (d)	7. (d)	8. (a)	9. (a)	10. (c)
11. (b)	12. (a)	13. (a)	14. (c)	15. (c)	16. (b)	17. (d)	18. (d)	19. (c)	20. (d)
21. (a)	22. (b)	23. (b)	24. (c)	25. (d)	26. (c)	27. (c)	28. (c)	29. (d)	30. (b)
31. (b)	32. (a)	33. (a)	34. (a)	35. (b)					

Hints and Solutions

7. (d)

The structure of ethane is $\begin{array}{ccccc} & & H & & H & \\ & & | & & | & \\ H & — & C & — & C & — & H \\ & & | & & | & \\ & & H & & H & \end{array}$. It has seven covalent bonds, six C—H and one C—C covalent bond.

9. (a)

Only (i) and (ii) has the same M.F. (C_4H_{10}) while (ii) and (iv) have C_4H_8 as the M.F.

22. (b)

E.C. of Ne = 2, 8

28. (c)

Rubbing alcohol is common name of isopropyl alcohol (C_3H_7OH)

29. (a)

The common name of methanol is wood alcohol.

10. Periodic Classification of Elements

Learning Objectives

* Early Attempts at the Classification of Elements
    * Laboisier classification
    * Dobereiner's triads
    * Newland's law of Octaves
* Mendeleev's Periodic Law
* Mendeleev's Periodic Table
* Modern periodic table
    * Position of elements in the modern periodic table
    * Removal of anomolies in Mendeleev's Periodic table
    * Merits of modern periodic table
    * Demerits of modern periodic table
    * Trends in the modern periodic table

Periodic Classification

We have already studied that matter around us is present in the form of elements. Around the year 1800 only 30 elements were known. By the year 1865, the number of elements known up to 63 and at present 118 elements are known. When a very few elements were known, study of these elements were easier. But with the increase of elements, it became difficult to study the properties of all of them separately. To overcome this problem, scientists started looking for some pattern in their properties on the basis of which they can classify all the known elements to make their study easier. This necessity led to the classification of elements.

Early Attempts at the Classification of Elements (Lavoisier Classification)

The earliest attempt to classify the elements was made by Lavoisier who divided the known elements into two broad groups of **metals** and **non-metals** in order to study their acidic and basis properties. Lavoisier classification was based on the basis of the physical properties of the elements, such as **hardness, malleability** and **lusture.** But this classification was not enough.

Later on in 1808, John Dalton, an English school teacher, proposed his **Atomic Theory**. According to his theory '**Atoms of one element can be distinguished from the other on the basis of their atomic masses (or atomic weights.) Therefore, all the earlier attempts at the classification of elements were based upon their atomic masses.**'

Dobereiner's Triads

In 1817, Johann Wolfgang Dobereiner,a German chemist tried to arrange the elements with similar properties into groups. He identified certain groups of three elements. These three elements were called Dobereiner's triads. **He observed when three elements of any particular triads were arranged in**

order of their increasing atomic masses, the atomic mass of the middle element was roughly the mean or overage of the atomic masses of the other two elements.

For example:

1.	Element	Symbol	Atomic mass	
	Lithium Sodium Potassium	Li Na Kt	6.9 u 23.0 u 39.0 u	Average of atomic Masses of Li and K $= \frac{6.9+39.0}{2} = 22.95\ u$
2.	**Element**	**Symbol**	**Atomic mass**	
	Chlorine Bromine Iodine	Cl Br I	35.5 u 79.9 u 126.9 u	Average of the atomic Masses of Cl and I $= \frac{35.5+126.9}{2} = 81.2\ u$
3.	**Element**	**Symbol**	**Atomic mass**	
	Calcium Strontium Barium	Ca Sr Ba	40.1 u 87.6 u 137.3 u	Average of atomic Masses of Can and Ba $= \frac{40.1+137.3}{2} = 88.7\ u$

Drawback of classification: All the elements at that time could not be arranged as Dobereiner's triads. For example, nitrogen (N), phosphorus (P) and arsenic (As) have similar properties. Therefore, they can be regarded to form triads. However, the actual atomic mass of the middle element (31.0 u) is much lower than the average (44.45 u) of the atomic masses of nitrogen and arsenic. Thus, these three elements do not constitute a Dobereiner's triads in spite of their similar chemical properties.

Element	Symbol	Atomic mass	
Nitrogen	N	14.0 u	Average of the atomic masses of N and As] $= \frac{14.0+74.9}{2} = 44.45\ u$
Phosphorous	P	31.0 u	
Arsenic	As	74.9 u	

Since he failed to arrange these known elements in the form of triads. His attempt at classification was not very successful.

Newland's Law of Octaves

According to Newland's Law of Octaves, '**When elements were arranged in horizontal rows in order of their increasing relative atomic masses, the properties of every eight elements were similar to the first one like the eighth note of a musical scale.**'

For example

	Sa	re	ga	ma	pa	dha	ni
Elements with atomic mass up to 40 u	H F Cl	Li Na K	Be Mg Ca	B Al	C Si	N P	O S
Elements with atomic mass > 40 u	Co and Ni Br	Cu Rb	Zn Sr	Cr Y Ce, La	Ti In Zr	Mn As —	Fe Se —

Now if we take Lithium (Li) as the first element then the eight elements from it will be sodium. According to New Law of Octaves, these two elements must have similar properties, It has actually been found that lithium and sodium have similar properties.

Note: There are seven musical notes. In Indian system of music, these are called : Sa, re, ga, ma, pa, dha, ni, while in western system of music, these are called do, re, ni, fa, so, la, ti. A musician uses only these seven notes for composing the music of a song. Obviously, there must be some repetition of notes. Every eight notes (Sa) is similar to the first one (Sa) and the whole music of the song is composed by repeating these seven notes over and over again.

Drawbacks of newland's Law of Octaves

1. Newland's law of octaves was applicable only on lighter elements having atomic masses up to 40u.
2. It was assumed by Newlands that only 56 elements existed in nature and no new elements would be discovered in the future. But later on, several new elements were discovered whose properties did not satisfy according to the law of Octaves.
3. In order to fit elements into his table, Newland's adjusted two elements in the same slote, but also put some unlike elements under the same slot. For example, cobalt and nickel are in the same slot and these are placed in the same column as fluorine, chlorine and bromine which have very different properties than these elements. Iron, which resembles cobalt and nickel in properties, has been placed far away from these elements.

Thus, Newland's Law of Octaves worked well with lighter elements only.

Newland's arrangement was applicable only to a few elements after that it was failed.

Mendeleev's Periodic Law

In 1869, a Russian chemist, Mendeleev on the basis of physical and chemical properties discovered a relation known as 'PERIODIC LAW'. According to Mendeleev's periodic law :

When elements are arranged in order of their increasing atomic masses, elements with similar properties are repeated after certain regular intervals. This repitition of properties of elements after certain regular intervals is called periodicity of properties.

Mendeleev's Periodic Table

This table consist of:

(a) Seven horizontal columns called periods. These are numbered from 1 to 7.

(b) Eight vertical columns are called groups. These are designated as I, II, III, IV, V, VI, VII and VIII. Except group VIII, each group is divided into two sub groups designated as A and B. The elements which lie on left hand side of each group constitute a sub group A. These are called **normal** or **representative elements.** The elements which lie on right hand side of each group constitute sub group B. These are called **transition elements.** This sub division is made on the basis of difference in their properties.

Group VIII contains nine transition elements in three sets each containing three elements. These three sets lie in the 4th, 5th and 6th period.

Note: Noble gases are not known at the time of Mendeleev. However when these gases were discovered, a new group called the zero group was added to the Mendeleev's periodic table.

Mendeleev's Periodic Table

Mendeleev's Periodic Table																	
Groups	I		II		III		IV		V		VI		VII		VIII		
Oxides	R_2O		RO		R_2O_3		RO_2		R_2O_5		RO_3		R_2O_7		RO_4		
Hydrides	RH		RH_2		RH_3		RH_4		RH_3		RH_2		RH		*Transition Series*		
Periods	A	B	A	B	A	B	A	B	A	B	A	B	A	B			
1	H 1.008																
2	Li 6.939		Be 9.012		B 10.81		C 12.001		N 17.007		O 15.999		F 18.998				
3	Na 22.99		Mg 24.31		Al 29.98		Si 28.09		P 30.974		S 32.06		Cl 35.453				
4:1st series	K 39.102		Ca 40.08			Sc 44.96		Ti 47.90		V 50.94		Cr 50.20		Mn 54.94	Fe 55.85	Co 58.93	Ni 58.71
2nd series		Cu 63.54		Zn 65.37	Ga 69.72		Ge 72.59		As 74.72		Se 78.96		Br 79.909				
5:1st series	Rb 85.47		Sr 87.62			Y 88.91		Zr 91.22		Nb 92.91		Mo 95.94		Tc 99	Ru 101.07	Rh 102.91	Pd 106.4
2nd series		Ag 107.87		Cd 112.40	In 114.82		Sn 118.69		Sb 121.75		Te 127.60		I 126.90				
6:1st series	Cs 132.90		Ba 137.34			La 138.91		Hf 178.49		Ta 180.95		W 183.85			Os 190.2	Ir 192.2	Pt 195.09
2nd series		Au 196.97		Hg 200.59	Ti 204.37		Pb 207.19		Bi 208.98								

Merits of mendeleev's periodic table

Merits of this periodic table are:

1. There was a regular gradation in physical and chemical properties of elements.
2. The group number of an element indicates highest oxidation state that it can attain.
3. There were many vacant spaces in Mendeleev's periodic table for the elements to be discovered. He named them Eka-Boron, Eka-Aluminium and Eka-silicon. He also predicted the properties of these undiscovered elements including atomic masses. These elements were discovered as Sc, Ga and Ge with same features as he predicated.
4. Mendeleev's arrangement helped to correct atomic masses of a number of elements.

Demerits of mendeleev's periodic table

1. Position of hydrogen in the periodic table is controversial, *i.e.*, no fixed position can be assigned to hydrogen in the periodic table.
2. There is no separate position for isotopes in his periodic table.
3. Alkali metal and coinage metals (Cu, Ag and Au) which differ widely in properties, are placed into the same group.
4. Elements with similar properties have been placed in different groups. For example, both Cu and Hg have many similar properties but Cu has been placed in group IB while Hg has been place in group II B.
5. The change in the atomic mass of two successive elements is not constant. Hence it is not possible to predict the number of missing elements by knowing the atomic masses of two known elements.

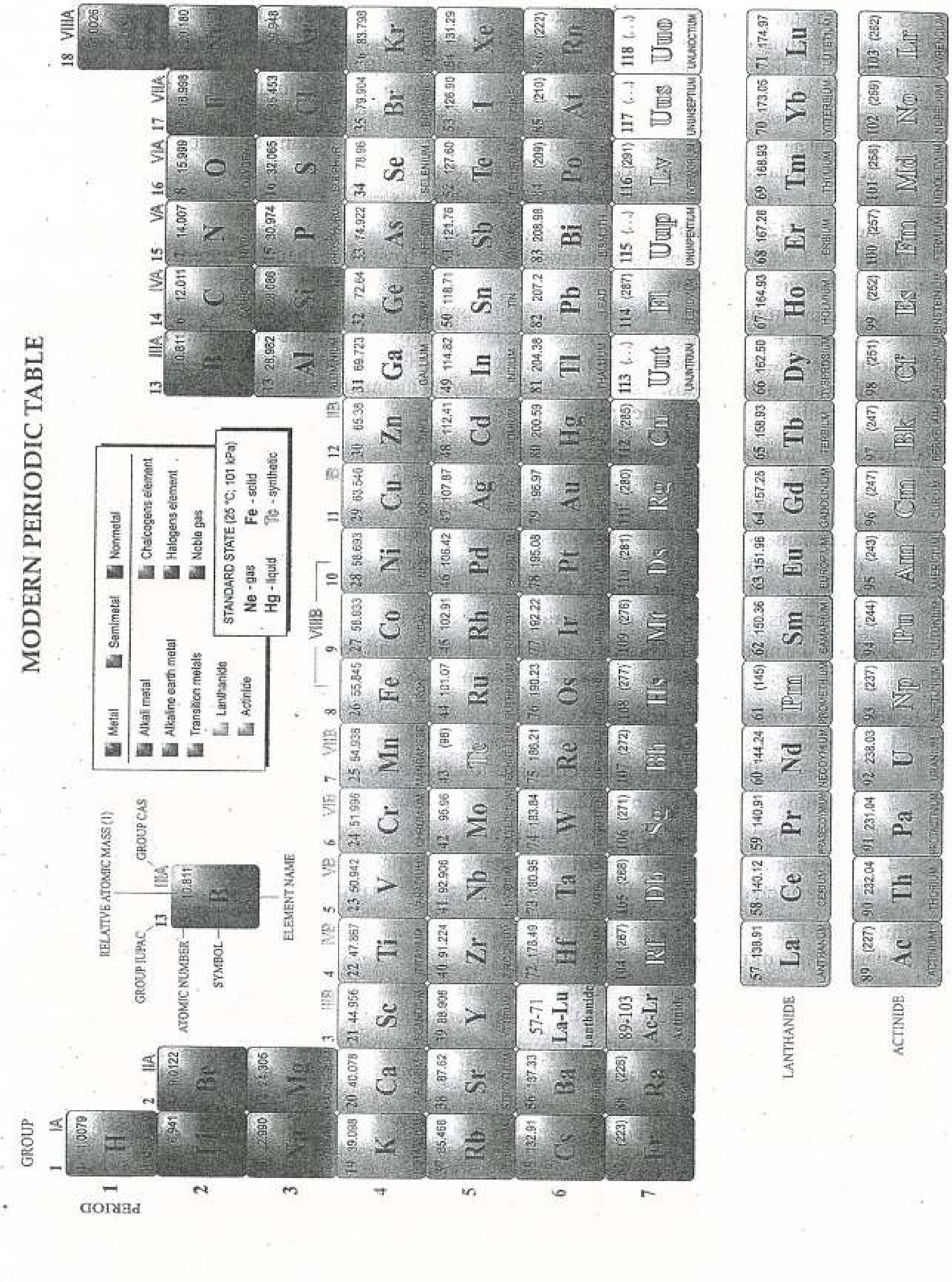
Modern Periodic Table

In 1913, Henry Moseley, showed that **the atomic number of an element is a more fundamental property than its atomic mass.** So, atomic number was adopted as the basis of the classification of elements in the Modern Periodic table. Accordingly, Mendeleev's Periodic Law was modified to Modern Period Law which states that **the properties of elements are a periodic function of their atomic numbers.**

In the modern periodic table or in the long form of the periodic table, **the elements are arranged in increasing order of their atomic numbers. This table was prepared by Bohr and is based upon the electronic configuration of elements.** That is why Modern periodic table is also called Bohr's table.

Position of elements in the modern periodic table: Modern periodic table consists of 18 vertical columns called groups and 7 horizontal rows called periods. These group are numbered from 1–18 and periods are numbered from 1–7.

Groups: Elements of Groups 1 and 2 on the left and groups 13–18 on the right are called **normal** or **representative elements.** Elements of group I are also called **alkali metals,** those of group 2 as **alkaline earth metals.** The elements of groups 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 are called **transition elements,** because their properties lies between the properties of elements of group 1 and 2 and group 13–18.


MODERN PERIODIC TABLE
Metal
Semimetal
Nonmetal
Alkali metal
Alkaline earth metal
Transition metals
Lanthanide
Actinide
Chalcogens element
Halogens element
Noble gas
STANDARD STATE (25 °C; 101 kPa)
Ne - gas
Fe - solid
Hg - liquid
Tc - synthetic
RELATIVE ATOMIC MASS (1)
GROUP IUPAC
GROUP CAS
ATOMIC NUMBER
SYMBOL
ELEMENT NAME
GROUP
PERIOD
LANTHANIDE
ACTINIDE

In periodic table, the elements have been broadly divided into metals and non metals by the thick zigzag line running diagonally across the periodic as shown. Those elements which lie on the left hand side of this line are **metals** and those which lie on the right hand side of this line are **non-metals**. However, the elements, silicon, germanium, arsenic, antimony and tellurium show the properties of both metals and non metals. These elements are called **semimetals** or **metalloids**.

Periods: The number of elements in any period is fixed by the maximum number of electrons that can be accommodated in that particular shell. For example,

K shell – $2 \times (1)^2 = 2$ hence first period has two elements.

L shell – $2 \times (2)^2 = 8$ hence second period has eight elements.

M shell – $2 \times (3)^2 = 18$ but the outermost shell cannot have more than 8 electrons. Therefore, third period also has eight electrons.

The maximum number of electrons 4^{th}, 5^{th}, 6^{th} and 7^{th} period are 18, 18, 32 and 32 respectively. Two series of 14 elements have been placed at the bottom of the periodic table. The first series having atomic number 58–71. These elements are collectively called **lanthanides** or **lanthanoids**. These are also called **rare earth metals.** The second series having atomic number 90–103. These elements are collectively called **actinides** or **actinods.**

Removal of anomolies in mendeleev's periodic table

1. All the isotopes of an element have the same atomic number. Therefore, they can be placed at one place in the same group of the periodic table.
2. The anamaly regarding for elements such as tellurium (Te)-Iodine (I) and argon (Ar)-potassium (K) were solved elegantly. Although Te had a higher atomic mass Mendeleev was forced to place it head of I which had a lower atomic mass. But if one sees their atomic numbers, Te is 52 and I is 53. Thus Te will naturally come before I when atomic numbers are considered.
3. Thus the modern periodic table of elements removed all anomolies of the Mendeleev's periodic table, by simple considering the atomic numbers of elements.

Merits of the modern periodic table

1. The elements are arranged in increasing order of their atomic numbers since the atomic numbers increase in the serial order, therefore it is much easy to remember.
2. Position of isotopes has been justified.
3. Anamolus position of some pairs of elements have been justified.
4. The position of elements linked with their electronic configurations. Therefore, by looking at the position of any element, it is possible to predict its properties.

Demerits of the modern periodic table

The main defects of modern periodic table are

1. Position of hydrogen still remains to be controversial. For convenience, it is usually placed in group I, period I because it has the lowest atomic number (1) and lowest atomic mass (1.008 u)
2. On the basis of electronic configuration, helium should be placed in group 2 along with alkaline earth metals but it has been placed in group 18 along the noble gases on the basis of its properties.
3. No proper position has been assigned to lanthanoides and actinoides, *i.e.*, they have not been included in the main body of the periodic table.

Trends in the modern periodic table

The physical and chemical properties of an element mainly depend upon its outer electronic configuration. Since the outer electronic configuration changes as we go from left to right in a period, therefore, within the same period, elements show a variation both in their physical and chemical properties.

On the other hand, within a group, the elements have the same outer electronic configuration. Therefore, their chemical properties are similar but their physical properties show a regular gradation (variation) as we move down the group from top to bottom due to a corresponding increase in the number of filled inner shells.

These properties which show a regular gradation (variation) on moving from top to bottom with the same group or from left to right along a period are called atomic properties.

For example: Valency, atomic size, metallic/non-metallic character and chemical reactivity.

1. **Valency:** Valency is **the combining capacity of an element.** It depends upon the number of valence electrons, *i.e.*, electrons present in the outermost shell of the atom.

   (a) Variation of valency in a period: On moving from left to right in a period, the number of valency electrons increases from 1 to 8.

   Sodium (Na) has 1, magnesium (Mg) has 2, aluminium has 3 valence electrons. Therefore, these elements can easily lose these electrons to acquire the stable electronic configuration of the nearest noble gas *i.e.*, Neon Ne (2,8)

$$\underset{2,8,1}{Na} \longrightarrow \underset{2,8}{Na^+ + e^-}$$

$$\underset{2,8,2}{Mg} \longrightarrow \underset{2,8}{Mg^{2+} + 2e^-}$$

$$\underset{2,8,3}{Al} \longrightarrow \underset{2,8}{Al^{3+} + 3e^-}$$

   Therefore the valency of Na is 1, that of Mg is 2, that of Al is 3.

   (b) Variation of valency in a group: All the elements in a group have similar outer electronic configuration. Therefore the valency of all the elements in a group is fixed or is the same.

2. **Atomic size:** Atomic size is commonly known as atomic radius. 'Atomic size is distance between the centre of the nucleus and the outermost shell which contains electrons of an isolated atom.'

   (a) Variation of atomic radii in a period: On moving from left to right in a period, the atomic radius decreases. This is due to the increased nuclear charge, the electrons are attracted closer to the nucleus and hence the atomic size decreases.

   (b) Variation of atomic radii in group: On moving a group, the atomic radii of elements increase gradually. This is because, as we move down a group, the number of shells increases, the distance between the nucleus and the last shell (valence shell) increases and thus the atomic size increase from top to bottom.

3. **Metallic and non-metallic character:** Metals are also called electropositive elements, whereas non-metal s are called electronegative elements.

   (a) Variation in period: On moving from left to right in a period, the metallic character decreases while the non-metallic character increases. This is because, as we move across a period from left to right, the number of valence electrons increase from 1 to 7. As a result, the effective nuclear charge acting on the valence electrons increases and hence the tendency of the element to gain electrons increases.

Elements of third period:

$$\underbrace{\text{Na Mg Al}}_{\text{Metals}}\ \underbrace{\text{Si}}_{\text{Metalloid}}\ \underbrace{\text{P S Cl}}_{\text{Non-metals}} \xrightarrow[\text{Non-metallic character increases}]{\text{Metallic character decreases}}$$

(b) **Variation in a group: On moving down in a group, the metallic character or the electropositive character increases:** This is due to when we move down the group the force of attraction between the molecules and the valence electrons decreases. Therefore the tendency of the element to lose electrons to form positive ions increases and hence the metallic or electropositive character increases as we move down the group.

4. **Chemical reactivity:** All the elements in the periodic table are not chemically equally reactive. The chemical reactivity of an element depends upon its position in the periodic table.

(a) **Variation in a period:** As we move from left to right across a period the chemical reactivity of elements first decreases and then increases.

Variation in chemical reactivity of the elements of the third period

Element	Na	Mg	Al	Si	P	S	Cl	Ar
No. of valence Electrons	1	2	3	4	5	6	7	8
Chemical Reactivity	Very reactive	less reactive	Still less	Least reactive	Quite reactive	More reactive	Very reactive	Unreactive

(b) **Variation in a group:** The chemical reactivity of metals increases from top to bottom in a group, whereas the chemical reactivity of non-metals decreases from top to bottom in a group.

Key Points

- ✓ Elements are classified on the basis of similarities in their properties.
- ✓ Dobereiner grouped the elements into triads and Newlands gave the law of Octaves.
- ✓ Mendeleev's Periodic Law states that the physical and chemical properties of the elements are a periodic function of their atomic masses.
- ✓ Henry Moseley in 1913 showed that **atomic number** was a more fundamental property of an element than its atomic mass.
- ✓ In the modern or long form of the periodic table, elements are arranged in increasing order of their atomic numbers.
- ✓ Elements in the modern periodic table are arranged in 18 vertical columns called groups and 7 horizontal rows called periods.
- ✓ The oxides of metals are basic while those of non-metals are acidic in nature.
- ✓ Elements thus arranged show periodicity of properties including atomic size, valency or combing capacity and metallic and non-metallic character.

- ✓ The valency of elements in a group is fixed but in a period, first it decreases from 1 to 4 and then decreases from four to zero.
- ✓ The atomic size decreases across a period from left to right but increases down a group.
- ✓ Across a period, the metallic character decreases while the non-metallic character increases. On the other hand in a group the metallic character increases while the non-metallic character decreases.

Multiple Choice Questions

1. Elements A, B and C Constitute a Dobereiner's triad. If the atomic mass of element A is 7 and that of element C is 39, then what is the atomic mass of element B ?
   (a) 23 (b) 46
   (c) 22 (d) 32
2. Which of the following represents a Dobereiner's triad ?
   (a) Na, Cl, Ca (b) Li, Br, Sr
   (c) K, I, Ba (d) Cl, Br, I
3. According to Newland's law how many elements are there in nature ?
   (a) 20 (b) 25
   (c) 56 (d) 65
4. X and Y are two elements having similar properties which obey Newland's Law of Octaves. The minimum and maximum number of elements in between X and Y, respectively are
   (a) 6 and 8 (b) 6 and 13
   (c) 7 and 15 (d) 8 and 14
5. Up to which element, the law of Octaves was found to be applicable
   (a) Oxygen (b) Potassium
   (c) Calcium (d) Cobalt
6. According to Mendeleev's Periodic Law, the elements were arranged in the periodic table in the order of
   (a) Increasing atomic masses (b) Decreasing atomic masses
   (c) Increasing atomic number (d) Decreasing atomic number
7. The two elements for which Mendeleev left blank places in his original periodic table were
   (a) Al, Ga (b) As, Sb
   (c) Ga, Ge (d) Si, Ti
8. Number of groups and periods, respectively present in modern periodic table are
   (a) 16, 7 (b) 6, 18
   (c) 18, 7 (d) 18, 6
9. Which pair of atomic numbers represents elements in the same group ?
   (a) 6, 12 (b) 11, 19
   (c) 4, 16 (d) 8, 17
10. Which of the following statement(s) about the modern periodic table are incorrect
    (i) The elements in the modern periodic table are arranged on the basis of their decreasing atomic number.
    (ii) Isotopes are placed in adjoining group(s) in the periodic table
    (iii) The elements in the modern period table are arranged on the basis of their increasing atomic masses.
    (iv) The elements in the modern periodic table are arranged on the basis of their increasing atomic number.

(a) (i) only
(b) (iv) only
(c) (i),(ii) and (iii)
(d) (i), (ii), and (iv)

11. Atomic number of the element which is surrounded by elements with atomic numbers 17, 34, 36 and 53 in the modern period table is
(a) 18
(b) 35
(c) 37
(d) 52

12. Which of the given element A, B, C, D and E with atomic numbers 2, 3, 7, 10 and 30, respectively belong to the same period ?
(a) A, B, C
(b) B, C, D
(c) A, D, E
(d) B, D, E

13. The elements A,B, C, D and E have atomic number 9, 11, 17, 12 and 13 respectively. Which pair of elements belong to the same group ?
(a) A and C
(b) A and D
(c) A and E
(d) B and D

14. Which among the following is the most reactive halogen ?
(a) F
(b) Cl
(c) Br
(d) I

15. The oxide of which of the following elements is not acidic ?
(a) Cl
(b) S
(c) Br
(d) Li

16. The correct sequences of atomic radii is
(a) Na > Mg > Al > Si
(b) Si >Al > Mg > Na
(c) Al > Si > Na > Mg
(d) Si > Al > Na > Mg

17. Match the items given in column A and column B.

Column A	Column B
(i) Uranium	A. Group 17
(ii) Silver	B. Oxygen family
(iii) Aluminium	C. Transition element
(iv) Eluorine	D. Borm family
(v) Sulphur	E. Actinoid

(a) (i) — B (ii) — C (iii) — D (iv) — A (v) —E
(b) (i) — E (ii) — C (iii) — D (iv) — A (v) — B
(c) (i) — C (ii) — D (iii) — E (iv) — B (v) — A
(d) (i) — D (ii) — A (iii) — B (iv) — C (v) — D

18. Which of the following statements about the modern period table is correct ?
(a) It has 18 horizontal rows known as periods
(b) It has 7 vertical columns known as periods
(c) It has 18 vertical columns known as periods
(d) It has 7 horizontal rows known as periods

19. Where would you locate the element with electronic configuration 2, 8 in the modern period table ?
   (a) Group 2
   (b) Group 8
   (c) Group 10
   (d) Group 18

20. Which one of the following elements exhibit maximum number of valence electrons ?
   (a) Na
   (b) P
   (c) Al
   (d) Si

21. Which of the following statements is not a correct regarding the trends when going from left to right across the periods of periodic table
   (a) The number of valence electrons increases
   (b) The atoms lose their electrons more easily
   (c) The elements become less metallic in nature
   (d) The oxides become more acidic

22. An element which is an essential constituent of all organic compounds belongs to
   (a) Group 1
   (b) Group 2
   (c) Group 14
   (d) Group 15

23. Which of the following gives the correct increasing order of the atomic radii of O, F and N ?
   (a) F, O, N
   (b) O, F, N
   (c) N, F, O
   (d) O, N, F

24. Which of the following elements would lose an electron easily ?
   (a) Na
   (b) Mg
   (c) Ca
   (d) K

25. Which of the following elements does not lose an electrons easily ?
   (a) Na
   (b) Mg
   (c) Al
   (d) F

26. Which of the following are the characteristics of isotopes of an element ?
   (i) Isotopes of an element have same atomic masses
   (ii) Isotopes of an element have same atomic number
   (iii) Isotopes of an element show same chemical properties
   (iv) Isotopes of an element show same physical properties
   (a) (i) and (iv)
   (b) (ii), (iii) and (iv)
   (c) (i) and (iii)
   (d) (ii) and (iv)

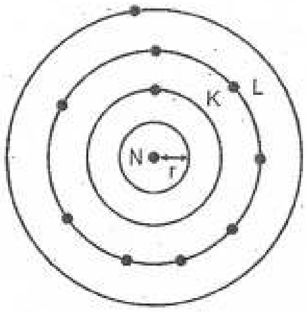
27. What type of oxide would Eka-aluminium form ?
   (a) EO_3
   (b) E_2O_3
   (c) E_3O_2
   (d) EO

28. Three elements B, Si and Ge are
   (a) metals
   (b) non-metals
   (c) metalloids
   (d) metal, non-metal and metalloid, respectively

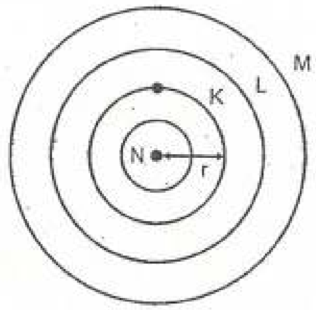
29. Arrange the following elements in the order of the their increasing non-metallic character Li,O, C, Be, F

(a) $F < O < C < Be < Li$
(b) $F < C < O < Be < Li$
(c) $Li < Be < C < O < F$
(d) $F < O < Be < C < Li$

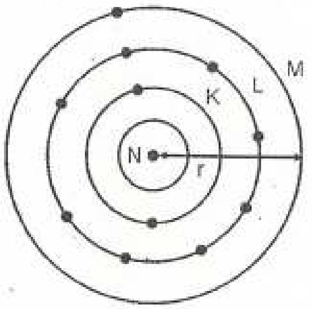
30. Which one of the following depict the correct representation of atomic radius (r) of an atom ?



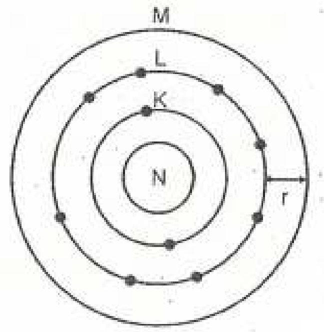
(i)



(ii)



(iii)



(iv)

(a) (i) and (ii)
(b) (i) and (iv)
(c) (ii) and (iii)
(d) (iii) and (iv)

31. Which of the following elements will form an acidic oxide ?

(a) An element with atomic number 3
(b) An element with atomic number 7
(c) An element with atomic number 12
(d) A element with atomic number 19

32. Which of the following set of elements is written in order of their increasing metallic character ?

(a) Na, Li, K
(b) Be, Mg, Ca
(c) C, ON
(d) Mg, Al, Si

33. Match the columns A and B

Column A	Column B
(i) Sulphur	(A) Amphoteric
(ii) Fluorine	(B) Radioactive
(iii) Aluminium	(C) Yellow solid
(iv) Silver	(D) Gas
(v) Uranium	(E) Coinage metal

(a) (i) — B (ii) — A (iii) — D (iv) — E (v)— C
(b) (i) — D (ii) — C (iii) — B (iv) — A (v) — E
(c) (i) — C (ii) — D (iii) — A (iv) — E (v) — B
(d) (i) — E (ii) — E (iii) — D (iv) — B (v) — A

34. Which of the following does not increase while moving down the group of the periodic table ?
(a) Atomic radius
(b) Valence
(c) Metallic character
(d) Number of shells in on element

35. The element with atomic number 14 is hard and forms acidic oxide and a covalent halide. To which of the following categories does the element belong ?
(a) Metal
(b) Non-metal
(c) Metalloid
(d) Left hand side element

36. The atomic masses of first and the third element of a Dobereiner's triad are 35.5 and 127. What is expected atomic mass of the middle element ?
(a) 23
(b) 40
(c) 80
(d) 137

37. In which year Mendeleev formulated the law of classification ?
(a) 1865
(b) 1870
(c) 1869
(d) 1875

38. Who gave modern periodic law ?
(a) Newland
(b) Mendeleev's
(c) Moseley
(d) Luther Mayer

39. Which group elements are known as alkali metals ?
(a) 1
(b) 2
(c) 3
(d) 4

40. Who gave octaves periodic law ?
(a) Moseley
(b) Newland
(c) Luther Mayer
(d) Mendeleev's

Answer Key

1. (a)	2. (d)	3. (c)	4. (b)	5. (c)	6. (a)	7. (c)	8. (c)	9. (b)	10. (c)
11. (b)	12. (b)	13. (a)	14. (a)	15. (d)	16. (a)	17. (b)	18. (c)	19. (d)	20. (b)
21. (b)	22. (c)	23. (a)	24. (d)	25. (d)	26. (c)	27. (b)	28. (c)	29. (c)	30. (c)
31. (b)	32. (b)	33. (c)	34. (b)	35. (c)	36. (c)	37. (c)	38. (c)	39. (a)	40. (b)

Hints and Solutions

9. (a)

the difference between atomic numbers is 8

11. (d)

elements in a period have consecutive atomic numbers *i.e.*, 34, 35, 36.

12. (b)

2^{nd} period contains elements with atomic numbers 3 (Li), 7 (N) 10 (Ne).

1. (a)

Elements which differ in atomic numbers by 8 *i.e.*, 9 (fluorine) and 17 (chlorine).

15. (d)

Oxide of Li is basic.

16. (a)

Within a period, atomic radii decrease from left to right.

19. (d)

Elements with electronic configuration (2, 8) is an inert gas *i.e.*, neon and hence belongs to group 18.

22. (c)

The essential constituent of all organic matter is carbon which belongs to group 17.

24. (d)

Larger the atomic radius of an element, more easily it can lose its valence electrons. K has the largest atomic radius, therefore it can lose on electron more easily.

25.(d)

Elements of 2^{nd} period have smaller size than those of the corresponding elements of the 3^{rd} period. Further is a period, halogen has the smallest size. Among Na, F, Mg and Al, F has the smallest size and hence it does not lose an electron easily

27.(b)

Eka-aluminium *i.e.*, gallium lies in group III of the Mendeleev's periodic table. Therefore, it has a valency of 3 and forms on oxide having molecular formula E_2O_3

29.(c)

Non-metallic character increases from left to right in a period *i.e.*, Li < Be < C < O < F.

31. (b)

Metallic character increases down a group and decreases along a period. Thus, metallic character increases in the order : Be, Mg, Ca.

34. (b)

In a group valency of all elements is fixed because of having the same outer shell electronic configuration while all the remaining three properties increase down the group.

35. (c)

Since the element with atomic number 14 *i.e.*, Si forms an acidic oxide and a covalent halide, it must be metalloid.

11. Life Process

Learning Objectives
* Define Living Things
* What are Life Processes
* Nutrition - Autotrophic and Heterotrophic
* Respiration
* Types of Respitation - Aerobic and Anaerobic
* Transportation
* Excretion
* Dialysis

Living Things

Living things have an organised structure made up of a cell or cells which require energy to survive, reproduction as well as metabolism. **All the plants and animals (including human beings) are alive or living things**. Now an important questions arises: What criteria do we use to decide whether something is alive? This is discussed below :

The most important criterion to decide whether something is alive (or not) is the movement. The movements in most of the animals are fast and can be observed easily but the movements in plants are usually slow. Animals can move from one place to another or they can move their body parts. For example, a bird moves when it flies in the sky. The plants are fixed in the soil at a place, so they cannot move like animals. Plants can only move parts of their body such as leaves, flowers, shoots and roots.

These are as follows:

(i) Living things can move by themselves.

(ii) Living things need food, air and water.

(iii) Living things respire and excrete

(iv) Living things are sensitive.

(v) Living things can grow and reproduce the young ones.

What are Life Processes

The basic functions performed by living organism to maintain their life on this earth are called life processes. The basic life processes are: Nutrition and Respiration, Movement and Reproduction, Control and coordination, Transport and Excretion.

Energy is needed to perform various life processes. The living organism use the chemical energy for carrying out various life processes. This chemical energy comes from food through chemical reactions. Energy is required by an organism even during asleep. This is because when we are asleep, a number of biological processes keep on occurring in the body which require energy. Our heart beats non-stop even when we are asleep to pump blood through out the body. And this beating of heart requires energy. Thus. the working of heart requires a continuous supply of energy.

Nutrition

'The process of nutrition involves the taking of nutrient inside the body and converting into smaller molecules which can be absorbed by the body.' A nutrient is a substance which an organism obtains from surroundings and uses it as source of energy for the biosynthesis of its body constituents (like tissue and organs). For example, Carbohydrate fats. Protein and mineral salts are nutrients.

There are different modes of nutrition. **Modes of nutrition means methods of obtaining food by an organism.** Two main modes of nutrition are as following.

1. **Autotrophic and**
2. **Heterotrophic**

Autotrophic

The word 'auto' means 'self' and 'trophe' means 'nutrition'. Thus autotrophic means 'self nutrition.'

'Autotrophic nutrition is that mode of nutrition in which an organism makes (or synthesizes) its own food from the simple inorganic materials like carbon dioxide and water present in the surroundings. (with the help of sunlight energy).'

This inorganic materials is converted into carbohydrates. Carbohydrates are utilised for providing energy to the plant. The carbohydrates which are not used immediately are stored in the form of starch. Green plants and some bacteria have an autotrophic mode of nutrition. Plants contain the green pigment called Chlorophyll which is capable of trapping sunlight energy. Thus, **The process by which green plants make their own food (like glucose) from carbon dioxide and water by using sunlight energy in the presence of chlorophyll, in called photosynthesis.** The process of photosynthesis can be represented as :

$$\underset{\substack{\text{Carbon dioxide}\\\text{(From air)}}}{6\,CO_2} + \underset{\substack{\text{Water}\\\text{(From soil)}}}{12\,H_2O} \xrightarrow[\text{Chlrophyll}]{\text{Sunlight}} \underset{\text{(Glucose)}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6\,O_2} + 6\,H_2O$$

The process of photosynthesis takes place in the green leaves of a plant. Carbon dioxide gas enters the leave through the tiny pores in them called **stomata** and the water is transported to the leaves from the soil through the roots and stem. The sunlight provides energy required to carry out the chemical reactions involved in the preparation of food. The green pigment called chlorophyll present in green leaves helps in absorbing energy from sunlight. Oxygen gas is produced as a by-product during photosynthesis. This oxygen gas goes into the air.

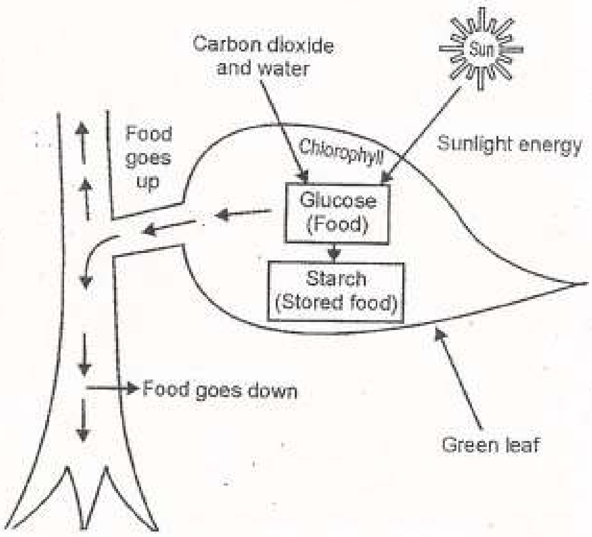


Fig: 11.1

Green plants make their own food by photosynthesis: The following steps occur during the process of photosynthesis:

(i) Absorption of sunlight by chlorophyll.

(ii) The sunlight energy is converted into chemical energy and water molecule is split up into hydrogen and oxygen.

(iii) Carbon dioxide is reduced to carbohydrates.

A part from there other raw material are also required by the plants for the process of growth and development.

Other materials like nitrogen, phosphorus, iron and magnesium are taken up from the soil by the plants Nitrogen is essential for the process of protein synthesis in the plants. It is used in the form of nitrates or nitrites.

Condition necessary for photosynthesis

The conditions necessary for photosynthesis to take place are:

1. Sunlight
2. Chlorophyll
3. Carbon dioxide and
4. Water

Sunlight is essential for the process of photosynthesis. Take a leaf from the plant in the sunlight and put it in a beaker and boil it for two minutes and then transfer it into the beaker containing alcohol and again warm it for few minutes. We observe that the leaf turns white which indicates that the chlorophyll has been removed. Now wash and dried the leaf and place it inside the beaker containing dilute iodine solution. We observe that the leaf turns bluish black which shows that leaf contains starch. On the other hand if we take the leaf of the plant which was not in sunlight for more than 24 hours and perform the same experiment we observe that the leaf colour does not change on putting it into iodine solution which shows that starch has not formed in this case.

Heterotrophic Nutrition

The word heteros means 'others' and trophe refers to 'nutrition'. Thus heterotrophic nutrition obtained from others.

Heterotrophic nutrition

It is that mode of the nutrition in which an organism cannot make its own food from simple inorganic materials but depends on other organism for its food.

All the animals have a heterotrophic mode of nutrition. Most bacteria and fungi also have heterotrophic mode of nutrition. There are three types of modes of heterotrophic nutrition:

(a) Saprotrophic nutrition

(b) Parasitic nutrition and

(c) Holozoic nutrition

Saprotrophic nutrition (or Saprophytic nutrition): Saprotrophic nutrition is that nutrition in which an organism obtains its food from decaying organic matter of dead plants, dead animals and rotten bread.

Saprophytes are the organism which obtain their food from dead plants (like rotten leaves), dead and decaying animals bodies and other decaying organic matter like rotten bread. Fungi and many bacteria are saprophytes.

The saprophytes break down the complex organic molecules present in dead and decaying matter and convert them into simpler substances outside their body. These simpler substances are then absorbed by saprophytes as their food.

Note: Saprotrophic nutrition is also known as saprophytic nutrition.

Fig: 11.2 Mushroom (fungus) has saprophytic mode of nutrition

Parasitic nutrition: 'The parasitic nutrition is that nutrition in which an organism derives its food from the body of another living organism without killing it.' The organism which obtains the food is called a parasite and the organism from whose body food is obtained is called the host. So, A parasite is an organism (plant or animal) which feeds on another living organism called its host. For example, Round worms, tapeworms, leeches, lice, ticks etc.

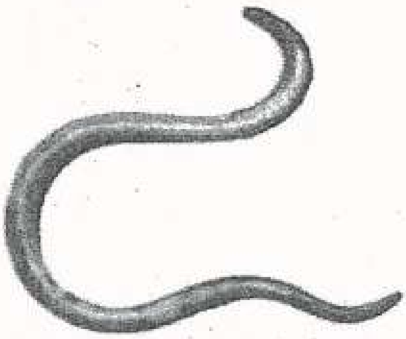


Fig: 11.3 Roundworm has parasitic mode of nutrition

Holozoic nutrition: The holozoic nutrition is that nutrition of an organism that 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 of the organism.

The undigested and unabsorbed part of the food is thrown out of the body of the organism by the process of egestion. Human beings, cat, dog, giraffe, frog, fish, amoeba, paramecium etc. have the holozoic mode of nutrition.

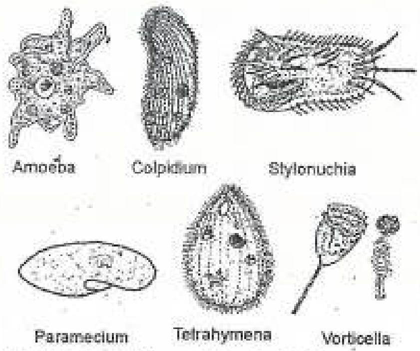


Fig: 11.4 Holozioic nutrition in different animals

Nutrition in animals: Since animals cannot make their own food they depend on readymade food. All the animals can be divided into three groups on the basis of their food habits. These are:

(i) Herbivores

(ii) Carnivores

(iii) Omnivores

Herbivores are plant eaters: Those animals which eat only plants are called **herbivores.** For example: Goat, Cow, Sheep, Horse, Squirrel etc.

Carnivores are meat eaters: These animals which eat only animals as food are called **carnivores. For example:** Lion, Tiger, Frog, Lizard etc.

Omnivores are plant eaters as well as meat eaters: Those animals which eat both plants and animals, are called omnivores. For example, Man, Dog, Bear, Ant etc.

Nutrition in amoeba: In single celled organism the food may be taken in the entire surface. Amoeba is a unicellular animal. Amoeba takes in food by temporary finger like projections called peseudopodia which fuse over the food particle forming a food vacuole. Inside the food vacuole, complex substances are broken down into simpler ones which then diffuse into the cytoplasm. The remaining undigested material is moved to the surface of the cell and thrown out.

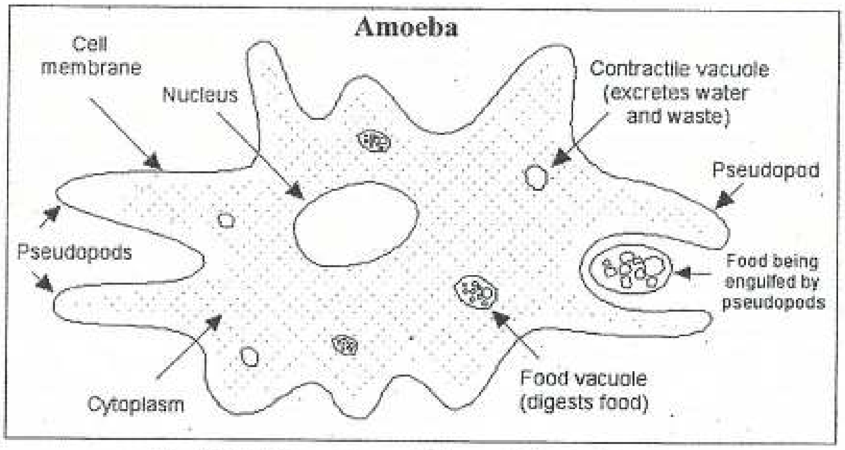
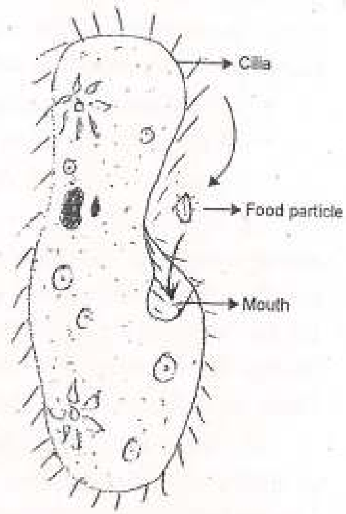


Fig: 11.5 Different stages in the nutrition of Amoeba

Nutrition in Paramecium: Paramecium is also a tiny unicellular animal which lives in water. **Paramecium uses its hair like structures called cilia to sweep the food particles from water and put them into its mouth.** This is the first step which is called ingestion. Ingestion is followed by other steps such as digestion, absorption, assimilation and egestion.



Nutrition in Paramecium

Fig: 11.6

Nutrition in human beings: The nutrition in human beings takes place through human digestive system. The human digestive system consists of mouth, oesophagus, liver, stomach, pancreas, small intestine, large intestine and anus. The human alimentary canal which runs from mouth to anus is about 9 metres long tube.

- The mouth consists of the oral cavity which contains tongue and teeth.
- The teeth helps in tearing and chewing of food in smaller pieces.
- The tongue consists of salivary gland which releases the enzymes called salivary amylase which breaks down starch and glycogen to simple sugar called maltose.
- This food is guided into the stomach through the food pipe called oesophagus via pharynx.

When the food reaches stomach the gastric gland releases the juice called gastric juice the gastric juice contains, three substances: hydrochloric acid, the enzyme pepsin and mucus. Due to the presence of hydrochloric acid the gastric juice is acidic in nature. In the acidic medium, **the enzyme pepsin begins the digestion of protein** present in food to form smaller molecules.

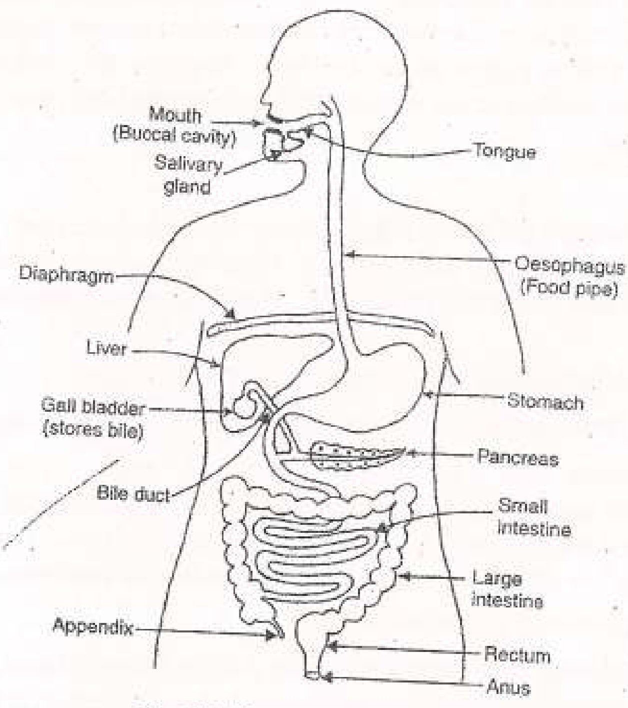


Fig: 11.7 Human digestive system

From the stomach, the partially digested food enters the small intestine. **The small intestine is largest part of alimentary canâl.** It is about 6.5 metres long in an adult man. It is divided into three parts called **duodenum, jujenum and ileum.** It is connected with the liver. **The liver is the largest gland of our body.** It secrets bile juice which helps in digestion of fats by breaking them into small globules. The acidic food coming from the stomach becomes alkaline when it is mixed with bile juice, which is essential for the enzymes catalyze to break down food in an alkaline medium. The pancreatic juice secrete by pancreas contains large number of digestive enzymes, such as

- Amylase for breaking down of polysaccharides
- Lipase for breaking down of fats
- Trypsin for break down of proteins

All this breaking down takes place in alkaline medium only. The major part of digestion and absorption takes place in last part of small intestine called ileum. The absorption of digested food in the small intestine takes place with the help of small finger like projection called **villi.** The villi increases the surface area for absorption of food molecules. It also contains large number of blood vessels, which carries the absorbed food molecules into the body and distributes it to the other parts. The food from ileum is then passed into large intestine.

The large intestine is further subdivided into two parts called **colon and rectum.** At the junction of ileum and colon there is a blind outgrowth called **caecum** which ends in **vermiform appendix.** In human being it is a **vestigial organ.** The blood carries digested and dissolved food to all the parts of the body where it becomes assimilated. In large intestine the excessive water is absorbed into the blood through the wall of intestine and residue is passed out in the form of faecal matters through anus.

Note: Dental caries or tooth decay causes gradual softening of enamel and dentine. It begins when bacteria acting on sugars produce acids that softens or demineralises the enamel. Masses of bacterial cells together with food particles stick to the teeth to from dental plaque. Salvia cannot reach the tooth surface to neutralise the acid as plaque covers the teeth. Brushing the teeth after eating removes the plaque before the bacteria produce acids. If untreated, microorganisms may invade the pulp, causing inflammation and infection.

Respiration

Most living things need oxygen (of air) to obtain energy from food. This oxygen reacts with the food molecules (like glucose) present in the body cells and burns them slowly to release energy. The energy thus released is stored in ATP molecules in the cells. The body can use this stored energy whenever it wants to do so.

The process of releasing energy from food is called respiration.

$$\text{Food} + \text{Oxygen} \longrightarrow \text{Carbon dioxide} + \text{water} + \text{energy}$$

Breathing and respiration

The mechanism by which organisms obtain oxygen from the air and release carbon dioxide is called breathing. Respiration includes breathing as well as the oxidation of food in the cells of the organism to release energy. Breathing is a physical process respiration is biochemical process of oxidation of food.

Respiration is just opposite of photosynthesis.

How energy is released during respiration is stored: All the energy released during respiration is not used immediately by an organism. The energy produced during respiration is stored in the form of ATP molecules in the cells of the body and used by the organism as and when required. The energy released during respiration is used to make ATP molecule from ADP and inorganic phosphate.

$$\underset{\substack{\text{(Adenosine Di–phosphate)} \\ \text{(Low energy)}}}{\text{ADP}} + \text{Phosphate} + \underset{\text{(From respiration)}}{\text{Energy}} \longrightarrow \underset{\text{(High energy)}}{\text{ATP}}$$

When the cell needs energy, then ATP can be broken down using water to release energy. Thus,

$$\text{ATP} \longrightarrow \text{ADP} + \text{Phosphate} + \text{Energy (For use in cells)}$$

The energy equivalent to 30.5 KJ/mole is released in this process. The energy released by ATP is used to carry out all the endothermic reactions taking place in the cells.

Just as a battery can provide energy for different purposes such as lighting, heating, running radio and computer etc. Similarly ATP can be used in the cells for the contraction of muscles, protein synthesis, conduction of nervous impulses and many other activities.

Types of respiration

There are two types of respiration:

(i) Aerobic respiration and

(ii) Anaerobic respiration

(i) **Aerobic respiration:** The respiration which takes place in presence of oxygen is called aerobic respiration. In aerobic respiration, the glucose food is completely broken down into carbon dioxide and water by oxidation

$$\underset{\text{(1 molecule)}}{\text{Glucose}} \xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \underset{\substack{\text{(Pyruvic acid)} \\ \text{(2 molecules)}}}{\text{Pyruvate}} \xrightarrow[\text{(in mitochondria)}]{\text{Oxygen (Kreb's cycle)}} 6\,CO_2 + 6\,H_2O + \underset{\text{Energy}}{38\text{ ATP}}$$

Mitochondria are the sites of aerobic respiration in the cells.

Notes: During aerobic respiration, 1 molecule of glucose (food) produces 38 energy rich ATP molecules. All the organism which obtain energy by aerobic respiration, cannot live without oxygen. This is because if there is no oxygen, they cannot get energy from the food which they eat.

(ii) **Anaerobic respiration:** The respiration which takes place in absence of oxygen is called anaerobic respiration. In anaerobic respiration, the microorganisms like yeast break down glucose into ethanol and carbon dioxide, and release energy. Anaerobic respiration carried out by yeast (plants) can be represented as follows :

$$\underset{\text{(1 molecule)}}{\text{Glucose}} \xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \underset{\substack{\text{(Pyruvic acid)} \\ \text{(2 molecules)}}}{\text{Pyruvate}} \xrightarrow[\substack{\text{(yeast)} \\ \text{(Fermentation)}}]{\text{In absence of oxygen}} 2\,\underset{\text{Ethanol}}{C_2H_5OH} + 2CO_2 + \underset{\text{Energy}}{2\text{ ATP}}$$

During vigorous physical exercise anaerobic respiration takes place in muscles. The anaerobic respiration by muscles brings about partial breakdown of glucose to form lactic acid. This lactic acid accumulates in the muscles. **The accumulation of lactic acid in the muscles causes muscle cramps.** Anaerobic respiration in muscles can be represented as follows:

$$\text{Glucose} \xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \text{Pyruvate} \xrightarrow[\text{(muscle tissue)}]{\text{In absence of oxygen}} 2\text{ Latic and} + 2\text{ ATP}$$

Note: During anaerobic respiration 1 molecule of glucose produces on 2 energy-rich ATP molecules.

Respiration in plants

Like animals, from plants also need energy. The plants get this energy by the process of respiration. Plants also use oxygen of air for respiration and release carbon dioxide. So oxygen and carbon dioxide are called respiratory gases. The respiration in plants differs from that in animals in three aspects:

1. All the parts of a plant (like root, stem and leaves) perform respiration individually. On the other hand, an animal performs respiration as a single unit.
2. During respiration in plants, there is a little transport of respiratory gases from one part of the plant to the other. On the other hand, respiratory gases are usually transported over long distances inside on animal during respiration.
3. The respiration in plants occurs at a slow rate. On the other hand the respiration in animals occurs at a much faster rate.

Plants have a branching shape, so they have quite a large surface area in comparison to their volume. Therefore, diffusion alone can supply all the cells of the plants with as much oxygen as they need for respiration. Diffusion occurs in the roots, stems and leaves of plants.

Respiration in animals

Different animals have different modes of respiration. For example:

(i) In simple unicellular animals like amoeba, respiration takes place by the simple diffusion of gases through the cells membrane.

(ii) Insects like grasshopper, cockroach, housefly and mosquito have tiny holes called spiracles on their body and the air tube called tracheae are the respiratory organs.

(iii) Aquatic animals like fish, prawns etc. have gills as the respiratory organs which extract oxygen dissolved in water and take away carbon dioxide from the body.

(iv) Animals like earth worm which live in the soil use their skin for respiration.

(v) The respiratory organs of the land animals such as man, birds, lizard, dog and frog etc. have lungs **(Frog, however breathe both by lungs and skin).**

Once the air enters the skin or lungs, blood absorbs the oxygen and transport to various tissues of the animal. Blood also picks up the carbon dioxide from the tissues and brings it back the to skin or lungs for throwing it out into the air.

All respiratory organs (whether skin, gills, trachea or lungs) have three common features.

1. All the respiratory organs have a large surface area to get enough oxygen.
2. All the respiratory organs have thin walls for any diffusion and exchange of respiratory gases.
3. All the respiratory organs like skin, gills and lungs have a rich blood supply for transporting respiratory gases (only in the tracheal system of respiration, air reaches the cells directly.)

Aquatic animals use the oxygen dissolved in water to carry out respiration. Since the amount of dissolved oxygen in water is low as compared to the amount of oxygen in the air, therefore, **the rate of breathing in aquatic animals is much faster than in terrestrial animals.** The terrestrial animals use the oxygen of air for breathing and respiration. Thus, a terrestrial animal has an advantage over an aquatic animal in regard to obtaining oxygen for respiration that it is surrounded by an oxygen-rich atmosphere from where it can take any amount of oxygen.

Respiration in humans

The process by which energy is released from food in our body is called respiration. In human beings, many organs take part in process of respiration. These care collectively called respiratory system. The main organs of human respiratory system are: Nose, Nasal passage, Trachea, Bronchi, Lungs and diaphragm.

The air for respiration is drawn into our body through the nostrils present in the nose. This air then goes into nasal passage. When air passes through the nasal passage, the dust particles and other impurities present in it are trapped by nasal hair and mucus so that clear air goes into the lungs. The part of throat between the mouth and wind pipe is called pharynx. From the nasal passage, air enters into pharynx and then goes into the wind pipe.

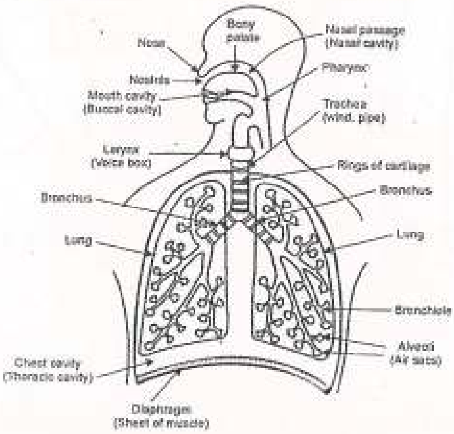


Fig: 11.8 Human respiratory system

Wind pipe is commonly known as trachea. The trachea consists of rings of cartilage muscles, which prevents it from collapsing when we inhale the air. The trachea is further divided into two parts before entering into two lungs called bronchi. The two bronchi are connected to the two lungs. The lungs lie in the chest cavity or thoracic cavity which is separated from abdominal cavity by a muscular partition called diaphragm. The lungs are covered by two thin membranes called **pleura**. The bronchi when enters into the lungs, it gets further subdivided into smaller capillaries called **bronchioles**, which finally terminates in balloon like structure called alveoli. The presence of millions of alveoli in the lungs provides a very large area for the exchange of gases. The blood brings carbon dioxide from the rest of the body and release in into lungs and takes up oxygen from lungs and carries it back to the body. The diaphragm helps in 'breathing in' and 'breathing out'. The proportions of oxygen, carbon dioxide and water vapour in 'inhaled air' 'exhaled air' are given below :

Inhaled air		
Oxygen	:	21 %
Carbon	:	0.04%
Water vapour	:	A little

Exhaled Air		
Oxygen	:	16.4%
Carbon dioxide	:	4.4%
Water vapour	:	A lot

Notes:

1. The average breathing rate in an adult man at rest is about 15 to 18 times per minute.
2. The deficiency of haemoglobin in the blood of a person reduces the oxygen-carrying capacity of blood resulting in breathing problems, tiredness and lack of energy
3. Carbon monoxide binds very strongly with haemoglobin in the blood and prevents it from carrying oxygen to the brain and other parts of the body.

Transportation

Transport means to carry things from one place to another. In biology, 'Transport is a life process in which a substance absorbed (or made) in one part of the body of an organism is carried to other parts of its body.

Transportation in plants

Transport system in plants is less elaborate than in animals, plants are less active, so their cells do not need to be supplied with materials so quickly.

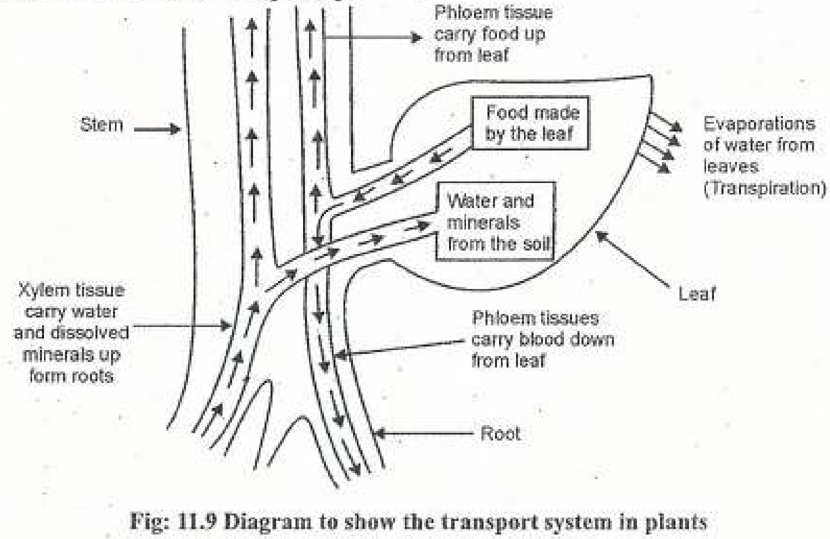


Fig: 11.9 Diagram to show the transport system in plants

The only substances which are to be supplied to a plant through a transport system are water and minerals. The plants have two types of conducting tissues called xylem and phloem. Xylem tissues carry water and minerals whereas phloem tissues carry the food prepared by the plants. The transport of minerals in a plant can be divided into parts:

(i) Transport of water and minerals and

(ii) Transport of food and other substances (like hormones).

(i) **Transport of water and minerals:** Water and minerals are taken from the soil and transported to the upper part of the plant through xylem tissue. Xylem tissue consist two types of elements called. **Xylem vessels** and **tracheids**. Xylem vessel is a non living, long tube which runs like a drain pipe through the plant and Tracheids are non living, long, thin, spindle shaped cells with pits in their thick cell walls.

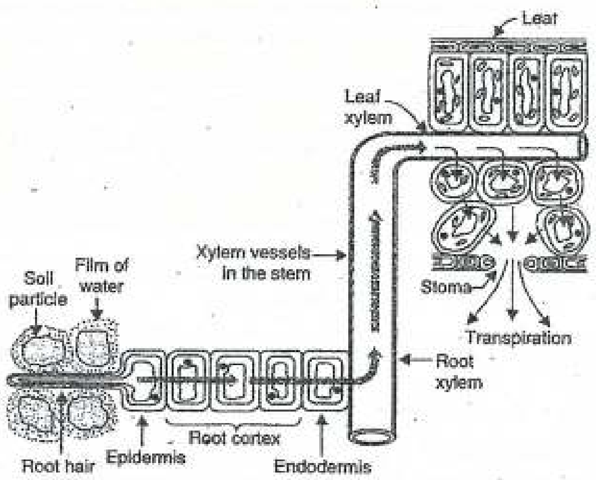


Fig: 11.10 To show how water (and dissolved minerals) are transported from the soil up the leaf of a plant

The roots of a plant have hair called root hairs. Root hairs absorb water and minerals from the soil. Water get into the root hairs by the process of diffusion. The water and minerals absorbed by the root hair from the soil pass from cell to cell by osmosis through the epidermis, root cortex, endodermis and reach the root xylem. The xylem vessels of the plant are connected to the xylem vessels of its stem. So, the water enters from the root xylem vessels to stem xylem vessels and then reach up to the leaves through the branched xylem vessels which enter from the petiole into each and every part of the leaf. Only about 1% to 2% of the water absorbed by the plant is used up by the plant in photosynthesis and other metabolic activities. The rest of water is lost as water vapour to the air through transpiration.

Note: **The loss of the water in the form of vapour from the aerial parts of the plants is known as transpiration.** Transpiration helps in the absorption and upward movement of water and minerals dissolved in it from roots to the leaves. It also helps in temperature regulation.

Transport of food and other substances: The other vascular tissue, phloem transports the prepared food materials from leaves to the other parts of the plant. **The transport of food from the leaves to other parts of the plant is called translocation.** The phloem tissue consist of **sieve tube, companion cells** and **phloem parenchyma.** Like xylem vessels, phloem is made of many cells joined end to end to form long tubes. **Sieve tubes which form phloem are living cells which contain cytoplasm but no nucleus.** The translocation of food and other substances takes place in the sieve tubes with the help of adjacent companion cells both in upward and downward directions the movenent of food in phloem takes place by utilizing energy.

The sugar (food) made in leaves is loaded into the sieve tubes of phloem tissue by using energy from ATP water now enters into sieve tubes containing sugar by the process of osmosis due to which the presence in the phloem tissue rises. This high pressure moves the food to all the parts of the plant having less pressure in their tissues.

Note: The movement of water (and dissolved salts) in xylem is always upwards (from soil to leaves) whereas the movement of food in phloem can be, however, upwards or downwards depending on the needs of the plant.

Transportation in human beings (human circulatory system)

The human blood circulatory system consists of the heart and the blood vessels through which the blood flows in the body. The blood flows through three types of blood vessels:

(i) Arteries

(ii) Veins and

(iii) Capillaries

In addition to blood circulatory system there is another system called lymphatic system which also helps in the transport of materials. The liquid which circulates and carries materials in the lymphatic system is called lymph. Thus, **in human beings the various substance are transported through the two liquids called blood and lymph.**

Blood: Blood is a connective tissue. Blood consists of four things:

1. Plasma
2. Red Blood Corpuscles (or Red Blood Cells)
3. White Blood Corpuscles (or White Blood Cells) and
4. Platelets

- The liquid part of blood is called plasma. Plasma is a colourless liquid which consists mainly of water with many substance dissolved in it. Plasma carries these substances from one part to another part in the body. Red blood cells, white blood cells and platelets are immersed in this liquid.
- Red blood cells carry oxygen from the lungs to all the cells of the body. Red blood cells do not have nuclei.
- White blood cells protect us from diseases white blood cells are called soldiers of the body.
- Platelets are the tiny fragments of special cells formed in the bone marrow. Platelets do not have nuclei. Platelets help in the coagulation of blood in a cut or wound.

Lymph: Lymphatic system consists of the following parts:

(i) Lymph capillaries

(ii) Larger lymph vessels

(iii) Lymph nodes (or Lymph glands) and

(iv) Lymph

Lymph is another medium of circulation in the human body. **But lymph flows in only one direction-from body tissues to the heart.** Lymph is colourless and contains less protein. Lymph drains into lymphatic capillaries from the intercellular spaces, which join to form large lymph vessels that finally open into larger veins. Lymph contains a special type of white blood cells called lymphocytes which help in fighting infection and disease. Lymph also helps in removing the waste products like fragments of dead cells etc.

Transport in human

The organ system of human beings (and other animals) which is responsible for the transport of materials inside the body is called circulatory system.

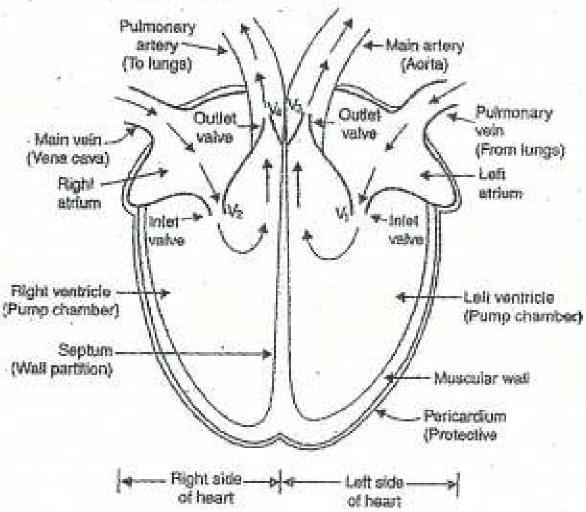


Fig: 11.11 Diagram to show the inside structure of human heart

Human circulatory system, consists of heart and blood capillaries. The human heart is divided into four parts, called chambers. The four chambers of heart are left and right auricles and left and right ventricles. It is divided into two parts, by a thick layer of membrane, called **septum.** The left and right auricles and ventricles are connected with each other by a small opening called **valves.** The oxygenated blood from lungs enters into the heart through left auricles via pulmonary veins. When the left auricles contracts blood is transferred to the left ventricles which expands. When the ventricles contracts the blood is pumped into the aorta for circulation to different parts of the body. The back flow of the blood is prevented by the closing of valves. After circulation through the body, the deoxygenated blood returns to the heart via **vena cava** into right auricles. When the auricles contracted the blood is forced into right ventricles through small opening called **valves.** This impure blood from right ventricles returns to lungs via **pulmonary artery,** where it is purified. This process continues throughout life of the human beings.

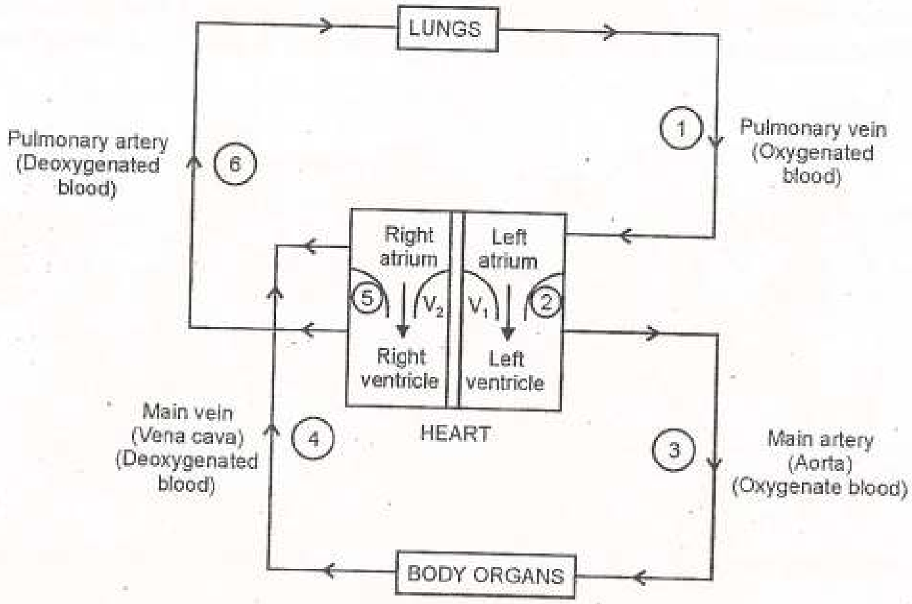


Fig: 11.12 Diagram to show blood circulation in human body

Note: **Heart beat:** One complete contraction and relaxation of the heart is called a heart beats. Average number of heart beats of person at rest is about 70 to 72 per minute.

Pulse: The expansion of an artery each time the blood is forced into it, is called pulse. The pulse rate is also in an adult person is 70 to 72 per minute.

Blood pressure: The pressure at which blood is pumped around the body by the heart is called blood pressure. Blood pressure of a person is always expressed in the form of two values called **Systolic pressure** and **diastolic pressure.** The maximum pressure at which the blood leaves the heart through the main artery during contraction phase, is called the systolic pressure. The minimum pressure in the arteries during the relaxation phase of heart is called the diastolic pressure. The normal blood pressure values are :

Systolic pressure = 120 mm Hg

Diastolic pressure = 80 mm Hg

This value is written as 120/80. Blood pressure is measured by using an instrument called sphygnomanometer.

Excretion

The process of removal of toxic wastes from the body of an organism is called excretion. Excretion takes place in plants as well as in animals.

Excretion in humans

The major wastes produced by the human body are : Carbon dioxide and urea. The human body has different organs for the removal of wastes from our body. These are lungs and kidneys. **Our lungs excrete carbon dioxide. Our kidneys excrete urea**. Skin is also an importent excretory organ.

Bowman's capsule is a double walled cup like structure, which surrounds the dense network of blood capillaries called **the glomerulus**. Some substance in the initial filtrate, such as glucose, amino acids, salts and major amount of water are selectively reabsorbed as the urine flows along the tube. The amount of water reabsorbed depends on how much excess water is there in the body and how much of dissolved waste is there to be excreted. The urine forming in each kidney eventually enters a long tube, **the ureter**, which connects the kidneys with the **urinary bladder**. Urine as stored in the urinary bladder until the pressure of the expand bladder leads to the urge to pass it out through **urethra.**

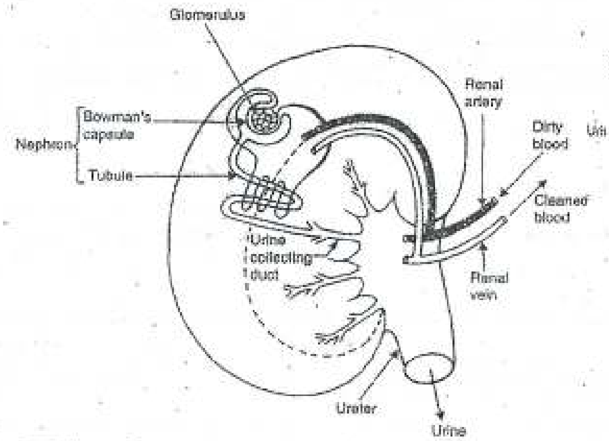


Fig: 11.13 The structure of kidney

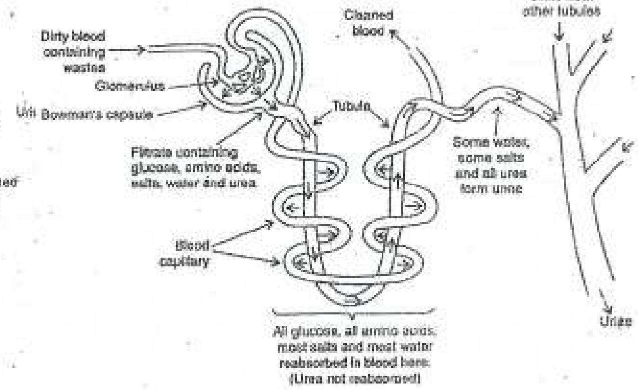


Fig: 11.14 Working of human excretory system

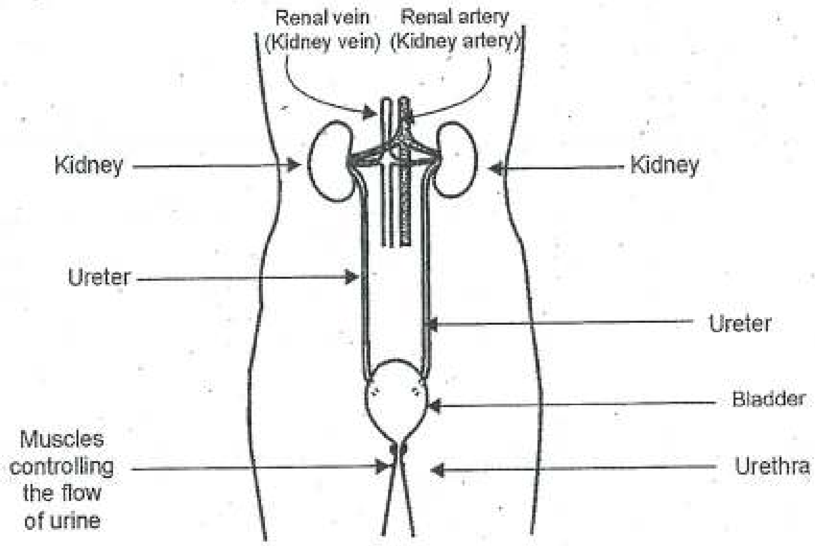


Fig: 11.15 Human excretory system (or urinary system)

Kidney is a bean shaped organ, which lies in the abdominal cavity one on each side of the vertebral column. Each of them is about 10 cm long and 150g in weight. It is enclosed in a thin, fibrous covering called the **capsule.** A renal artery brings blood into the kidney along with nitrogenous waste materials, which after filtration in the kidney leaves the kidney through a renal vein. The outer region of kidney is called **cortex** and inner region is called **medulla**. Each kidney is made up of numerous coiled excretory tubules, called **nephrons which is the structural and functional unit of kidney.** It performs three functions, such as **filtration, reabsorption** and **secretion.** A nephron consists of a long tubules and the **Malpighion corpuscle.** The proximal end of the tubules consist of **Bowman's capsule and the glomerulus.**

Dialysis: Sometime, it is possible, kidney may get damaged due to infection, injuries and extreme blood pressure. **The procedure used for cleaning the blood of a person by separating the waste substance (urea) from it is called dialysis.**

The blood from an artery in the patient's arm is made to flow into the dialyser of a dialysis machine made of long tubes of selectively permeable membrane (like cellulose) which are coiled in tank containing dialysing solution The dialysing solution contains water, glucose and salts in similar concentrations to those in normal blood. As the patient's blood passes through the dialysing solution, most of the wastes like urea present in it pass through the selectively permeable cellulose tubes into the dialysing solution. The clear blood is pumped back into a vein of the patient's arm.

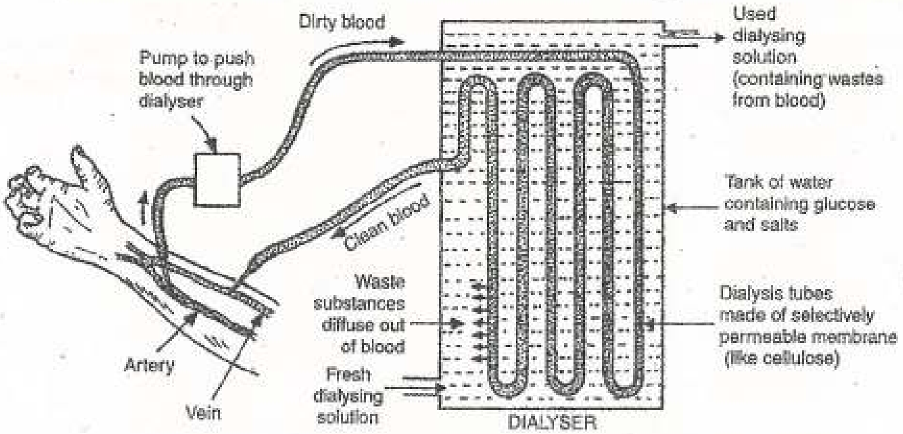


Fig: 11.16 The principle of the kidney dialysis machine

Excretion in plants

The plants have no special organ for waste removal like the animals. Plants produce waste products very slowly and in very small amounts. The main waste products produced by plants are carbon dioxide, water vapour and oxygen. Plant remove their waste products by different methods :

(i) The plants get rid of gaseous waste products through stomata in leaves and lenticels in stems.

(ii) The plants get rid of stored solid and liquid wastes by the shedding of leaves, peeling of bark and falling of fruits.

(iii) The plants get rid of wastes by secreting them in the form gums and resin.

(iv) Plants also excrete some waste substances into the soil around them.

Excretion in animals

Different animals have different arrangements for excretion:

1. In amoeba (and other single celled animals), the waste material is carbon dioxide which is removed by diffusion through the cell membrane, but nitrogenous wastes (like ammonia) and excess water are removed by the contractile vacuole.
2. In the earthworm, the tubular structures called nephridia are the excretory organs. In addition to nephridia, the moist skin of earthworm also acts as an excretory organ.

Key Points

- ✓ Movement is one of the most important signs of life in an organism.
- ✓ The sequence of process which is followed to maintain in the life process are nutrition; respiration, transportation and excretion of wastes.
- ✓ In human beings, the food eaten is broken down by various steps along the alimentary canal and the digested food in absorbed in the small intestine to be sent to all cells in the body.
- ✓ The two modes of nutrition are autotrophic and heterotrophic.
- ✓ During the process of respiration, complex organic compounds are broken down to provide energy in the form of ATP.
- ✓ Respiration may be aerobic or anaerobic.
- ✓ In human beings circulatory system consists of the heart, blood and blood vessels.
- ✓ In plants transportation occurs through the xylem and phloem.
- ✓ In human beings excretory products in the form of soluble nitrogen compounds are removed by the nephrons in the kidneys.
- ✓ Plants use a variety of techniques to get rid of waste material. For example waste material may be stored in the cell vacuoles or as gum and resin, removed in the falling leaves or excreted into the surrounding soil.

Multiple Choice Questions

1. The autotrophic mode of nutrition requires
   (a) Sunlight
   (b) Chlorophyll
   (c) Carbon dioxide and water
   (d) All of the above
2. The process of obtaining food by Amoeba in known as
   (a) Dialysis
   (b) Cytokinesis
   (c) phagocytosis
   (d) amoebasis
3. Which among the following has holozoic mode of nutrition
   (a) Diatoms
   (b) Cliates
   (c) Colpidium
   (d) Water molds
4. Which of the following has the longest small intestine ?
   (a) Carnivore
   (b) Omnivore
   (c) Herbivore
   (d) Autotroph
5. The length of small intestine in a human adult is about
   (a) 4.5 m
   (b) 1.5 m
   (c) 3.5 m
   (d) 6.5 m
6. The correct order of steps occurring in nutrition in animals is
   (a) Ingestion → Digestion → Assimilation → Absorption → Egestion
   (b) Ingestion → Digestion → Absorption → Assimilation → Egestion
   (c) Ingestion → Absorption → Digestion → Assimilation → Egestion
   (d) Ingestion → Assimilation → Digestion → Absorption → Egestion
7. In human digestive system, the enzymes pepsin and tryspin are secreted respectively by
   (a) Pancreas and gall bladder
   (b) Stomach and pancreas
   (c) Stomach and salivary glands
   (d) Pancreas and liver
8. If the salvia is lacking in salivary amylase, then which of the following processes taking place in the buccal cavity will be affected ?
   (a) Proteins breaking down into amino acids
   (b) Starch breaking down into sugars
   (c) Fats breaking down into fatty acids and glycerol
   (d) Internal layer breaking down leading to ulcers
9. Which of the following is the correct sequence of parts as they occur in the human alimentary canal?
   (a) Mouth → stomach → oesophagus → small intestine → large intestine
   (b) Mouth → stomach → small intestine → oesophagus → large intestine
   (c) Mouth → oesophagus → stomach → small intestine → large intestine
   (d) Mouth → oesophagus → stomach → large intestine → small intestine
10. Which of the following events does not occur in photosynthesis ?
    (a) Conversion of light energy into chemical energy
    (b) Oxidation of carbon to carbon dioxide

(c) Reduction of carbon dioxide to carbohydrates

(d) Absorption of light energy of chlorophyll

11. Match the organism given in column I with the processes given in column II

Column-I	Column-II
(i) Leech	(A) Holozoic nutrition
(ii) Amoeba	(B) Autotrophic nutrition
(iii) Mushroom	(C) Parasitic nutrition
(iv) Green plant	(D) Saprophytic nutrition

(a) (i) → C, (ii) → A, (iii) → D, (iv) → B
(b) (i) → B, (ii) → C, (iii) → D, (iv) → A
(c) (i) → C, (ii) → D, (iii) → B, (iv) → A
(d) (i) → D, (ii) → B, (iii) → A, (iv) → C

12. In which of the following groups of organism the food material is broken down outside the body and then absorbed ?

(a) Mushroom, Green plants, Amoeba
(b) Paramecium, Amoeba, Cuscutta
(c) Yeast, Mushroom, Bread mould
(d) Cuscutta, Lice, Tapeworm

13. The xylem in plants are responsible for

(a) Transport of oxygen
(b) Transport of water
(c) Transport of food
(d) Transport of amino acids

14. Internal respiration may be defined as

(a) Breathing in and releasing of oxygen in the tissue
(b) Getting rid of carbon dioxide that would accumulate in the tissues
(c) The oxidation of food substances to release energy
(d) The building up (synthesis) of complex substances

15. Which of the following is the correct sequence of air passage during inhalation ?

(a) Nostrils → larynx → pharynx → trachea → lungs
(b) Nostrils → pharynx → larynx → trachea → alveoli
(c) Nasal passage → trachea → pharynx → larynx → alveoli
(d) Larynx → nostrils → pharynx → lungs

16. The two organism which breathe only through their moist skin are

(a) Fish and frog
(b) Leech and earthworm
(c) Frog and earthworm
(d) Fish and earthworm

17. The photosynthesis in a plant is not taking place during the day time if the plant is releasing :

(a) Water vapour
(b) Carbon dioxide
(c) Oxygen
(d) All the above

18. The breathing and respiration in woody stem of a plant takes place through

(a) Lenticels
(b) Root hairs
(c) Closed stomata
(d) Open stomata

19. The end product of glycolysis is

(a) Pyruvate
(b) ATP
(c) ADP
(d) Lactic acid

20. During marathon, we sometimes get painful contractions of leg muscles due to the accumulation of one of the following in leg muscles. This is
    (a) Alcohol
    (b) Lactose
    (c) Lactic acid
    (d) Carbon dioxide
21. In cockroaches, air enters the body through
    (a) Lungs
    (b) Gills
    (c) Skin
    (d) Spiracles
22. The breakdown of pyruvate to give carbon dioxide, water and energy takes place in
    (a) Chloroplast
    (b) Nucleus
    (c) Cytoplasm
    (d) Mitochondria
23. Which type of respiration takes place in mitochondria ?
    (a) Aerobic
    (b) Anaerobic
    (c) Reduction
    (d) All of these
24. One of the following does not have a nucleus. This one is
    (a) Red blood cell
    (b) White blood cell
    (c) Guard cell
    (d) Epidermal cell
25. The lungs are covered in two thin membranes called
    (a) Alveoli
    (b) Thoracic cavity
    (c) Ventilator
    (d) Pleura
26. Ultrafiltration occurs in
    (a) Henle's loop
    (b) Proximal convoluted tubule
    (c) Distal convoluted tubule
    (d) Bowman's capsule
27. Match the column A to column B

Column A	Column B
(A) Aerobic respiration	1. Trachea
(B) Cartilaginous rings	2. Xylem
(C) Transport of hormones	3. Presence of oxygen
(D) Ascent of rap	4. Blood

	A	B	C	D
(a)	1	2	3	4
(b)	3	1	4	2
(c)	3	2	1	4
(d)	2	4	3	2

28. One of the following is not a constituent of blood. This one is
    (a) Platelets
    (b) Sieve plates
    (c) Red blood cells
    (d) White blood cells
29. Which vein brings clean blood from the lungs into the heart?
    (a) Renal vein
    (b) Hepatic vein
    (c) Pulmonary vein
    (d) Vena cava

30. Which blood vessel does not carry any carbon dioxide?
(a) Pulmonary artery
(b) Pulmonary vein
(c) Vena cava
(d) Hepatic vein

31. If a patient is put on dialysis, he is most likely suffering from a severe aliment of the
(a) Circulatory system
(b) Excretory system
(c) Digestive system
(d) Respiratory system

32. Which one of the following has cytoplasm but no nucleus
(a) Xylem vessel
(b) Tracheid
(c) Companion
(d) Sieve tube

33. The process of carrying food from the leaves to other parts of a plant is called
(a) Transportation
(b) Translocation
(c) Transpiration
(d) Transformation

34. Which of the following is the only conducting tissue is non-flowering plants ?
(a) Sieve tubes
(b) Tracheids
(c) Xylem vessels
(d) Companion cells

35. Which one of following does not have valves ?
(a) Heart
(b) Veins
(c) Arteries
(d) Capillaries

36. Coagulation of blood in a cut or wound is brough about by
(a) RBC
(b) WBC
(c) Platelets
(d) Plasma

37. The instrument for measuring blood pressure is called
(a) Manometer
(b) Barometer
(c) Potentiometer
(d) Sphygmomano meter

38. The excretory unit in the human excretory system is called
(a) Neuron
(b) Nephron
(c) Nephridia
(d) Kidneyon

39. What prevents the backflow of blood inside the heart during contraction ?
(a) Thin wall of atria
(b) Thick muscular walls of ventricles
(c) Valves
(d) All of the above

40. Which of the following is the correct path taken by urine in our body ?
(a) Kidney → water → urethra → bladder
(b) Kidney → water → bladder → urethra
(c) Kidney → bladder → urethra → ureter
(d) Balder → kidney → ureter → urethra

41. The substance which is not reabsorbed into the blood capillaries surrounding the tubule of a nephron is mainly
(a) Glucose
(b) Urea
(c) Water
(d) Amino acid

42. The wave of expansion of an artery when blood is forced into it is called
   (a) Heart beat
   (b) Pulse
   (c) Flow
   (d) Ticking

43. An animal having double circulation in three-chambered heart is
   (a) Snake
   (b) Deer
   (c) Sparrow
   (d) Fish

44. Which of the following statements are correct ?
   (i) Pyruvate can be converted into ethanol and carbon dioxide by yeast
   (ii) Fermentation takes place in the case of aerobic bacteria
   (iii) Fermentation takes place in mitochondria
   (iv) Fermentation is a form of anaerobic respiration
   (a) (i) and (iii)
   (b) (i) and (iv)
   (c) (ii) and (iv)
   (d) (ii) and (iii)

45. The opening and closing of the stomatal pores depends upon
   (a) Oxygen
   (b) Temperature
   (c) Water in guard cell
   (d) Concentration of CO_2 in stomata

Answers Key

1. (d)	2. (c)	3. (c)	4. (c)	5. (d)	6. (b)	7. (b)	8. (b)	9. (c)	10. (b)
11. (a)	12. (c)	13. (b)	14. (c)	15. (b)	16. (b)	17. (b)	18. (a)	19. (a)	20. (c)
21. (d)	22. (d)	23. (a)	24. (a)	25. (d)	26. (d)	27. (b)	28. (b)	29. (c)	30. (b)
31. (b)	32. (d)	33. (b)	34. (b)	35. (d)	36. (c)	37. (d)	38. (b)	39. (c)	40. (b)
41. (b)	42. (b)	43. (a)	44. (b)	45. (c)					

12. Reproduction in Organism

Learning Objectives

* Do Organisims Create Exact Copies of Themselves
    * Importance of variation
* Types of Reproduction
    * Asexual reproduction
    * Fission
    * Budding
    * Spore formation
    * Regeneration
    * Fragmentation
    * Vegetative Propagation
    * Sexual reproduction
* Sexual Reproduction in Flowering Plants
* Sexual Reproduction in Human Beings - MAle and Female
* Birth Control Methods
    * Barrier methods
    * Chemical methods
    * Intra uterine contraceptive device (IUCD)
    * Surgical methods
* Sexually Transmitted Diseases (STD)

Every living organism have a certain life span after which it dies. So new organisms have to be produced in place of the dead organisms. Thus the production of new organism from pre existing organisms of the same species is known as **reproduction.**

The reproduction ensures the continuity of life on earth. It gives rise to more organism with same basic characteristics as their parents.

Do organisms Create Exact Copies of Themselves?

Organisms look similar, because their body designs should be similar. If the design are to be similar, the blue print for these designs should be similar. Thus the reproduction at its most basic level will involve making copies of the blueprints of body designs.

The **DNA** in the cell nucleus is the information source for making proteins. If the information is changed, different proteins will be made which eventually lead to altered body designs. Therefore, basic events in reproduction is the creation of **DNA copy.**

Cells use the chemical reactions to build copies of their **DNA.** They create two copies of the DNA in a reproducing cell which need to be separated from each other. However, keeping one copy of DNA in the original cell and simply pushing the other one out would not work, because the copy pushed out would not have any organised cellular structure for maintaining life process. Therefore, DNA copying is accompanied by the creation of an additional cellular apparatus. The DNA copies separate, each of its own cellular apparatus, effectively a cells divides to give rise to two cells.

Importance of Variation

The importance of variations in organisms introduced during reproduction is that it helps the species of various organisms to survive and flourish even in adverse environment. For example, There may be some drastic changes like excessive heat or cold or shortage of water etc. If all the organisms of a population living in that habitat are exactly identical, then there is danger that all of them may die and no one would survive under those conditions. However if some variations were to present in a few individuals in these populations, there would be some chance for them to survive. Thus, if there were a population of bacteria living in temperature waters, and if the water temperature were to be increased by global warming, most of these bacteria would die, but the few variants resistant to heat would survive and grow further. Variation is thus useful for the survival of species over time.

Types of Reproduction

There are two modes of reproduction in living organisms such a **asexual** and **sexual** reproduction. In case of asexual reproduction, the offspring arises from a single parent. Whereas in sexual reproduction the offspring arises from two parents of different sexes : a male sex, a female sex.

For example: Binary fission in amoeba in Hydra etc. whereas in sexual reproduction, the sex cell of one parent fuses with the sex cell of the other parent to form a new cell called 'Zygote'. The zygote grows and develops to form a new organism.

Asexual Reproduction

The production of new organism from a single parent without the involvement of sex cells (or gametes) is called asexual reproduction. In asexual reproduction, certain body cells of the parent organism undergo repeated mitotic cell divisions to form two (or more) new organism of the same kind. Asexual reproduction takes placed by six different methods.

There are:

(i) Fission
(ii) Budding
(iii) Spore formation
(iv) Regeneration
(v) Fragmentation
(vi) Vegetative propagation

Fission

Many single celled organisms like protozoa and bacteria just split (or break) into two identical halves during cell division, leading to the creation of new organisms. This is called fission. The types of fission are:

(a) Binary fission: In this methods single divides to form two new organism. The unicellular organisms like amoeba, paramecium, leishmania, bacteria etc. reproduce by binary fission. In amoeba, the splitting of the two cells during division can take place in any plane.

Amoeba reproducing by binary fission, two daughter cells.

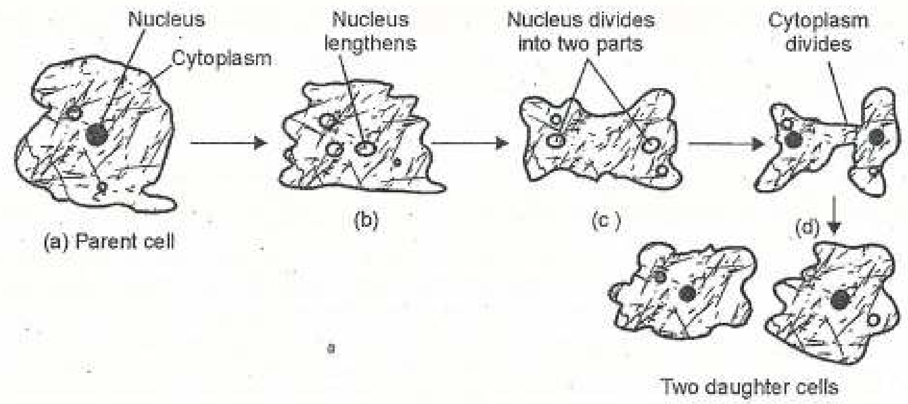


Fig: 12.1 Amoeba reproducing by binary fission

(b) Multiple fission: In this method 'the parent organism spilts to form many new organism at the same time.' For example, plasmodium reproduce by this method.

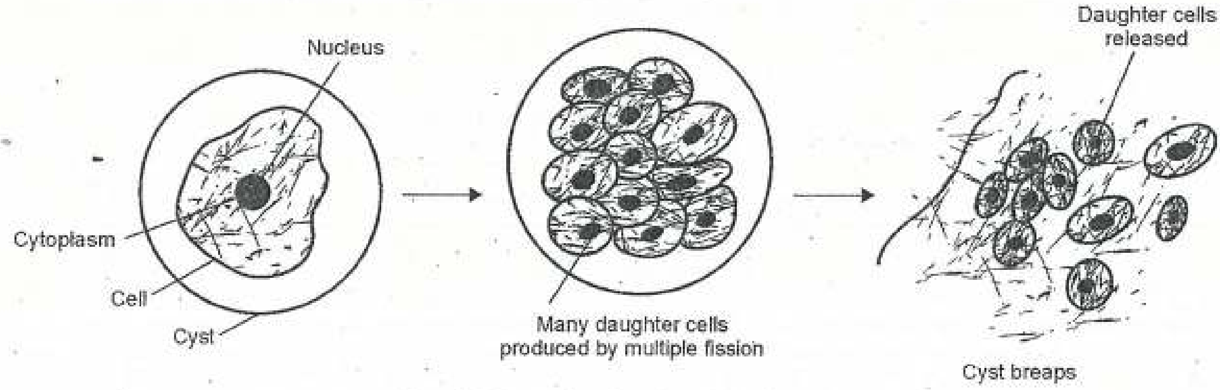


Fig: 12.2 Reproduction of multiple fission

Budding

In budding, 'small part of the body of the parent organism grows out as 'bud' which then detaches and becomes a new organism.'

The asexual reproduction by budding is observed in hydra and yeast.

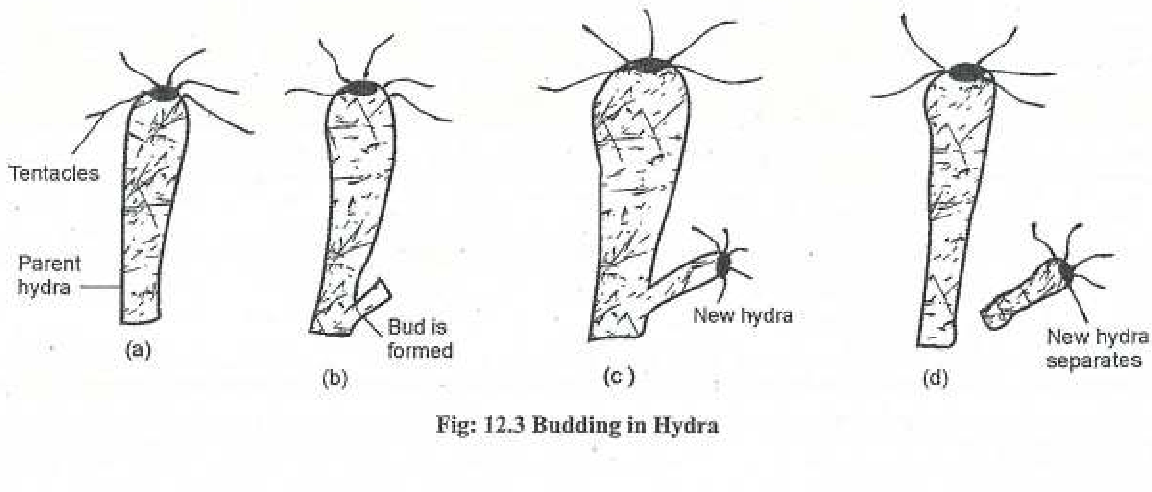


Fig: 12.3 Budding in Hydra

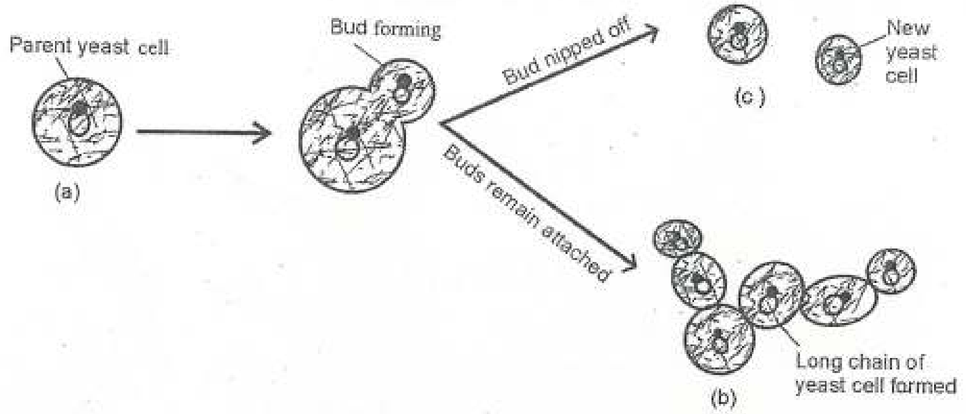


Fig: 12.4 Yeart reproducing by budding

Spore formation

In spore formation, 'the parent plant produces hundreds of microscope reproductive units called 'Spores'. When the spore case of the plant burst, then the spores spread into air, with the favourable conditions, these spores germinate to develop into the new plant. Most of the fungi (like Rhizopus, mucor etc.), bacteria and non-flowering plants such as ferns and mosses reproduce by the method of spore formation.

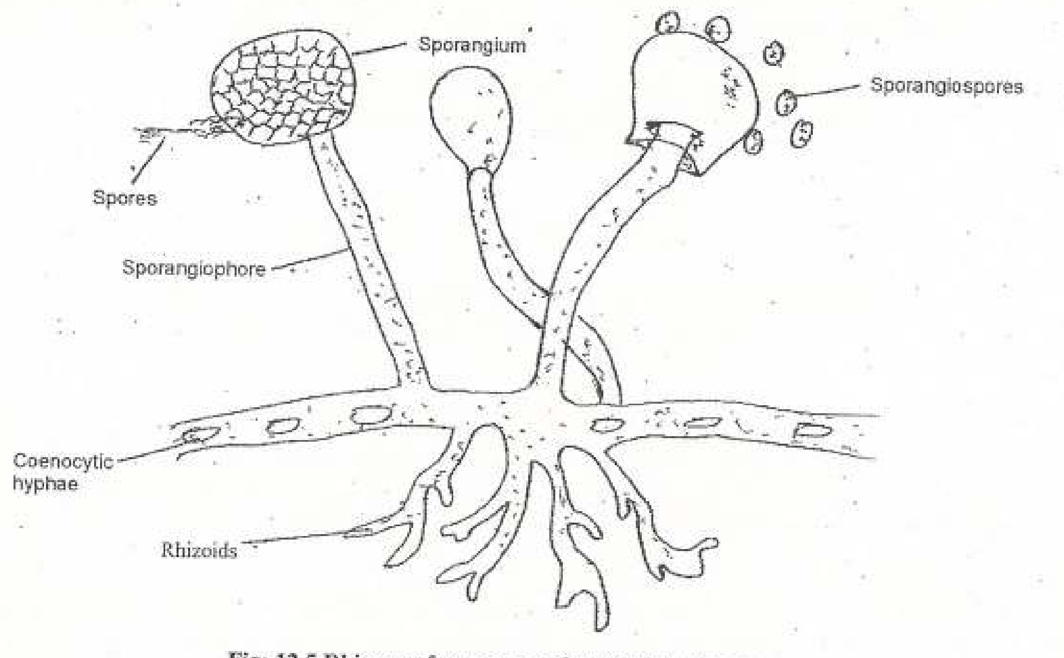


Fig: 12.5 Rhizopus fungus reproduce by forming spores

Regeneration

The process of getting back a full organism from its body parts is called regeneration. For example, simple animals like Hydra and Planaria can be cut into any number of pieces and each piece grows into a complete organism. This method of reproduction is not possible for the complex multi-cellular organism. However, regeneration is not the same as reproduction, since most organisms would not normally depend on being cut up to be able to reproduce.

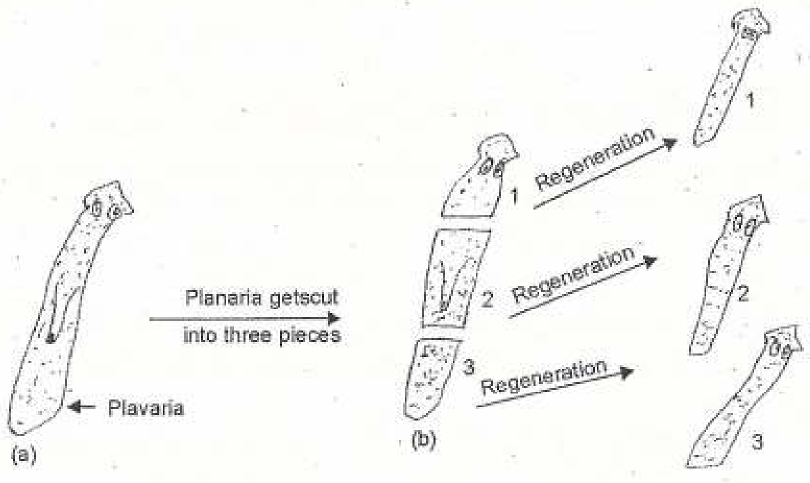


Fig: 12.6 Regeneration in Planaria

Fragmentation

The breaking up of the body of a multi-cellular organism into two (for more) piece on maturing each of which subsequently grows to form a complete new organism, is called fragmentation.

The organism like **spirogyra** and **Sea anemones** can reproduce by the method of fragmentation.

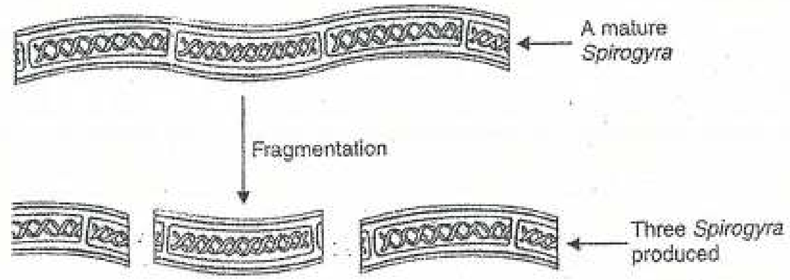


Fig: 12.7 Spirogyra reproduce by the method of fragmentation

Note: The main difference between fission and fragmentation is that in fission, a unicellular organism breaks up to form two (or more) daughter organisms, whereas in fragmentation, a multi-cellular organism breaks up to form two (or more) daughter organisms.

Vegetative propagation

In this method, new plants are obtained from the parts of old plants either of the steams, roots, leaves etc. develop roots on favourable conditions and grows into a new plant, without the help of any reproductive organs. For example, The green grass grows in the fields after rains from the dry, old stems of grass plants present in the fields, by this method of Bryophyllum plants can reproduce by a piece of its stem or its leaves, Money plant can also be grown by this method by using piece of its stem.

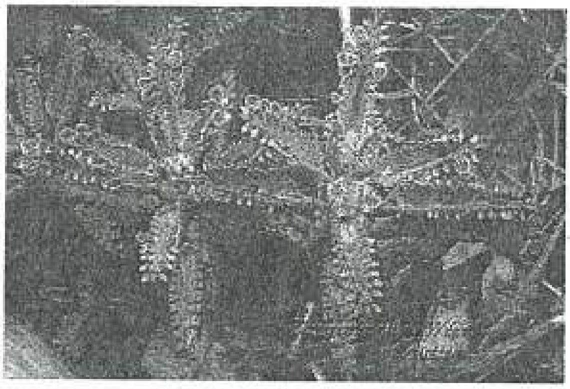
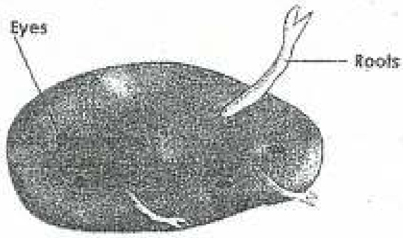


Fig: 12.8 Vegetative propagation in Bryophyllum plants

Such method also make possible, the propagation of plants such as banana, orange, rose, jasmine, guava, onion and potato tuber



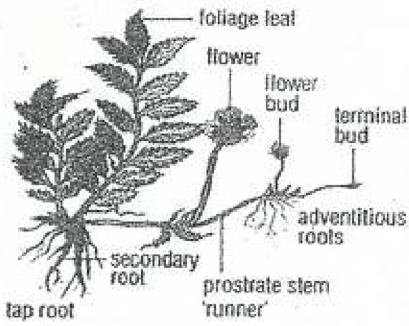


Fig: 12.9 Vegetative propagation in potato

Note: The vegetative propagation method of producing potato plant by tubers is much faster than the production of potato plants from seeds.

Tissue culture: 'The production of new plants from a small piece of plants tissue (or cells) removed from the growing tips of a plant in a suitable growth medium (called culture solution) is called tissue culture,

The process of tissue culture is carried out as follows :

1. The cells are placed in an artificial medium where they divide rapidly to form a small group of cells or **callus.**
2. The callus is transferred to another medium containing hormones for growth and differentiation.
3. The callus having roots and shoots separates into tiny plantlets, many tiny plantlets are produced from just a few original plant cells (or tissue).

4. The plantlets thus produced are transplanted into pots or soil where they can grow to from mature plants.

Using tissue culture, many plants can be grown from one parent in disease free conditions. This technique is commonly used for ornamental plants.

Sexual Reproduction

Sexual reproduction takes place by the combination of special reproductive cells called 'Sex cells'. In this reproduction both male and female are involved. The female egg cell fuse with the male egg cell to form **Zygote,** which then develops into the new individual.

Why the amount of DNA does not get doubled during sexual reproduction: In sexual reproduction, though the genetic material DNA (in the form of chromosomes) from two gametes, male and female gametes, combines to form a new cells 'Zygote' but the amount of DNA in Zygote does not get doubled. This can explained as follows: The gametes are special type of cells called reproductive cells which contain only half the amount of DNA (or half the number of chromosomes) as compared to the normal body cells of an organism. So when a male gamete combines with a female gamete then the new cell 'Zygote' will have the normal amount of the DNA. For example, the human sperm has 23 chromosomes and the human egg (or ovum) has also 23 chromosomes. So, when a sperm and an egg fuse together during fertilisation, then the zygote formed will have 23 + 23 = 46 chromosomes, which is the normal number of chromosomes.

Sexual reproduction in flowering plants

The following plants reproduce though 'sexual reproduction' method. The sex organs (or reproductive organs) of a plant are in its flowers.

The function of a flower is to make male and female gametes and to ensure that fertilisation will to be place to make new seeds for the reproduction of plant. The main parts of a flower are : **Receptacle, Sepals, Stamen and Carpel.**

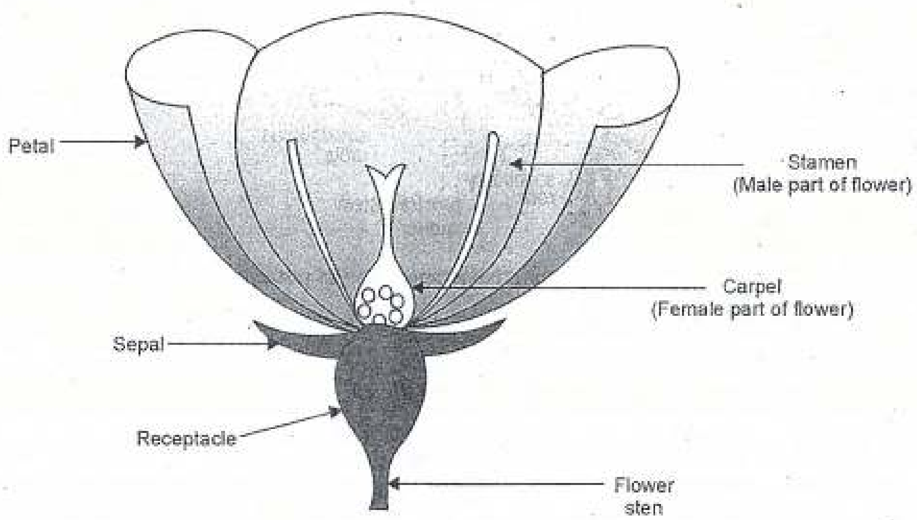


Fig: 12.10 Parts of a flower

Stamen is the male reproductive organ of the plant and the male gametes of a plant are made in the anther of stamen.

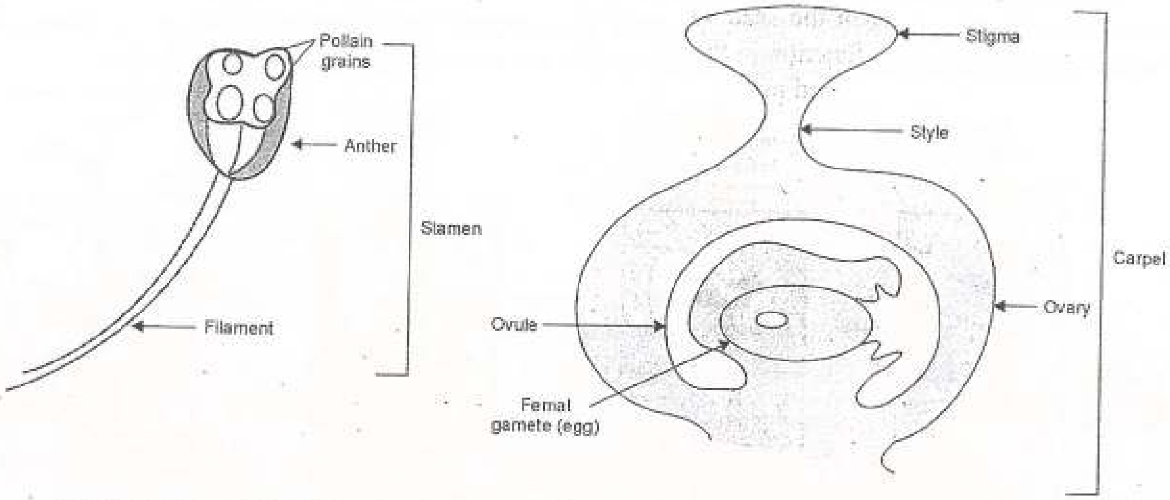


Fig: 12.11 Stamen : Male reproductive organ of plant Carpel : Female reproductive organ of plant

Carpel is also called Pistil. It is the female reproductive organ of the plant and female gametes are made in the ovary of carpel.

Note: The flower which contain only one sex organ, either stamens or carpel are called unisexual flowers. **The flowers of papaya and water melon plants are unisexual flowers.**

On the other hand, the flowers which contain both the sex organs, stamens are well as carpel, are called bisexual flowers. **The flowers of Hibiscus and mustard plants are bisexual flower.**

A new seed of the plant is formed when the male gamete present in a pollen grain unites with the female gamete present in the ovule. This happens in two steps : pollination and fertilisation.

***Pollination*: The transfer of pollen grains from the anther of stamen to the stigma of a carpel is called Pollination.** Pollination can occur in two ways: self pollination, and cross pollination.

'When the pollen grains from the anther of a flower are transferred to the stigma of the same flower (or another flower on the same plant), it is called self- pollination.'

"When the pollen grains from the anther of a flower on one plant are transferred to the stigma of a flower on another similar plant, it is called cross pollination.' Pollination is done by insects (like bees and butterflies), birds, wind and water.

Fertilisation: After a pollen grain falls on the stigma, the next step is fertilization. **Fertilisation occurs when the male gamete present in pollen grains joins with the female gamete (or egg) prevent in ovule.** This happens as follows:

When a pollen grains falls on the stigma of the carpel, it burst open and grows a pollen tube downwards through the style towards the female gamete in the ovary.

Formation of fruits and seeds: After fertilisation, the zygote divides several times to form an embryo within the ovule. **The ovule develops a tough coat and is gradually converted into seed. The ovary grows rapidly and ripens to form a fruit.** Mean while, the petals, sepals, stamens, style and stigma may shrivel and fall off.

Germination of seeds: The seeds obtained from a plant are usually very dry. In this dry state, the seeds can remain alive but inactive for long periods. When a seed gets water, air and wormth etc. it begins to grow. When a seed begins it is grow, it is said to be germinate. Thus, **the beginning of the growth of seeds is called germination of seeds.**

Germination begins when the seed absorbs water, swells and bursts through the seed coat. The water helps the enzymes to function in the seed. The enzyme digest the stored food in cotyledons and make it soluble. This soluble food makes the radicle and plumule present in the seed to grow.

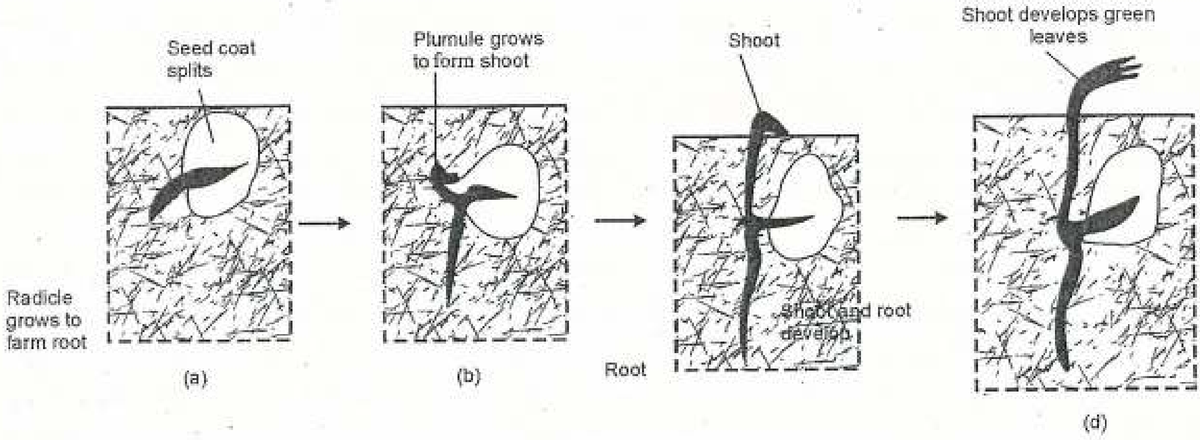


Fig: 12.12 Germination of bean seed to form a new plant

The radical of the seed grows first to form the root. The root pushes down into the soil and begins to absorb water and minerals from the soil. After this the plumule grows upwards to from the shoot. The shoot and root grow further. When the shoot comes up above the ground, it develops green leaves. The green leaves of the shoot begin to synthesize own food in the presence to sunlight. This grows gradually and ultimately becomes a new plant.

Sexual reproduction in human beings

The human use sexual mode of reproduction. The organs associated with the process of reproduction in human males and human females are different, so the reproductive system in males and females are different which are known as male reproductive system and female reproductive system respectively. The reproductive systems in human beings become functional at definite age called puberty.

Puberty: When a child is small, sometimes it becomes difficult to tell from appearance whether it is a boy or girl. This is because all boys and girls have the same body shape. A time of rapid growth and body changes starts in the early teens which makes the boy and the girl appear different. These changes start earlier in girls than in boys. We call the time childhood and adulthood **'adolescence'.** Ultimately the boys and girls become sexually nature and their reproductive systems start functioning. **The age at which the sex hormones (or gametes) begin to be produced and the boy and girl become sexual nature is called puberty.**

Puberty tends to start earlier in females than in males. Generally boys attain puberty at the age of 13 to 14 years while girls reach puberty at a comparatively lower age of 10 to 12 years on attaining puberty, the male gonads called testes start producing male gametes called sperms and the female gonads called ovaries start producing female gametes called ova (or eggs). With the onset of puberty testes produces the male sex hormone called testosterone, and the ovaries produce two female sex hormones, estrogen and progesterone. The sex hormones play an important role in the process of reproduction.

Puberty is the age at which the reproductive organs reach maturity and secondary sexual characteristics develop.

Male reproductive system: The human male reproductive system consists of the following organs: testes, scrotum, epididymis vas deferens (or sperm duct), seminal vesicles, prostate gland and penis. **Testes are the primary reproductive organs in man (or males).** The formation of germ-cells or sperms take place in the testes. There are located outside the abdominal cavity in scrotum because sperm formation requires a lower temperature than the normal body temperature. Testes secretes a hormone testosterone which regulate the formation of sperm and brings about changes appearance seen in boys at the time of puberty.

The sperms formed in testes come out and go into a coiled tube called epididymis. The sperms get stored temporarily epididymis. From epidymis the sperms are carried by a long tube called vas deference (or sperm duct) which joins with another tube called urethra coming from the bladder. Along the path of vas deferens, the glands called seminal vesicles and prostate gland add their secretions to sperms so that the sperm are now a liquid. This liquid plus the sperms it contains is called semen (which is a thick liquid). **The secretions of seminal vesicles and prostrate gland provide nutrition to the sperms and also make their further transport easier.** Urethra forms a common passage for sperms and urine. Urethra carries the sperm to an organ called penis which opens out side the body. The penis enters the sperms from the men's body into vagina in the women's body during mating for the purpose of reproduction.

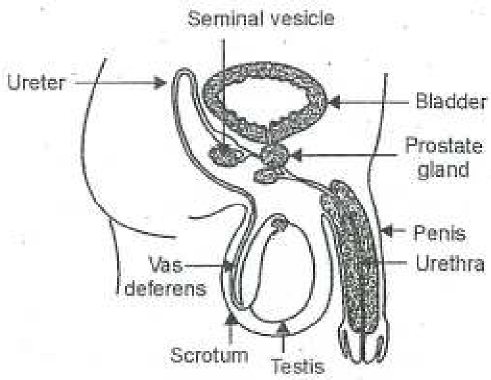


Fig: 12.13 Male reproductive system

Note : In man (or human male) there is only one opening for the urine and sperms to pass out of the body.

Female reproductive system: The female reproductive system consist of the following organs:

Ovaries, oviducts (fall opian tubes) Uterus and vagina. The human female reproductive system is shown as below:

Ovaries are the primary reproductive organs in a woman: The female germ cells or eggs are made in the ovaries. They are also responsible for the production of some hormones (called oestrogen and progesteron). Each ovary is composed of several thousand follicles (which are a kind of unripe eggs or unripe ova). At purely these follicles mature to form the ripe eggs or ripe ova (required for fertilisation)

One egg is produced every month by one of the ovaries. The egg is carried from the ovary to the womb through a thin oviduct or fallopian tube. The two oviducts unite into a classic bag like structure known as the uterus. The uterus open into the vagina through the cervix vagina receives the penis for pulling sperms into the woman's body. Vagina is a tubular structure. Vagina is also called 'birth canal' because through this passage the baby is born after the completion of development inside the uterus of the mother.

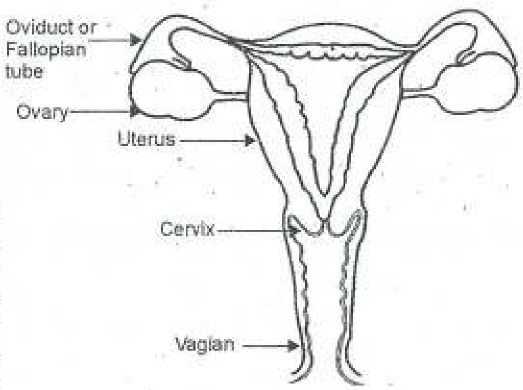


Fig: 12.14 Female reproductive system

Note: In women the opening for passing out urine (called urethra) and the vaginal opening are separate.

Fertilisation: In human beings internal fertilisation takes place. The sperms made in testes introduced into the vagina through penis during copulation. In this way, millions of sperms are released into the vagina at one time. The sperms are highly active and mobile (moving). The sperms move up through cervix into the uterus. From uterus, the sperms pass into the oviducts. One of the oviducts contains an ovum (or egg cell) released by the ovary during ovulation. Only one sperm fuses with the ovum (or egg) in the oviduct to form a zygote. This is called fertilisation. Thus, **the fertilisation of the ovum (or egg) takes place in the oviduct.**

Development of embryo : When the egg is fertilised, a zygote is formed. The zygote divides rapidly by mitosis as it moves down slowly in the oviduct and forms a hollow ball of hundreds of cells. These cells now called **embryo,** sinks into the soft and thick lining of the uterus and gets embedded in it. **The embedding of embryo in the thick lining of the uterus is called implantation.**

The embryo gets nutrition from the mother's blood with the help of a special tissue called **placenta.** This is a disc which is embedded in the uterine wall. It contains villi on the embryo's side of the tissue. On the mother's side are blood spaces, which surround the villi. This provides a large surface area a for glucose and oxygen to pass from the mother to the embryo. The developing embryo will also generate waste substances which can be removed by transferring them the mother's blood through the placenta.

Gestation: The time period from the fertilisation up to birth of the body is called **gestation.** The average gestation period in humans is about nine months (or about 38 weeks). During the gestation period, the foetus grows to become a baby. Birth begins when the strong muscles in the walls of the uterus start to contract rhythmically. The rhythmic contraction of uterus muscles gradually pushed the baby out of the mother's body through vagina.

What happens when the egg not is not fertilised (Menstruation): If egg is not fertilised, it lives for about one month. Since the ovary release one egg every month, the uterus also prepares itself every month to receive a fertilised egg. Thus its lining becomes thick and spongy. Thus, would be required for nourishing the embryo if fertilisation had taken place. Now, however, this lining is not needed any longer. So, the lining slowly breaks and comes out through the vagina as blood and mucous.

The breakdown and removal of the inner, thick and soft lining of the uterus along with its blood vessels in the form of vaginal bleeding is called menstrual flow or menstruation. Menstruation occurs every 28 days because ovulation (release of ovum or egg by ovary) occurs every 28 days.

Notes: The first occurrence of menstruation (or periods) at puberty is called **menarche.** On the other hand, the permanent stoppage of menstruation in a woman is called **menopause.**

Birth Control Methods

Birth control can be done by preventing pregnancy in females. The prevention of pregnancy in women (by preventing fertilisation) is called contraception and the chemical (drug) which prevents pregnancy is woman is called contraceptive. Birth control methods can be divided into following categories:

Barrier Methods

In the barrier methods of preventing pregnancy the physical devices such as condoms and diaphragum (or caps) are used. Condoms are used by males (by putting them as a covering on the penis) diaphragum is used by females in the vagina to cover the cervix). An important benefit in the condom use that it protects a person from the sexually transmitted diseases such as gonorrhoea, syphilis and AIDS.

Chemical Methods

In chemical methods, the females use two types of pills : oral pills and vaginal pills. The oral pills contain hormones which stop the ovaries from releasing ovum (or egg) in the oviduct. The vaginal pills contain the chemical spermicides which kill the sperms.

Intra-uterine contraceptive device (IUCD)

The IUCD called copper-T is also very effective preventing pregnancy. A copper-T is place inside the uterus by a doctor or a trained nurse. Copper-T prevents the implementation of fertilised egg in the uterus.

Copper-T cannot protect a woman from acquiring sexually transmitted disease (if her partner has such a disease).

Surgical methods

Surgical methods of birth control are available for males as well as females. In males, a small portion of the sperm duct (or vas deferens) is removed by surgical operation and both the cut ends are tied properly. This prevents the sperms from coming out. The surgical procedure carried out in the males in called 'vasectomy'.

In females, a small portion of the oviducts is removed by the surgical and the cut ends are tied. This prevents the ovum (or egg) from entering into the oviduct. The surgical procedure carried out in females is called **tubectomy.**

Sexually Transmitted Diseases (STD)

The diseases which are spread by sexual contact with an infected person are called sexually transmitted diseases (or STD). Thus, a healthy person can get STD by making sexual contact with an infected person. Some of the common sexually transmitted disease are:

(i) Gonorrhoea

(ii) Syphillis and

(iii) AIDS (Acquired Immune Deficiency Syndrome)

Gonorrhoea and syphilis are caused by bacteria. Common symptoms of these diseases are burning sensation at urination, passing of urethral discharge (containing pus) and sores in the genitals. These diseases are curable diseases.

AIDS is caused by a virus called HIV (Human immuno-deficiency virus) AIDS damages the body's immune system so that the body becomes weak and cannot protect itself against infection. So AIDS is very dangerous disease which leads to death.

Notes:

1. The largest cell in the human body is the female egg and the smallest is the male sperm.
2. The colour of eyes depends on the genes get from parents but at birth most babies appear to have blue eyes.

Key Points

✓ The process of production of organisms of its own kind is called reproduction.

✓ Reproduction, unlike other life processes, is not essential to maintain the life of an individual organism.

✓ There are two methods of reproduction : asexual and sexual.

✓ Asexual reproduction involves single individual for creation of a new individual

✓ The different methods of asexual reproduction are fission, budding, fragmentation, regeneration, vegetative propagation, and spore formation.

✓ Sexual reproduction involves two individuals for the creation of new individual.

✓ Reproduction involves DNA copying

✓ Reproduction of flowering plants involve transfer of pollen grains from the anther to the stigma which is referred to as pollination. This is followed by fertilisation.

✓ The male reproductive system consists of testis, vas deference seminal vesicles, prostate gland, urethra and penis.

✓ The female reproductive system consists of ovaries, follows tube, uterus and vagina.

✓ Different method of birth controls are condoms, oral pills, copper-T and surgical methods.

Multiple Choice Questions

1. Asexual reproduction is
   (a) A fusion of specialised cells
   (b) A method producing genetically identical offspring
   (c) A method in which a more than one parent are involved
   (d) A method by which all types of organisms reproduce

2. Asexual reproduction through budding takes place in
   (i) Amoeba and yeast
   (ii) Yeast and Hydra
   (iii) Hydra and plasmodium
   (iv) Corals and sponges
   (a) (i) and (ii)
   (b) Only (ii)
   (c) (i) and (iii)
   (d) (ii) and (iv)

3. In asexual reproduction, two off springs having the same genetic material and the same body features are called
   (a) Twins
   (b) Clones
   (c) Chromosomes
   (d) Callus

4. A feature of reproduction that is common to Amoeba, yeast and bacterium is that
   (a) They are all unicellular
   (b) They are all multicellular
   (c) They reproduce asexually
   (d) They reproduce only sexually

5. A multicellular organism which reproduces by budding is
   (a) Yeast
   (b) Hydra
   (c) Amoeba
   (d) Leishmania

6. Reproduction is essential for living organism in order to
   (a) Keep the individual organ alive
   (b) Maintain growth
   (c) Continue the species for ever
   (d) Fulfill their energy requirements

7. Match of the columns I and II

Column I	Column II
(i) Plasmodium	(A) Leaves
(ii) Spirogyra	(B) Layering
(iii) Jasmine	(C) Multiple fission
(iv) Apple tree	(D) Fragmentation
(v) Bryophyllum	(E) Grafting

   (a) (i) → B, (ii) → A, (iii) → D, (iv) → E, (v) → C
   (b) (i) → D, (ii) → C, (iii) → E, (iv) → B, (v) → A
   (c) (i) → E, (ii) → C, (iii) → A, (iv) → D, (v) → B
   (d) (i) → C, (ii) → D, (iii) → B, (iv) → E, (v) → A

8. The anther contains
   (a) Sepals
   (b) Carpel
   (c) Pollen grains
   (d) Ovules

9. Which of the following is not a part of human male reproductive system. This is
   (a) Tesrtis (b) Seminal vesicle
   (c) Prostrate gland (d) Oviduct
10. Which of the following is not sexually transmitted disease ?
   (a) Gonorrhoea (b) hepatitis
   (c) Syphillis (d) AIDS
11. AIDS is a deadly disease which is caused by
   (a) A protozoan (b) A virus
   (c) A fungus (d) A bacterium
12. Which one of the following, best describes the function of the umbilical cord? It
   (a) Supplies oxygenated blood from the mother to the embryo
   (b) Feeds of the embryo with digested substances
   (c) Coveys nutrients and wastes to and from the embryo respectively
   (d) Removes waste from the embryo to the mother's blood
13. The normal body cell of an organism contains 28 pairs of chromosomes. The number of chromosomes present in its germ cell will be
   (a) 14 (b) 42
   (c) 28 (d) 56
14. The male gamete in a flower and in a human are produced respectively in
   (a) Stigma and ovary (b) Ovary and testes
   (c) Anther and testes (d) Anther and style
15. Which of the following flower is bisexual
   (a) Jasmine (b) Hibiscus
   (c) Lotus (d) Rose
16. The disease kala-azar is caused by a microorganism is known as
   (a) Leech (b) Leishmania
   (c) Planaria (d) Plasmodium
17. Which of the following animal shows external fertilisation
   (a) Goat (b) Reptiles
   (c) Toads (d) Birds
18. The protozoan having a flagellum at its one end is
   (a) Hydra (b) Leishmania
   (c) Paramecium (d) Amoeba
19. A simple multicellular animal having tentacles which lives in fresh water usually reproduces by the asexual process of
   (a) Spore formation (b) Fragmentation
   (c) Budding (d) Binary fission
20. Binary fission describes the type of reproduction where the organism divides to form
   (a) Many buds (b) Two daughters
   (c) Two hyphal (d) Many spores

21. Vegetative propagation refers to the formation of new plants from the following existing organs of the old plants

(a) Stems, roots and flowers
(b) Stems, leaves and flowers
(c) Stems, roots and leaves
(d) Stem, flowers and fruits

22. Which one of the following is a male sex chromosomes

(a) XX
(b) YY
(c) XY
(d) All of the these

23. The sexually transmitted disease which is caused by bacteria is

(a) Malaria
(b) Gonorrhoea
(c) AIDS
(d) Diarrhoea

24. In which one of the following birth control methods, a small portion of oviducts of a woman is removed by surgical operation and the cut ends are ligated ?

(a) Copper-T
(b) Vasectomy
(c) Tubectomy
(d) Diaphragm

25. The ratio of number of chromosomes in a human zygote and a human sperm is

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

26. The advantage of internal fertilisation over external fertilisation is that in internal fertilisation

(a) Copulation and fusion of gametes is passive
(b) Fewer individuals are produced
(c) New off-springs are exactly like the parent
(d) Production of large numbers of gametes is unnecessary

27. In a flower, the parts that produce male and female gametes are respectively:

(a) Filament and stigma
(b) Anther and ovary
(c) Stamen and style
(d) Sepal and anther

28. Characters that are transmitted from parents to offspring during sexual reproduction show

(a) Only similarities with parents
(b) Only variations with parents
(c) Both similarities and variations with parents
(d) Neither similarities nor variations with parents

29. The length of pollen tube depends on the distance between

(a) Upper surface of stigma and lower part of style
(b) Pollen grain and upper surface of stigma
(c) Pollen grain on upper surface of stigma and ovule
(d) Pollen grain in anther and upper surface of stigma

30. In human males, the testes lie in the scrotum outside the body because it helps in the

(a) Process of mating
(b) Easy transfer of sperms
(c) Formation of sperms
(d) All the above

31. Which of the following statements are true for flowers ?
   (i) Flowers are always bisexual
   (ii) They contain sexual reproductive organs
   (iii) They are produce in all groups of plants
   (iv) After fertilisation they give rise to fruits
   (a) (i) and (ii) (b) (ii) and (iii)
   (c) (ii) and (iv) (d) (i) and (iv)

32. The correct sequence of organs in the male reproductive system for the transport of sperm is
   (a) Testis → vas deferens → ureter (b) Testis → vas deferens → urethra
   (c) Testis → ureter → urethra (d) Testis → urethra → ureter

33. In the figure given alongside, the parts marked A, B and C are sequentially
   (a) Plumule, radical and cotyledon
   (b) Radical, cotyledon and plumule
   (c) Plumule, cotyledon and radical
   (d) Cotyledon, plumule and radical

34. One of the following process does not lead to the formation of clones. This is
   (a) Fragmentation (b) Fission
   (c) Fertilisation (d) Tissue culture

35. In human females, an event that indicates the onset of reproductive phase is
   (a) Growth of body (b) Change in voice
   (c) Menstruation (d) Change in hair pattern

36. The number of chromosomes in parents and offsprings of a particular species remains constant due to
   (a) Doubling of chromosomes after gamete formation
   (b) Halving of chromosomes after gamete formation
   (c) Doubling of chromosomes after zygote formation
   (d) Halving of chromosomes during gamete formation

37. The figure given alongside show the human male reproductive organs, which structures make sperms and seminal fluid ?
   (a) X makes sperms and W makes seminal fluid
   (b) Y makes sperms and V makes seminal fluid
   (c) V makes sperms and X makes seminal fluid
   (d) W makes sperms and Y makes seminal fluid

38. Match the organisms given in column I with the methods of reproduction/propagation given in

Column I	Column II
(i) Potatoes	A. Spore formation
(ii) Rhizopus	B. Binary fission
(iii) Hydra	C. Tubers
(iv) Planaria	D. Budding
(v) Leishmania	E. Regeneration

(a) (i) → B (ii) → C (iii) → E (iv) → A (v) → D

(b) (i) → C (ii) → A (iii) → D (iv) → E (v) → B

(c) (i) → D (ii) → E (iii) → B (iv) → C (v) → A

(d) (i) → E (ii) → D (iii) → A (iv) → B (v) → C

39. In spirogyra asexual reproduction takes place by

(a) Division of a cell into two cells
(b) Division of a cell into many cells
(c) Breaking up of filaments into smaller bits
(d) Formation of a large number of buds

40. An organism having a whip-like structure of one end which reproduces by the process of binary fission is

(a) Hydra
(b) Leishmania
(c) Plasmodium
(d) Paramecium

41. A planaria worm is cut horizontally into two halves P and Q such that the part P contains the whole head of the worm. Another Planaria worm is cut vertically into two halves R and S in such a way that both the cut pieces R and S contain half head each. Which of the two planaria worms could regenerate to form the complete respective worms ?

(a) Only R and S
(b) Only P
(c) P, R and S
(d) P, Q, R and S

42. The factors responsible for the rapid spreading of bread mould on slices of bread are :

(i) Presence of large number of spores in air
(ii) Presence of large number of thread-like branches hyphae
(iii) Presence of moisture and nutrients
(iv) Formation of round shaped sporangia

(a) (i) and (ii)
(b) (i) and (iii)
(c) (ii) and (iv)
(d) (iii) and (iv)

43. Which of the following method of contraception protects a person from acquiring a sexually transmitted disease?

(a) Oral pills
(b) Surgery
(c) Condom
(d) Copper-T

44. Which among the following statements are true for unisexual flowers ?

(i) They possess both stamen and pistil
(ii) They possess either stamen or pistil
(iii) They exhibit cross pollination
(iv) Unisexual flower possessing only stamens cannot produce fruits

(a) (i) and (ii)
(b) (ii) and (iii)
(c) (ii), (iii) and (iv)
(d) (i), (ii) and (iv)

45. The off springs formed as a result of sexual reproduction exhibit more variations because

(a) Sexual reproduction is lengthy process
(b) Genetic material comes from two parents of some species
(c) Genetic material comes from two parents of different species
(d) Genetic material comes from many parents.

Answer Key

1. (b)	2. (d)	3. (b)	4. (c)	5. (b)	6. (c)	7. (d)	8. (c)	9. (d)	10. (b)
11. (b)	12. (c)	13. (c)	14. (c)	15. (b)	16. (b)	17. (c)	18. (b)	19. (c)	20. (b)
21. (c)	22. (c)	23. (b)	24. (c)	25. (a)	26. (b)	27. (b)	28. (c)	29. (c)	30. (c)
31. (c)	32. (b)	33. (c)	34. (c)	35. (c)	36. (d)	37. (b)	38. (b)	39. (c)	40. (b)
41. (d)	42. (b)	43. (c)	44. (c)	45. (b)					

13. Heredity and Evolution

Learning Objectves

* Variation
* Accumulation of Variations
* Heredity
* Mendel's Law of Inheritance
    * Law of segregation
    * Law of Independent assortment
* How are Characteristics Transmitted to Progeny
* Sex determination
* Acquired and Inherited Traits
* Evolution
* Evidences for Evolution
    * Homologus organs
    * Analogus Organs
    * Fossils
* Darwin's Theory of Evolution
* Origin of Life on Earth
* Speciation
    * Evolution of stages
    * Evolution of eyes
    * Evolution of feathers
    * Evolution of artificial selection
* Evolution should not be Equated with Progress
    * Human evolution

Variation

All the organisms are the results of reproduction. A recognizable feature of a human being like height, shape, size and completion are called **traits.** The transmission of characters from the parents to their offsprings is called heredity. In sexual reproduction both male and female are involved. The new offspring evolves with similar characteristics as of their parents. The hereditary information is present in the sex cells (or gametes) of the parents. Thus, gametes constitute the link between one generation and the next, and pass on the parental and maternal characters or traits to the offspring. But the new offspring is not the true copy of the parents. **This difference which arises in the offsprings from one generation to the next is called variation.** The variation is produced during both sexual and asexual reproduction. **For example,**` Mango plants, they all appears to be similar, but there is difference in the taste of mangoes of different plants, and size also. The variation is essential for organic evolution. The evolution of new species is only due to the variation in the organisms.

Accumulation of Variations

The variations produced in organisms during successive generations get accumulated in the organisms. The significance of a variation shows up only if it continues to be inherited by the offsprings for several generations. **For example,** A bacterium produces two bacteria by asexual reproduction. Suppose one of offspring bacterium has a variation due to which it can tolerate a little higher temperature than the other one. Now this, variation of little more heat resistance will go an accumulating in the off springs of successive generation of this bacterium. And this will ultimately give rise to a variant of bacteria which will be highly heat resistant and able to survive even at very high temperatures.

The great advantage of variation to a species is that it increases the chances of its survival in a changing environment. The organisms which shows positive variation, survives. Those who do not shows variations get extinct.

Heredity

The transmission of traits from one generation to the next is called **heredity.** The study of the mode of transmission of traits from parents to their offspring it called **genetics.** It is actually to the gene, a unit of DNA on a chromosomes which governs the synthesis of one protein that controls a specific characteristic (or trait) of an organism. **Genes are the basic unit or the functional unit of heredity.**

The gene which decides the appearance of an organism even in the presence of an alternative gene is known as a **dominant gene,** which is represented by capital letter. On the other hand, the gene which can decide the appearance of an organism only in the presence of another identical gene is called a **recessive gene,** which is represents by the small letter. The genetic constitution of an individual organisms is called **genotype.** The outer environment also affects the variation in an individual. This also leads to the development of new traits in an individual and are visible in the physical appearance, which is called its **phenotype.**

Mendel's Law of Inheritance

Inheritance is the transmission of genetically controlled characteristics (or traits) from one generation to the next. The traits of the child can be influenced by DNA of both the parents and thus for each traits, there are two versions in each child. On the basis of this Mendel's worked out the main rule of inheritance, known as **Mendel's laws of inheritance.** George J. Mendel was a botanist from Australia, who is known as the **father of genetics.**

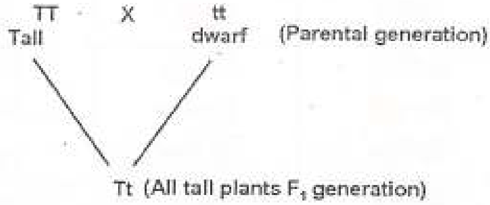
Mendel choose pea plants for studying inheritance because pea plants had a number of clear cut differences which were easy to tell apart. He gave the following laws of inheritance.

Monohybrid inheritance and the law of segregation

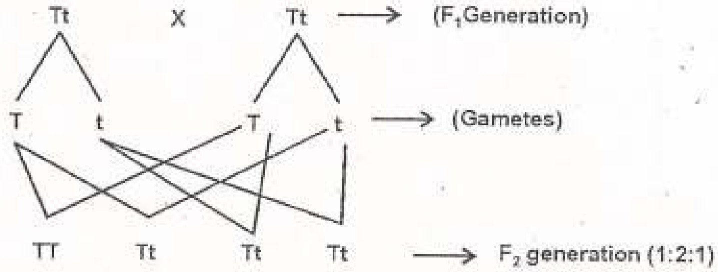
According to this law–'The characteristics (or traits) of an organism are determined by internal 'factors' which occur in pairs. Only one of a pair of such factors can be present in a single gamete.'

Mendel first crossed pure-breed tall pea plants with pure-breed dwarf pea plants and found that only tall pea plants were produced in the first generation or F_1 generation.

From this Mendel concluded that F_1 generation showed traits of only one of the parent plants: tallness



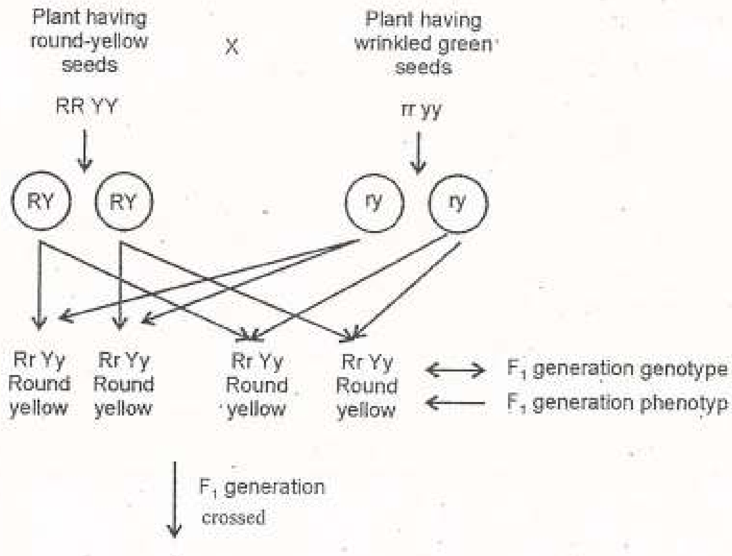
Mendel then crossed the tall pea plants of the first generation (F_1) and found that tall plants and dwarf plants were obtained in the second generation (or F_2 generation) in the ratio of 3:1. From this, Mendel concluded that the repressed traits of 'dwarfness' as 'recessive trait' and the expressed trait of 'tallness' as the 'dominant trait'.



Thus, **in the first law of inheritance genotypic ratio is 1:2:1 and phenotypic ratio is 3:1.**

Dihybrid inheritance and the law of Independent assortment

After performing the experiments on the inheritance to traits of one character, he performed an experiment with the two character or dihybrid cross. He crossed the plants of round and yellow seeds with the plants of wrinkled and green seeds, and found that all the plants in F_1 generation are round and yellow when the plants of F_1 generation were crossed among themselves he found that it give rise to four types of seeds. There were **round-yellow, round-green, wrinkled-yellow** and Wrinkled-green seeds. Mendel collected a total 556 F_2 seeds and counted them shape wise and colour wise. He got the following result.



	RY	Ry	rY	ry
RY	RRYY Round Yellow	RRYy Round Yellow	RrYY Round Yellow	RrYy Round Yellow
Ry	RRYy Round Yellow	RRyy Round Green	RrYy Round Yellow	Rryy Round Green
rY	RrYY Round Yellow	RrYy Round Yellow	rrYY Round Yellow	rrYy Round Yellow
ry	RrYy Round Yellow	Rryy Round Green	rrYy Round Yellow	rryy Round Green

F_2 ratio : Round-yellow seeds 315

Round-green seeds 108

Wrinkled-yellow seeds 101

Wrinkled-green seeds 32

So, phenotypic ratio is :

So, phenotypic ratio is : 315 : 108 : 101 : 32

9 : 3 : 3 : 1

Genotypic ratio is = 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

This is known as **dihybrid ratio.** So, according to Mendel's second law of inheritance, 'In the inheritance of more than one pair of traits is a cross simultaneously, the factors responsible for each pair of traits are distributed independently to the gametes.'

How are Characteristics (or Traits) Transmitted to Progeny

Genes are responsible for the characteristic features (or traits) of an organism : plant or animal. The characteristics or traits of parents are transmitted to their progeny (offspring) through genes present on their chromosomes during the process of sexual reproduction. This happens as follows:

Genes work in pairs. There is a pair of genes for each characteristics of an organism (one is dominant gene and the other is receive gene). Each parent possesses a pair of genes for each characteristic on a pair of chromosomes. However, each parent passes only one of the two genes of the pair for each characteristic to its progeny through gametes. Thus, the male gamete and female gamete carry one gene for each characteristics from the pairs of parents (which are located on the pair of chromosomes).

But when male gamete fuses with a female gamete during fertilisation, they make a new cell called zygote with full set of genes (on full set of chromosomes). This zygote grows and develops to form a new organism having characteristics (or traits) from both the parents which it has inherited through genes. The two genes responsible for a particular characteristic are always present on the corresponding position of the pair of chromosomes.

Sex Determination

A person can have a male sex or a female sex. **The process by which the sex of a person determined is called sex determination.** Genetics is involved in the determination of the sex of a person.

The **chromosomes which determine the sex of a person are called sex chromosomes.** The sex chromosomes carries two types of genes X and Y, there are total number of 46 chromosomes in an individual; half of them comes from mother and half of them comes from father. Out of these **46 chromosomes, 44 are autosomes and 2 are sex chromosomes.** In female the sex chromosomes are **XX** and in male the sex chromosomes are **XY.** During gametes formation the number of chromosomes is halved and is called haploid. It is **22 + X** chromosomes from female and **22 + X or Y** chromosomes from male. If the X chromosomes of male fertilised with X chromosomes of female then the new born baby is female and if the Y chromosomes of male combine with X chromosomes of female then the new born baby is male.

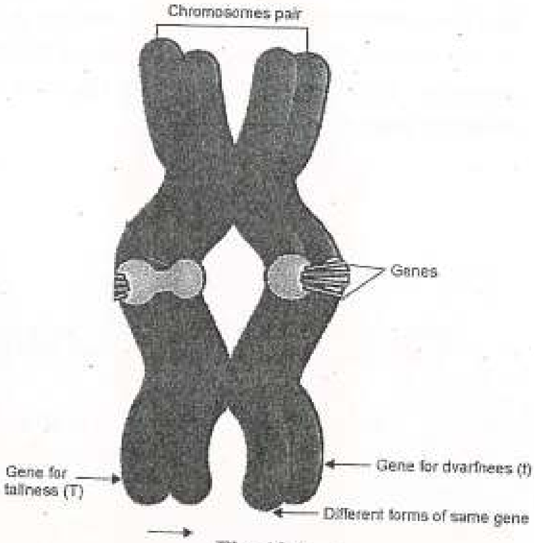


Fig: 13.1

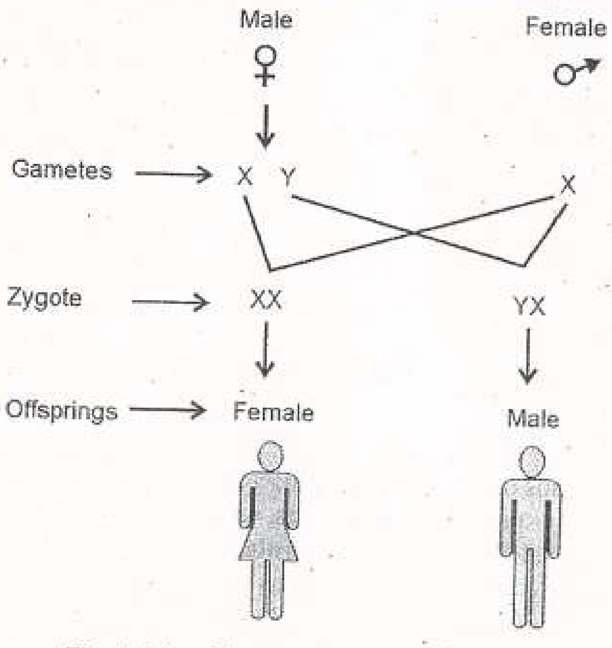
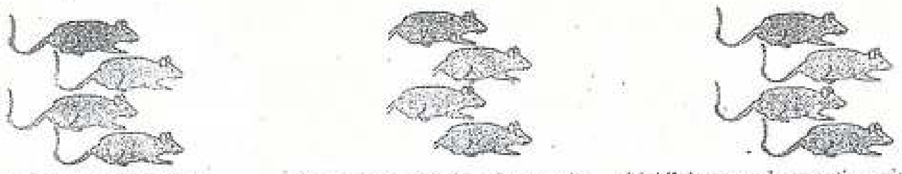


Fig: 13.2 Sex determination in human beings

Acquired and Inherited Traits

Acquired traits: 'A trait (or characteristic) of an organism which is 'not inherited' but develops in response to the environment is called an **acquired trait.**' The acquired traits of organisms can not be passed on their future generation. Only those traits can be transmitted from one generation to the next, in which change have occurred in the genes present in the reproductive cells of parents. **For example,** If we breed some mice, all the progeny of mice will have tails, just like their parents. Now if we cut the tails of these first generation mice surgically and breed them, we will get new mice, all with full tails. It has been observed that even after cutting the tails of mice for number of generations, a tail-less mouse is never born. Actually, **the cut tail of mice is an acquired trait which is never passed on to their progeny. This is because cutting the tails of mice does not change the genes of their reproductive cells (or gametes).**



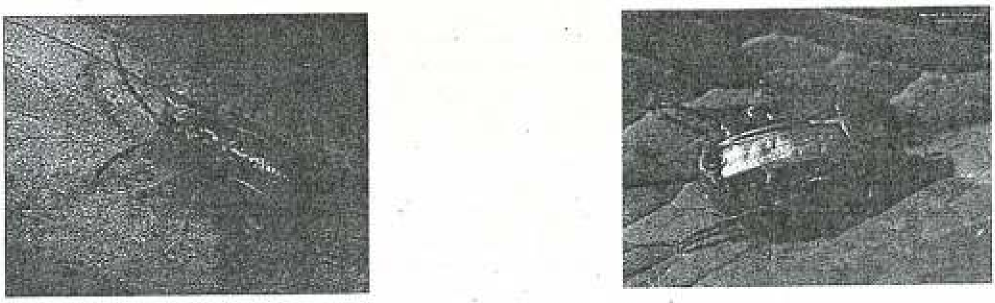
(a) These are first generation mice. All these mice have full tails

(b) The tails of all the mice are cut surgically so that they btecome tail-less

(c) All the second generation mice produced by breeding cut-tail mice have full tails. No tail-less mouse is born

Fig: 13.3 The cut tail of mice is an acquired trait which cannot be passed on to their progeny in future generations through the process of reproduction

Inherited traits: 'A trait of an organism which is cause by change in its genes (or DNA) is called an **inherited traits.** Inherited traits can be passed on to the progeny of the organism because they have produced change in the genes (or DNA) of the organism. For example, the colour of red beetles changes from red to green during reproduction. This change of colour in the beetles has been due to change in the genes of the reproductive cell.



(a) Red bettle

(b) Green beetle

Fig: 13.4 Inherited trait

Evolution

There are millions of life forms on the earth. The different life forms on the earth is due to evolution of new species from pre-existing species, and variations, which occur from one generation to the next. The evolution of new organism is also called **organic evolution.**

Evolution also known as biological or organic evolution is the change over time in one or more inherited traits, found in populations of organism over the time. Inherited traits are particular distinguishing characteristics, including **anatomical, biochemical** or **behavioral** characteristics, that are passed on from one generation to the next. Evolution many occur when there is variation of inherited traits within a population. The major sources of such variation are mutation, genetic recombination and gene flow. Evolution has led to the diversification of all living organisms from a common ancestor, which are described by Charles Darwin.

There are four common mechanisms of evolution :

1. The first mechanism is natural selection, a process in which there is differential survival and/or reproduction of organisms that differ in one or more inherited traits.

2. A second mechanism is genetic drift, a process in which there are random change to the proportions of two or more inherited traits within a population.
3. A third mechanism is mutation, which is a permanent change in a DNA sequence.
4. Finally, the fourth mechanism is gene flow, which is the incorporation of genes from one population into another.

Evidences for Evolution

Various biological studies tell us that since their origin, living organisms have been undergoing changes in their organization to evolve into new forms. A number of common features of different kinds of organism provide evidence in favour of evolution because they can be considered to have evolved from the common ancestor. The more characteristics two species have in common, the more closely they will be related. And the more closely they are related, the more recently they will have had a common ancestor. Some of the important sources which provide evidences for evolution are :

(i) Homologous organs
(ii) Analogous organs and
(iii) Fossils

Homologous Organs

'These organs which have the same basic structure (or same basic design) but different functions are called homologous organs.' For example, the forelimb of a man, a lizard, frog, bat, bird etc. have the same basic structure but different functions.

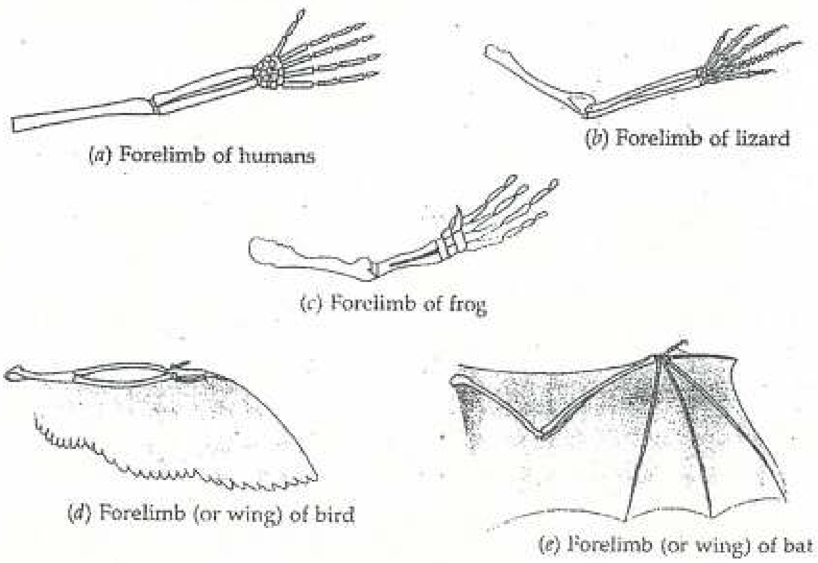


Fig: 13.5 Homologous organs

The presence of homologous organs in different animals provides evidence for evolution by telling us that they are derived from the same ancestor who had the 'basic design' of the organ on which all the homologous organs are based.

Analogous

Those organs which have different basic structure (or different basic design) but have similar appearance and perform similar functions are called analogous organs." For example, wings of birds and insect have different basic structure but performs similar function and helps in flying in the sky.

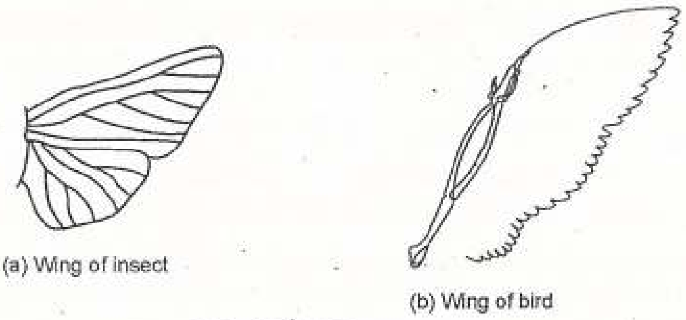


Fig: 13.6 Analogous organs

The presence of analogous organs in different animals provide evidence for evolution by telling us that though they are not derived from common ancestors, they can still evolve to perform similar functions to survive, flourish and keep on evolving in the prevailing environment. The analogous organs actually provide a mechanism for evolution.

Fig: 13.7 Archaeopteryx is a connecting link between reptiles and birds

Fossils

Fossils are defined as the remains of dead plant buried deep into the earth crust. It also provides evidence for evolution. For example, the fossil of the bird **archaeopteryx,** which shows the relationship between birds and reptiles. When the organism dies, its bodies decomposes and its bones structure remain in the earth for long time. *How to know how old the fossils are?* The age of fossils can be estimated in two ways : **by the relative method and by the carbon dating method.** In the relative method, when we dig into the earth, we find fossils at different depths. The fossils which we find in layers closer to the surface of the earth are more recent, the fossils which are found in deeper layers are older; whereas the fossils found in the deepest layers of earth are the oldest ones.

The second way of dating fossils is by detecting the ratios of different isotopes of the same element in the fossil material. **How do fossils from layer by layer:** Usually, when organism (plants or animals) die, their bodies will decompose by the action of microorganisms in the presence of oxygen, moisture etc. Sometimes, however, the conditions in the environment are such (like absence or oxygen or moisture, etc.) which do not let the body of the organism to decompose completely. It is such body (or body parts) of an organism which we get as fossil on digging the earth. Sometimes, soft parts of plants and animals (which usually decompose quickly) are preserved as fossils in the form of their impressions inside the rocks. For example, If a dead leaf gets caught in mud, it will not compose quickly. The mud around the leaf will set around it a mould, gradually harden to form a rock and retain the impression of the whole leaf. This forms a leaf fossil which can be dug out from the earth a long time later. The fossil of a dead insect caught in mud is also formed in a similar way to leaf fossil. All such preserved impressions of the body parts of the once living organisms are also called fossil

Note: There are various kinds of fossils : ammonite, trilobite and dinosaur.

Darwin's Theory of Evolution

Darwin gave the theory of evolution of species. According to this theory of evolution

1. Within a population there is s natural variation, of which some are positive and some are negative.
2. The population remain constant even though all species produce large number of offsprings.
3. There is a continuous struggle for food, shelter and mating between the members of the same species.
4. Only the individual with favourable variations will survive and other will eliminate.
5. The favourable variations are passed onto next generation.
6. Thevariations accumulated over the long period leads to the evolution of new species.

Charles Robert Darwin gave the theory of evolution in his famous book **'The origin of species.'** The theory of evolution proposed by Darwin is known as **'The theory of natural selection.'** According to this theory only those traits are passed from one generation to the next which are favourable for the survival and reproduction of the organism. The other traits are not passed on to the next generation. Darwin's theory of evolution applied to plants as well as animals.

Origin of Life on Earth

Mendel's experiments tell us the mode of inheritance of traits from one generation to the next and Darwin's theory of evolution tells us how organisms develop from simple to more complex forms. But neither tells us anything about how life originated on earth (or began on earth).

A British scientist **J.B.S. Haldane** suggested in **1929** that life must have developed from the simple inorganic molecule (such as methane, ammonia, hydrogen sulphide etc.) which was present on the earth soon after it was formed. He said that the conditions on earth at that time (including frequent lighting) could have converted simple inorganic molecules into complex organic molecules which were necessary for life. These complex organic molecules must have joined together to form first primitive living organisms.

The theory of origin of life on earth proposed by Haldane was confirmed by experiments conducted by **Stanley L. Miller** and **Harold C. Urey in 1953.** They assembled an apparatus to create an early earth atmosphere which was supposed to consist of gases like methane, ammonia and hydrogen sulphide etc. **(but no oxygen),** over water. This was maintained at a temperature just below 100°C and sparks were passed through the mixture of gases to stimulate lighting. At the end of a week, 15% of the carbon (from methane) had been converted to simple compounds of carbon including amino acids which make up protein molecules found in living organisms. This experiments provides the evidence that the life originated from inanimate matter (or lifeless matter) like inorganic molecules.

Speciation

A species is a population of organisms consisting of similar individuals which can breed together and produce fertile offspring. Species can be of plants or of animals.

'The process by which new species develop from the existing species is known as speciation.'

There are some important factors which could lead to the rise (or formation) of a new species are the following:

(i) Geographical isolation of a population caused by various types of barriers (such as mountain ranges, rivers and sea). The geographical isolation leads to reproductive isolation due to which there is no flow of genes between separated groups of population.

(ii) Genetic drift caused by drastic changes in the frequencies of particular genes of by change alone.

(iii) Variations caused in individuals due to natural selection.

Note: Geographical isolation is the major factor in the speciation of sexually reproducing animals because it interrupts the flow of genes between their isolated populations through the gametes. The geographical isolation, however cannot be major factor in the speciation of a self poalinating plant species because is does a not have to look to other plants for its process of reproduction to being carried out. Geographical isolation also cannot be a major factor in the speciation of an asexually reproducing organism because it does not require any other organism to carry out reproduction.

Evolution by stage

1. **Evolution of eyes:** The eye is a complicated organ which cannot be generated by single DNA change. **The complex body organs of animals such as eyes have been created in 'stages' over many generations.** First of all the rudimentary eye (basic eye) like that of planria (flatworm) was formed. Starting from this basic design, more and more complex eyes were then evolved in various organisms. Most of animals have eyes. The structure of eyes in all the organisms is however, different which suggest their separate evolutionary origins. **The evolution of eye is an example of evolution of stages.**

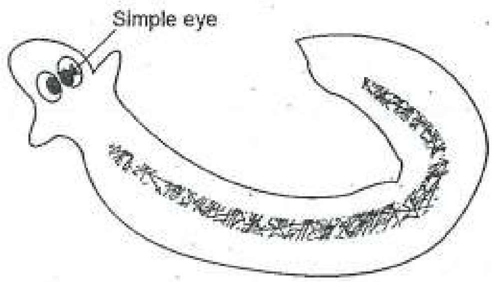
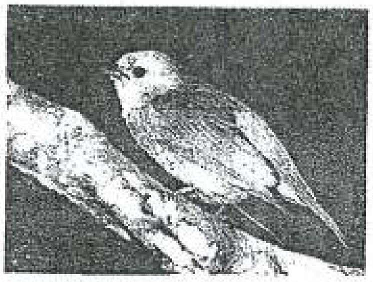
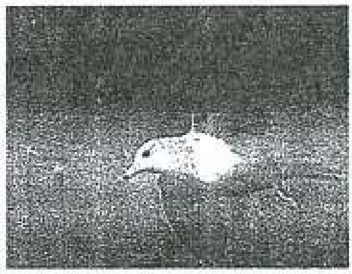


Fig: 13.8 A flatworm (palanaria) has very simple eyes called rudimentary eyes

2. **Evolution of feathers:** Sometimes an evolutionary change produced in an organism for one purpose later on becomes more useful for an entirely different function. For example, Birds evolved feathers as a means of providing insulation to their bodies in cold weather but later on these feathers became more useful for flight. In fact, some dinosaurs had feather, although they could not fly using the feathers. Birds seem to have later adapted the feathers to flight. This, of course, means that birds are very closely related to reptiles, since dinosaurs were reptiles.



(a) Birds evolved feathers as a means of providing insulation to their bodies in cold



(b) Later on, feathers become more useful to the birds for the purpose of flying weather.

Fig: 13.9 Evolution of feathers

3. **Evolution by Artificial Selection:** It is all very well to say that very dissimilar looking structures evolve from a common ancestral design. The wild cabbage plant is a good example to prove that entirely different looking organisms can evolve from the same organism by the process of evolution. The only difference is that here we are using artificial selection for evolution in place of natural selection. So,

(i) Some farmers wanted to have very short distance between the leaves of wild cabbage and produced the common variety of 'cabbage'

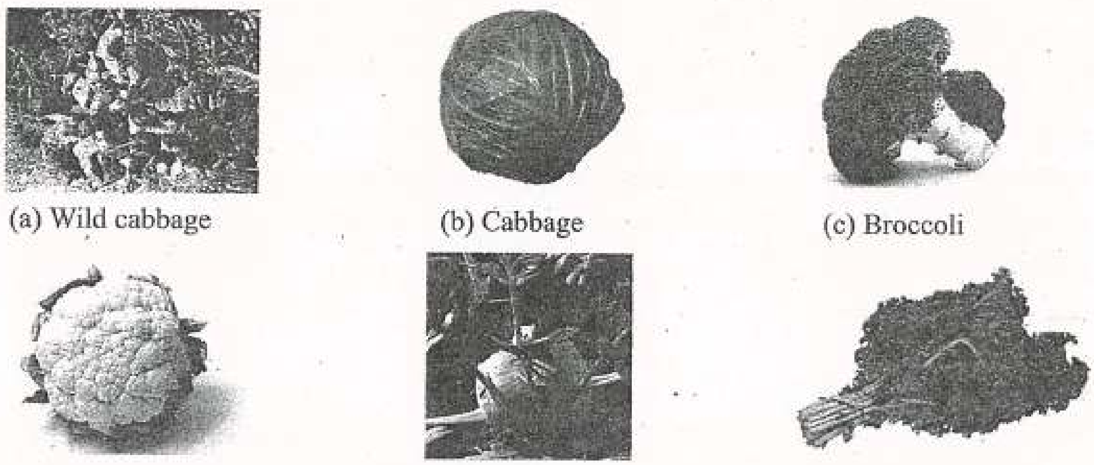
(ii) Some have wanted to select for arrested flower development, and have breed 'broccoli'

(iii) Some farmers went in for sterile flowers of wild cabbage and developed another variety of cabbage called 'cauliflower.

(iv) Some have selected for swollen parts, and come up with kohlrabi

(v) And finally, the farmers wanted to grow large leaves of wild cabbage and ended up producing a leafy vegetable called 'kale'.

Now, wild cabbage is the ancestor of cabbage, broccoli, cauliflower, kohlrabi and kale are all its varieties which have been obtained by evolution 'Induced artificially' by the farmers.



(a) Wild cabbage (b) Cabbage (c) Broccoli

(d) Cauliflower (e) Kohlrabi (f) Kale

Fig: 13.10 Evolution of wild cabbage

Evolution Should not Equate with Progress

There is no real progress in the field of evolution, rather it is just the production of diversity of life forms and shaping of this diversity by the environmental selection. The only progress in the evolution which appears to us is that the organism with more and more complex body designs have emerged over the ages. It is not that with the appearance of organisms with complex body designs the simpler organisms will disappear. It depends on the environmental condition of the place.

It is not as if the newly generated species are in any way 'better' than the older one. It is just that natural selection and genetic drift have together led to the formation of a population that cannot reproduce with the original one.

So, for example, It is a common belief that chimpanzees are the ancestors of human beings. It is however, not true that human beings have evolved from chimpanzees. Actually both chimpanzees and human beings had a common ancestor long time ago. Two offsprings of that ancestor evolved in their own separate ways to form the modern day chimpanzees and human beings.

Again, it is not as if the body designs of older organisms were inefficient. This is because many of the older and simpler forms of organisms still survive on earth. For example, one of the simplest a primitive life forms called bacteria still inhibits in some of the most inhospitable habitats such as hot springs deep sea, thermal vents and the ice in Antarctica. Most other organisms cannot survive in such harsh environments.

Human Evolution

Human evolution has been studies by using the various tools of tracing evolutionary relationships like excavating (digging earth), carbon-dating, studying fossils and determining DNA sequences. There is a great diversity of human forms and features across the planet, that for long time people used to talk about different 'races' of human beings. The human races were even identified on the basis of their skin colour and named as white, black, yellow or brown. It is now known that the so called human races have not evolve differently. In fact, there is no biological basis for dividing human beings into different 'races'. All human beings (whether white, black, yellow or brown) are single species (called Homo species).

It has now been established by research that the earliest members of the human species (Homo species) came from Africa. So, irrespective of where we have lived for the past few thousand years, we have come from Africa. In other words, our genetic footprints tell us that we have African roots. About hundred thousand years ago, some of our ancestors left Africa while others stayed back. Those who left Africa slowly spread across the whole earth.

Note:

1. There's no hereditary trait that influences a predisposition to having identical twins.
2. Birth rates for identical twins are consistent across populations; it is the same regardless of race, geography or maternal age.

Key Points

- ✓ The changes which arises in an organism from one generation to the next is called **variations.**
- ✓ The variations may lead to increased survival of the individuals.
- ✓ These variations is minimum in asexual reproduction and maximum in sexual reproduction.
- ✓ Sexually reproducing individuals have two copies of genes for the same trait. If the copies are not identical, the trait that gets expressed is called the dominant trait and the other is called the recessive trait.
- ✓ The new born child is male if the Y chromosomes of the male combines with the X chromosomes of female, but if the X chromosomes of male combines with X chromosome of female, then the new born child is female.
- ✓ The transmission of characters from the parents to their offsprings is called heredity.
- ✓ Changes in the non-reproductive tissues caused by environmental factors are not inheritable.
- ✓ The DNA is responsible for the transmission of character from one generation to the next.
- ✓ Speciation may take place when variation is combined with geographical isolation.
- ✓ Evolutionary relationship are traced in the classification of organisms.
- ✓ Evolution can be worked out by the study of not just living species, but also fossils.

- ✓ Natural selection is the process of evolution of s species whereby characteristics which help individual organisms to survive and reproduce are passed on the their offspring, and those characteristics which do not help are not passed on.
- ✓ Tracing common ancestors back in time brought us to the idea that at some point of time, non-living material must have given rise to life.
- ✓ Complex organs may have evolved because of the survival advantage of even the intermediate stages.
- ✓ Evolution cannot be said to progress from lower forms to higher forms. Rather, evolution seems to have given rise to more complex body designs even while the simpler body designs continue to flourish.
- ✓ Study of the evolution of human beings indicates that the earliest members of human species came from Africa and slowly spread across the whole earth.

Multiple Choice Questions

1. When two parents are crossed, the offspring are referred to as
   (a) F_1 generation (b) F_2 generation
   (c) Test cross (d) Recessives
2. Which of the following sex chromosomes give rise to the male child
   (a) XX (b) XY
   (c) YY (d) XYX
3. A cross between two individuals results in ratio of 9 : 3 : 3 : 1 for four possible phenotypes of progeny. This is an example of a
   (a) Test cross (b) Monohybrid cross
   (c) Dihybrid cross (d) None of these
4. Which of the following may be used to obtain an F_2 generation ?
   (a) Cross-pollinating two parent plants
   (b) Cross-pollinating an F_1 plant with a parent plant
   (c) Allowing flowers on an F_1 plant to be self pollinated
   (d) Allowing flowers on a parent plant to be self pollinated
5. A normal cell of human body contains 23 pairs of chromosomes. The number of chromosomes in a sex cell (sperm ovum) of a human being as most likely to be
   (a) 21 (b) 42
   (c) 23 (d) 46
6. The palisade cells of a species of plant contain 28 chromosomes. How many chromosomes will there in each gamete produced by the plant?
   (a) 4 (b) 14
   (c) 28 (d) 56
7. In evolution terms, we have more in common with:
   (a) A Chinese school boy (b) A spider
   (c) A bacteria (d) A chimpanzee
8. Match the items, given in column A to appropriate items, given in column B. Chose the correct answer using the codes given below the column

Column-A	Column-B
(A) Phenotype	1. DNA
(B) Missing link	2. Natural selection
(C) Watson and crick	3. External appearance
(D) Darwin	4. Archaeopteryx

   (A) (B) (C) (D)
   (a) 1 2 3 4 (b) 2 1 4 3
   (c) 3 4 1 2 (d) 3 2 4 1

9. According to scientists, aves have evolved from
   (a) Amphibians
   (b) Reptiles
   (c) Arthropods
   (d) Mammals
10. The human species has genetic roots in
   (a) America
   (b) Australia
   (c) Africa
   (d) Antarctica
11. Beside human beings, XX-XY sex determination mechanism is depicted by
   (a) A snake
   (b) A turtle
   (c) A lizard
   (d) A crocodile
12. Which one of the following is not present in the Darwin's theory of evolution?
   (a) Over population
   (b) Natural selection
   (c) Struggle for existence
   (d) Use and disuse of organ
13. The presence of which of the following types of organs in two organisms indicates that they are derived from the same ancestor?
   (a) Homologous organs
   (b) Analogous organs
   (c) Digestive organs
   (d) Respiratory organs
14. The fossil trilobite was originally:
   (a) An ave
   (b) A reptile
   (c) An invertebrate
   (d) An arthropod
15. The presence of which of the following types of organs in two animals indicates that they are not derived from the same ancestor?
   (a) Homologous organs
   (b) Analogous organs
   (c) Excretory organs
   (d) Reproductive organs
16. One pair of organs in the following animals are not homologous. This is
   (a) Forelimbs in lizard and frog
   (b) Forelimbs in human and lizard
   (c) Wings in butterfly and bat
   (d) Wings in bat and bird
17. The wings of a housefly and the wings of a sparrow are an example of
   (a) Homologous organs
   (b) Analogous organs
   (c) vestigial organs
   (d) respiratory organs
18. According to evolutionary theory, formation of new species in generally due to
   (a) Sudden creation by nature
   (b) Movement of individuals from one habitat to another
   (c) Accumulation variations over several generations
   (d) Clones formed during asexual reproduction
19. One of the following traits of the parents cannot be passed on to their future generations. This trait is
   (a) Pointed chin
   (b) Scarred chin
   (c) Broad chin
   (d) Cleft chin

20. There are two structures as shown:
    (i) Stem tendril in passiflora and
    (ii) Thorn of Bougainvillea

These two are
(a) Homologous organs
(b) Analogous organs
(c) Vestigial organs
(d) Heterologus organs

21. Archacopteryx was having characters of
(a) Invertebrates and vertebrates
(b) Fishes and amphibians
(c) Reptiles and birds
(d) Birds and mammals

22. The visible characteristic in an organism is known as
(a) Genotype
(b) Phenotype
(c) Prototype
(d) Stereotype

23. The following results were obtained by a scientist who crossed the F_1 generation of pure-breeding parents for round and wrinkled seeds

Dominant trait	Recessive trait	No. of F_2 offspring
Round seeds	Wrinkled seeds	7524

From these results, it can be concluded that the actual number of round seeds that obtained was
(a) 1881
(b) 2508
(c) 5643
(d) 22572

24. A trait in an organism is influenced by
(a) Material DNA only
(b) Paternal DNA only
(c) Both maternal and paternal DNA
(d) Neither by paternal nor by maternal DNA

25. The exchange of genetic material takes place in
(a) Budding
(b) Sexual reproduction
(c) Asexual reproduction
(d) Vegetative reproduction

26. A cross between a tall plant (TT) and short plant (tt) resulted in progeny that were all tall plants because
(a) Tallness is dominant trait
(b) Tallness is recessive trait
(c) Shortness is the dominant trait
(d) Height of plant is not governed by gene trait

27. Match the terms given in column I with those given in column II

Column I	Column II
(i) Fossil	(A) A famous evolutionist
(ii) A theory of evolution	(B) Survival of the fittest
(iii) Probable ancestor of bird	(C) Petrified remains of prehistoric life
(iv) Charles DarwinLife	(D) Father of genitics
(v) Gregor Mendel	(E) Archaeopteryx

(a) (i) → B, (ii) → C, (iii) → A, (iv) → E, (v) → D
(b) (i) → C, (ii) → B, (iii) → E, (iv) → A, (v) → D
(c) (i) → E, (ii) → D, (iii) → B, (iv) → C, (v) → A
(d) (i) → D, (ii) → A, (iii) → C, (iv) → B, (v) → E

28. One of the following traits cannot be inherited. This one is
(a) Colour of eyes
(b) Colour of skin
(c) Nature of hair
(d) Size of body

29. Which of the following statement is incorrect with respect to variations?
(a) Change in genetic composition results in variations
(b) Selection of variations of environmentsal factors form the basis of evolutionary process
(c) All variations in a species have equal chance of survival
(d) Variations are the minimum in asexual reproduction

30. Wings of an insect and forelimbs of a birds are
(a) Homologous organs
(b) Analogous organs
(c) Analeptic organs
(d) Homophobic organs

31. One of the following has not been produced from wild cabbage by the process of artificial selection. This one is
(a) Cabbage
(b) Spinach
(c) Kale
(d) Kohlrabi

32. The organs which perform different functions but have the same basic structure are known as
(a) Homologous organs
(b) Analogous organs
(c) Hemolytic organs
(d) Analytic organs

33. On one of the following characteristics of the parents can be inherited by their children. This one is
(a) Technique of swimming
(b) Cut nose
(c) Snub nose
(d) Deep scar in chin

34. In human males all the chromosomes are paired perfectly except one. This/these unpaired chromosomes is/are
(i) Small chromosome
(ii) Large chromosome
(iii) Y chromosome
(iv) X chromosome
(a) (i) and (ii)
(b) (ii) and (iii)
(c) (iii) and (iv)
(d) (ii) and (iv)

35. The sex of a child is determined by which of the following
   (a) The length of time between volution and copulation
   (b) The presence of a Y chromosome in a sperm
   (c) The presence of an X chromosome in an ovum
   (d) The length of the mother's pregnancy

36. The zygote which has inherited an X chromosome from the father will develop into
   (a) Adult
   (b) Baby boy
   (c) Baby girl
   (d) Either boy or girl

37. Which of the following statement is incorrect ?
   (a) For every hormone there is a gene
   (b) For every type of fat there is a gene
   (c) For every protein there is a gene
   (d) For production of every enzyme there is a gene

38. If the fossil of an organism is found in the deeper layer of earth, then we can predict that
   (a) The extinction of organism has occurred recently
   (b) The fossil position in the layers of earth is not related to its time of extinction
   (c) The extinction of organism has occurred thousands of years ago
   (d) Time of the extinction cannot be determined

39. Some dinosours had feathers although they could not fly but birds have feathers that help them to fly. In the context of evolution, this means that
   (a) Feathers are homologous structures in both the organisms
   (b) There is no evolutionary connection between reptiles and birds
   (c) Reptiles have evolved from birds
   (d) Birds have evolved from reptiles

40. New species may be formed if
   (i) There is no change in genetic material
   (ii) Chromosome number change in the gamete
   (iii) DNA undergoes significant changes in germ cells
   (iv) Mating does not take place
   (a) (i) and (ii)
   (b) (ii) and (iii)
   (c) (iii) and (iv)
   (d) (i) and (iv)

41. In peas, a pure tall plant (TT) is crossed with a pure short plant (tt). The ratio of pure tall plants to pure short plants in F_2 generation will be
   (a) 1 : 1
   (b) 2 : 1
   (c) 1 : 3
   (d) 3 : 1

42. The two versions of a trait (character) which are brought in by the male and female gametes are situated on :
   (a) Any chromosomes
   (b) Two different chromosomes
   (c) Sex chromosomes
   (d) Copies of the same chromosome

43. Select the statements that describe characteristics of genes :

(i) Genes are specific sequence of bases in a DNA molecule

(ii) In individuals of a given species, a specific gene is located on a particular chromosome

(iii) A gene does not code for proteins

(iv) Each chromosome has only one gene

(a) (i) and (ii)
(b) (ii) and (iii)
(c) (i) and (iii)
(d) (i) and (iv)

44. Select the in correct statement from the following :

(a) Traits which are not inherited over generations evolution

(b) Low weight parents can have heavy weight progeny

(c) Reduction in the weight of an organism due to starvation is genetically controlled

(d) Frequency of certain genes in population changes over several generations resulting in evolution.

45. Select the group which shares the maximum number of common characters :

(a) Two genera of two families

(b) Two genera of a family

(c) Two individuals of species

(d) Two species of a genus

Answer Key

1. (a)	2. (b)	3. (c)	4. (c)	5. (c)	6. (b)	7. (d)	8. (c)	9. (b)	10. (c)
11. (c)	12. (d)	13. (a)	14. (d)	15. (b)	16. (c)	17. (b)	18. (c)	19. (b)	20. (a)
21. (c)	22. (b)	23. (c)	24. (c)	25. (b)	26. (a)	27. (b)	28. (d)	29. (c)	30. (b)
31. (b)	32. (b)	33. (c)	34. (c)	35. (b)	36. (c)	37. (b)	38. (c)	39. (d)	40. (b)
41. (a)	42. (d)	43. (a)	44. (c)	45. (c)					

14. Our Environment

Learning Objectives

* Ecosystem and its Components
* Food Chains
* Trophic Levels in a Food Chain
* Ten Percent Law
* Depletion of Ozone Layer and its Effets
* Managing the Garbage and its Disposal

Environment

The physical and biological world where we live is called our environment It includes our physical surroundings like air water bodies, soil, all living organisms such as plants, animals, human beings and microorganisms like bacteria and fungi. Human beings are the only organisms who change the natural environment to fulfill their needs of food, clothing, housing, transport etc. The uncontrolled activities of human beings are damaging the balanced and healthy environment more and more.

Ecosystem

The various organisms such as plants, animals, microorganisms and human beings interact among themselves as well as with their physical environment like soil, water and air and maintain a balance in nature in a particular area. They collectively form a self-sustaining system. This system of living and non-living components is called an ecosystem.

An ecosystem needs only the input of sunlight energy for its functioning. The examples are a grassland, a forest, desert, a mountain, a river, and sea. Most of the ecosystems in the world are natural ecosystems but some of them are man-made artificial ecosystems like gardens, acquarium.

Components of Ecosystem

All the ecosystems are made up of two main components.

1. **Abiotic components:** These are non-living components which include physical environment the soil, water and air along with the inorganic substances like carbon dioxide, Nitrogen, oxygen, water, phosphorus and other elements present in them. The climatic factors like light temperature, pressure and humidity are also considered abiotic.
2. **Biotic components:** These are living components of an ecosystem, made up of many different species of plants and animals along with made population of human beings. There are three types of organisms in the biotic community of an ecosystem.
   (i) **Producer organisms (or Autotrophs)** synthesize their own food. All green plants are autotrophs.
   (ii) **Consumer organisms (or Heterotrophs)** depend on others for food. All animals and human beings are heterotrophs.
   (iii) **Decomposers organisms (or Saprotrophs)** consume the dead remains of other organisms. All fungi and certain bacteria saprotrophs.

Functioning of an Ecosystem

From the nutrient pool of the earth (soil, water and air), CO_2 and water are absorbed by the producer organisms (green plants). With the help of sunlight, they convert these inorganic substances into organic compounds like carbohydrates which act as a food.

Thus, produces trap to the solar energy and then provide the basic food or energy for all other life forms in the ecosystem. The consumers (animals) derive the their energy needs from producers (plants). When plants and animals die, then the decomposer organisms act on their dead bodies to return the various elements back to the nutrient pool.

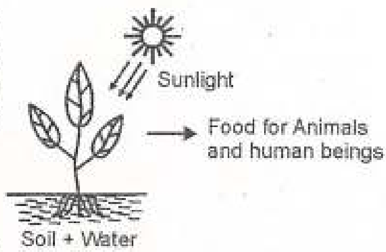


Fig: 14.1

Food Chains

We eat food to obtain energy which is helpful to do physical work. The food can be transferred from one organism to the other through food chains. This series of organisms taking part of various biotic levels form a food chain. Producers (plants) are always at the starting point of every food chain. This chain shows '**Who eats whom**'.

Grass (Producer) → Deer (Herbivore) → Lion (Carnivore)

Grass (Producer) → Insect (Herbivore) → Frog (Carnivore) → Eagle (Top Carnivore)

Food Web

A large number of food chains exist in a community of living organisms in an ecosystem such as a grass land, forest or a like. The interconnected food chains operating in an ecosystem which establish a network of relationships between various species is called a food web. This means that the various food chains in an ecosystem do not operate in isolation. They operate in the form a network of food chains and form a web.

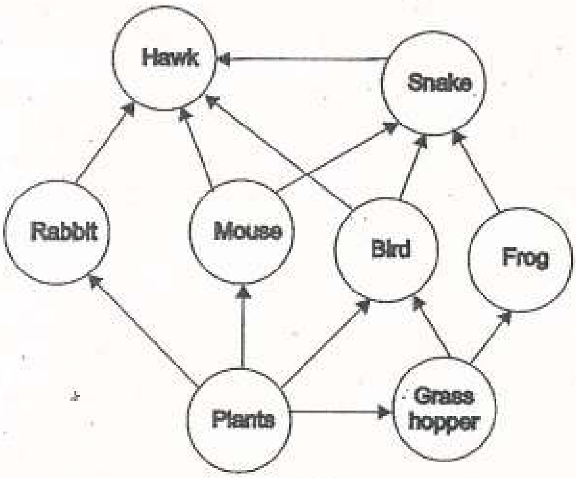


Fig: 14.2

Trophic Levels

The various steps in a food chain at which the transfer of food (or energy) takes place are called trophic levels. In a food chain each step representing on organism forms a trophic level.

- Producer (autotrophs) constitute the **first trophic level.** They fix up the sun's energy and make it available for consumers (hetrotrophs).

- Herbivors which feed upon plants are the primary consumers and they form the **second trophic level.**
- Carnivores that feed upon herbivores constitute the **third trophic level.**
- Large carnivores or top carnivores that feed upon small carnivores constitute the **fourth trophic level.**

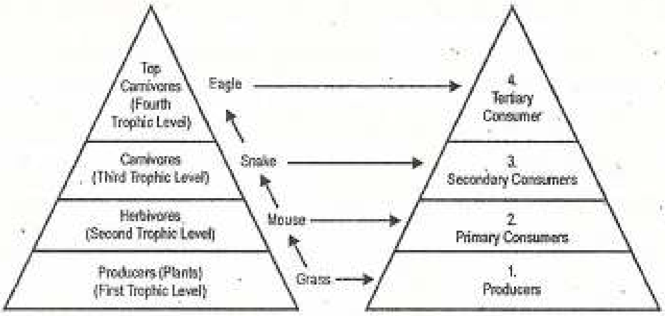


Fig: 14.3

Ten Present Law

There is a continuous transfer of energy from one trophic level of organisms to the next trophic level in a food chain. For example plants transfer energy to the hervivores, and the herbivores to carnivores. This energy transfer place in the form of chemical energy of food.

There is a loss of energy at each energy transfer in various trophic levels of organisms which goes into the environment as heat and remain unutilised. No transfer of energy of 100 per cent.

Raymond Lindeman in the year 1942 revealed a **10 per cent law** according to which, only 10 per cent of the energy entering a particular trophic level is available for transfer to the next higher trophic level. Thus, there is a progressive decline in the amount of the energy available as we go from producer level to the higher trophic levels of organisms.

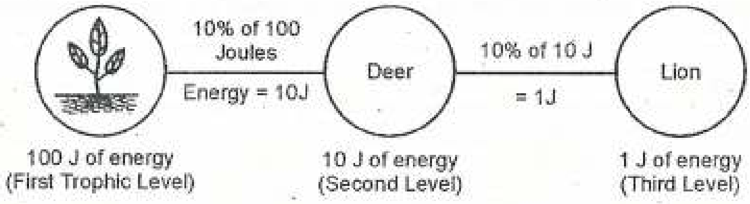


Fig: 14.4

Depletion of Ozone Layer

Ozone (O3), though a deadly poison performs an essential function of shedding the surface of the earth from the harmful ultraviolet (UV) radiations of the sun. These radiations are highly damaging to the living organisms like it causes skin cancer in human beings.

Ozone at higher levels of the atmosphere is the product of UV radiation acting on oxygen (O_2) molecule.

$$\text{(Oxygen molecule) } O_2 \xrightarrow{UV} O + O \text{ (Free oxygen atoms)}$$
$$O + O_2 \longrightarrow O_2 \text{ (ozone)}$$

It has now been that the amount of ozone is getting depleted or reduced due to which the ozone layer present in the upper atmosphere is becoming thinner and thinner day by day. **The depletion of ozone layer is due to the use of chlorofluorocarbons (CFC).**

CFCs are chemicals which are widely used in refrigeration as a coolant; in fire extinguishers and in aerosol sprayers.

Chlorofluorocarbons released into the air react with ozone gas prevent in the ozone layer and destroy it gradually. This causes UVs to reach the earth in more quantity. In 1987, in an attempt to protect ozone layer, the United Environment Programme (UNEP) forgeable an agreement among its member countries to freeze CFC production at 1986 levels.

Managing the Garbage Produced by Man

The household wastes such as left-over food, fruit and vegetable peels, leaves of potted plants, packaging material, disposable plates, cups, unwanted plastic objects as polythene bags, toys, etc, glass articles, broken metal items, old wooden furniture, rags, discarded shoes and sewage constitutes **garbage.**

If the household garbage or domestic waste is not disposed off properly, it can pollute the environment like air, water and soil. This disposal of waste (getting rid of waste) should be done in a scientific way so as to reduce the chances of any type of pollution created by it. There are different methods of waste disposal. The method to be adopted depends on the nature of the waste to be disposed. There are primarily five methods of waste disposal.

1. **Recycling:** The solid wastes like old newspapers, hard board, plastic and metals are recycles by reprocessing method and mould into reusable new products. We use recycled paper for making greeting cards, cheap plastic goods made from recycled plastic.
2. **Preparation of compost:** Biodegradable wastes such as left-over food decayed fruits and vegetables, leaves of potted plants can be converted into compost by burying in a pit dug into ground, and is later used as manure.
3. **Incineration:** The burning of biological waste at high temperature of more than 1000 °C to form ash is called incineration. This process greatly reduced the volume of chemical waste, household waste and hospital west this is disposed off as land fill. All the organic matter present in waste is removed as carbon dioxide and water vapour.
4. **Land fill:** The disposal of wastes by putting it in low-lying areas of ground and covering it with soil is called land fill. Most of the solid waste in urban areas is dumped in law-lying grounds and covered with soil to level the uneven ground.
5. **Sewage treatment:** The dirty drain water containing urine and human fecas which is carried from our homes by the underground sewer pipes is called sewage. If this waste is flowed into the river, it can pollute the river water. Thus, sewage is disposed off by treating it at the sewage treatment plant. The organic matter present in the sewage is digested in the digesters of the plant to produce sewage gas (a kind of biogas) and manure; and the clean water a discharged into the river.

Key Points

- ✓ Ecosystem consists of biotic (living) and abiotic (non-living) components.
- ✓ The ultimate source of energy for all the living organisms in sun. The light energy of sun is absorbed by plants.
- ✓ The various components of an ecosystem are interdependent for their existence.
- ✓ There is loss of energy as we go from one trophic level to the next, each time only 10% of the energy is carried forward and rest is released as heat in the air.
- ✓ The thick layer of ozone (O_3) molecule in the upper layer of atmosphere is called ozone layer.
- ✓ Ozone layer protects us from the harmful ultraviolet radiations which causes skin cancer, eye irritation and many other harmful oilments
- ✓ The gas which causes the depletion of ozone layer in chlorofluorocarbons (CFC) released from refrigerants coolant and aerosol sprays.
- ✓ The waste we generate may be biodegradable or non-biodegradable.
- ✓ We can dispose of this waste by recycling, preparing compost, incineration and sewage treatment.

Multiple Choice Questions

1. Decomposition of house hold wastes under natural conditions is known
   (a) Non-biodegradable process
   (b) Biodegradable process
   (c) Decomposition process
   (d) Compost formation process
2. Green house gases include
   (a) CO_2, CFC, CH_4, NO_2
   (b) CO_2, O_2, N_2, NH_3
   (c) CFC, CO_2 O_3 CH_4
   (d) CFC, NO_2 NH_3, O_3
3. The organisms which obtain their food from dead plants, dead animal bodies and other decaying organic matters are known as
   (a) Autotrophs
   (b) Heterotophs
   (c) Parasites
   (d) Saprophytes
4. Ozone layer in uppermost atmosphere is destroyed by
   (a) SO_2
   (b) CO
   (c) CFC
   (d) Smog
5. The word 'Sapro' means
   (a) Dead
   (b) Alive
   (c) Fermented
   (d) Rotten
6. The degradation of organic wastes through the consumption by earth worms is called
   (a) Vermicomposting
   (b) Nitrogen fertilisers
   (c) Complex fertiliser
   (d) Nitrogen fixation
7. In a food chain, the initial organism is usually
   (a) Saprophytic
   (b) Photosynthetic
   (c) Herbivorous
   (d) parasitic
8. Identify the biodegradable waste among the following
   (a) Plastic
   (b) DDT
   (c) Glass
   (d) Jute
9. Which of these is an artificial ecosystem ?
   (a) pond
   (b) lake
   (c) forest
   (d) crop field
10. Disposable plastic plates should not be used because
    (a) They are made of non-biodegradable material
    (b) They are made of biodegradable material
    (c) They are made of artificial material
    (d) They are made of toxic material
11. In a food chain, the third trophic level is always occupied by
    (a) Herbivores
    (b) Carnivores
    (c) Top carnivores
    (d) Parasites
12. Which one of these is a biotic component of the ecosystem ?
    (a) Air
    (b) Plant
    (c) Water
    (d) Land

13. Accumulation of non-biodegradable pesticides in the food chain in increasing amount at each higher trophic level is known as
    (a) Eutrophication (b) Biomagnification
    (c) Accumulation (d) Pollution
14. In a food chain a grasshopper is eaten by a frog, the energy transfer will be from
    (a) Producer primary consumer
    (b) Primary consumer to secondary consumer
    (c) Producer to decomposer
    (d) Secondary consumer to tertiary consumer
15. The decomposers in an ecosystem
    (a) Convert organic material to inorganic form
    (b) Convert inorganic material to organic form
    (c) Convert inorganic material to a complex form
    (d) Do not break down organic compounds
16. Which one of the following is not a terrestrial ecosystem?
    (a) Desert (b) Grass land
    (c) Forest (d) River
17. What will happen if deer is missing in the food chain given below
    Grass → Deer → Tiger
    (a) The population of grass decreases as more deer are saved
    (b) The population of tigersincreases as they can eat more grass
    (c) The population of tigers decreases and the grass increases enormously
    (d) None of these
18. The one which is not biodegradable material is
    (a) Cotton (b) Animal bone
    (c) Aluminium foil (d) Wooden chair
19. Which of the following is not a producer ?
    (a) Zooplankton (b) Grass
    (c) Phytoplankton (d) Paddy
20. One of the following is a mirco-consumer. This one is
    (a) Ant (b) Lice
    (c) Mosquito (d) Fungi
21. Organisms which synthesis carbohydrates from inorganic compounds by using radiant energy are called
    (a) Decomposers (b) Herbivores
    (c) Producers (d) Omnivores
22. Organism of a higher trophic level which feed on several types of organisms belonging to number of lower trophic levels of different food chains constitute the
    (a) Ecosystem (b) Food web
    (c) Ecological pyramid (d) Food network

23. Which one of these is a non-biodegradable waste ?
(a) Polythene
(b) PVC
(c) Bakellite
(d) All of these

24. Some organisms produce their own food using simple inorganic substances under photosynthesis process. Identify the organism which does this activity ?
(a) Green Algae
(b) Fungi
(c) Bacteria
(d) Virus

25. Which one among the following is a lotic ecosystem?
(a) River
(b) Stream
(c) Spring
(d) All of these

26. Which of these is a lentic ecosystem ?
(a) Lake
(b) Pond
(c) Swamp
(d) All of the these

27. Which of these is a terrestrial ecosystem ?
(a) Desert
(b) Forest
(c) Grassland
(d) All of these

28. The use one ___________ will pollute the environment.
(a) Carry bag made of nylon cloth
(b) Carry bag made of cotton cloth
(c) Carry bag made of jute fibre
(d) Carry bag made of paper

29. Which of the following act as decomposers in an ecosystem?
(a) Cyanobacteria
(b) Lactobacillus bacteria
(c) Putrefying bacteria
(d) Rhizobium bacteria

30. In the food chain comprising of a snake, grass, insect and frog, the secondary consumer is
(a) Snake
(b) Frog
(c) Insect
(d) Grass

31. If 10 Joules of energy is available of producer level, then the energy transferred to the lion in the following food chain is

Plants $\rightarrow$ Deer $\rightarrow$ Lion

(a) 1 J
(b) 5 J
(c) 0.1 J
(d) 0.5 J

32. The ozone layer is composed of
(a) O
(b) O_3
(c) O_2
(d) Combination of 3 oxygen atoms

33. Sahara desert was formed over a period of time due to
(a) Excessive deforestation
(b) Excessive killing of large herbivores
(c) Excessive killing of large carnivores
(d) Excessive use of poisonous chemicals

34. The ultimate source of energy in our ecosystem is
(a) Water
(b) Sun
(c) Air
(d) Microbes

35. The 'Ten-percent Law' of energy flow in food chain is proposed by
(a) Raymond Lindeman
(b) Charles Lindeman
(c) Raymond Hilary
(d) Lindeman Jhones

36. What provides the energy which then flows through a food chain ?
(a) Glucose
(b) Oxygen
(c) Respiration
(d) Sunlight

37. In a food chain the per cent energy available for transfer at different trophic levels in the form of
(a) Heat energy
(b) Light energy
(c) Mechanical energy
(d) Chemical energy

38. The flow of energy is an ecosystem is always
(a) Cyclic
(b) Unidirectional
(c) Multidirectional
(d) Bidirectional

39. In the food chain given below, if the energy at fourth trophic level is 3 kJ, what was the energy available at producer level ?
(a) 30 kJ
(b) 300 kJ
(c) 3000 kJ
(d) 3 kJ

40. The excessive exposure of humans to ultraviolet rays results in
(a) Damage to immune system
(b) Skin cancer
(c) Both (a) and (b)
(d) Neither (a) nor (b)

41. Which of the following gets the minimum energy through the food chain in an ecosystem ?
(a) Herbivores
(b) Producers
(c) Carnivores
(d) Large carnivores

42. Most of the water surface of a lake is covered with algae. This algae is part of the food chain which also includes small fish, bird, larvae and a big fish. Which of the following will obtain maximum energy ?
(a) Larvae
(b) Small fish
(c) Bird
(d) Big fish

43. Oxygen molecule (O_2) is converted into ozone (O_3) by the action of
(a) Infrared radiations
(b) Ultraviolet radiations
(c) Gamma radiations
(d) Cosmic radiations

44. Which of the following is the source of CFC gas, released into the atmosphere causing ozone depletion?
(a) Coolers
(b) Refrigerators
(c) Vehicles
(d) Factory

45. Which of the following cannot be added in a composting pit to prepare compost ?
(a) Sunflower plants
(b) Fruit and vegetable peels
(c) Plastic flowers
(d) Read earth worms

Answer Key

1. (b)	2. (a)	3. (d)	4. (c)	5. (d)	6. (a)	7. (b)	8. (d)	9. (d)	10. (a)
11. (b)	12. (b)	13. (b)	14. (b)	15. (a)	16. (d)	17. (c)	18. (c)	19. (a)	20. (d)
21. (c)	22. (b)	23. (d)	24. (a)	25. (d)	26. (d)	27. (d)	28. (a)	29. (c)	30. (b)
31. (b)	32. (b)	33. (c)	34. (b)	35. (a)	36. (d)	37. (d)	38. (b)	39. (c)	40. (c)
41. (d)	42. (a)	43. (b)	44. (b)	45. (c)					

Achievers Section

Questions Based on Achievers Section

1. Which of the following statenents are correct?
   (i) The cells in our blood which destroy disease-causing germs are WBCs
   (ii) Fish has a much higher breathing rate than dog, man or sparrow.
   (iii) Respiration is an aerobic process.
   (a) (i) and (ii)
   (b) (ii) and (iii)
   (c) (i) and (iii)
   (d) (i), (ii) and (iii)
2. Match the position of the object (given in Column A) with position of the image (given in column B) for the formation of image by a concave mirror,

Column A	Column B
(1) At infinity	(P) Between F and C
(2) Beyond C	(Q) Behind the mirror
(3) Between F and P	(R) At F

   (a) $1 \rightarrow P, 2 \rightarrow R, 3 \rightarrow Q$
   (b) $1 \rightarrow R, 2 \rightarrow P, 3 \rightarrow Q$
   (c) $1 \rightarrow R, 2 \rightarrow Q, 3 \rightarrow P$
   (d) $1 \rightarrow Q, 2 \rightarrow P, 3 \rightarrow R$

Direction (3-6): Fill in the blanks with appropriate option:

3. The front transparent part of the eye which is bulged outwards is called __________.
   (a) Cornea
   (b) Vitreous body
   (c) Pupil
   (d) Iris
4. __________ is used in making the filament of an electric bulb?
   (a) Copper
   (b) Aluminium
   (c) Tungsten
   (d) Silver
5. pH of Ammonium chloride, (NH_4Cl) or copper sulphate (C_4SO_4) solution will be __________.
   (a) 7
   (b) > 7
   (c) < 7
   (d) O
6. The number of pair (s) of sex chromosomes in the zygote of human is __________.
   (a) One
   (b) Two
   (c) Three
   (d) four
7. **Statement 1:** Light travels in a straight line and cannot pass through any opaque object.
   Statement 2: Light is electomagnetic waves which do not require any medium to travel.
   (a) Statement 1 is correct but statement 2 is false.
   (b) Statement 2 is correct but statement 1 is false.
   (c) Both statement 1 and 2 are correct and statement 2 is the correct reason for statement 1.
   (d) Both statements are correct but statement 2 is not the correct reason for statement 1.

Direction (8-11): Fill in the blanks with appropriate option:

8. The transmission of the __________ from one generation to the next is called heredity.
   (a) Trait
   (b) Specification
   (c) Variations
   (d) Properties

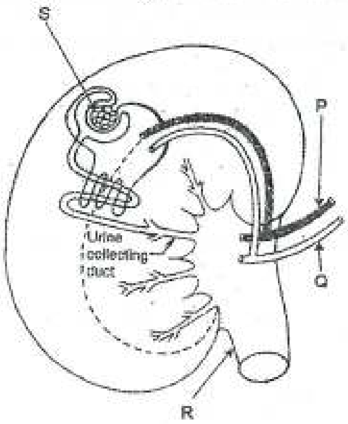
9. A plant with two small genes breed with a plant with two tall genes to produce __________.
   (a) All small plants
   (b) All tall plants
   (c) Small plants and tall plants in the ratio 1 : 3
   (d) Tall plants and small plants in the ratio 3 : 1

10. The gas __________ was not present in early earth a atmosphere?
   (a) Methane
   (b) Ammonia
   (c) Hydrogen sulphide
   (d) Oxygen

11. The evolution of new organism is also called __________.
   (a) Organic evolution
   (b) Anatomical evolution
   (c) Biochemical evolution
   (d) Behavioral evolution

12. Which of the following is not true.
   (a) Newland grouped the elements into triodes and Dobereiner gave the law of Octaves
   (b) The oxides of metals are basic while those of non-metals are acidic in nature.
   (c) Elements are classified on the basis of similarities in their properties
   (d) None of these

13. Which of the following labelled figure brings blood into the kidney of a human being.

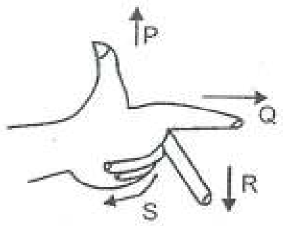


The Structure of Kidney

   (a) P
   (b) Q
   (c) R
   (d) S

14. **Statement 1:** Magnetic field lines are widely spaced near the poles and denser near the centre
   Statement 2: Magnetic field lines always emerge from north pole and converge at south pole.
   (a) Statement 1 is true but statement 2 is false.
   (b) Statement 2 is true but statement 1 is false.
   (c) Both statement 1 and statement 2 are true but statement 2 is not the reason of statement 1.
   (d) Both statement 1 and statement 2 are true and statement 2 is the correct reason for statement 1.

15. Which of the labelling in the given figure shows the direction of the current using Fleming's Left-Hand Rule?



(a) P
(b) Q
(c) R
(d) S

16. Which of the following statement is true?
   (a) In a combination reaction two or more substances combine to form a new single substance.
   (b) Two different atoms or groups of atoms (ions) are exchanged in double displacement reaction.
   (c) Decomposition reactions are opposite to combination reactions
   (d) All of these

Direction (17-20): Fill in the blanks with appropriate option:

17. __________ is a method to prevent rusting by coating the surface of iron objects with a thin layer of zinc.
   (a) Painting
   (b) Galvanisation
   (c) Corrosion
   (d) Electrolysis

18. Oxidation is defined as a process which involves__________.
   (a) Gain of oxygen
   (b) Loss of hydrogen
   (c) Both (a) and (b)
   (d) None of these

19. __________ is the process of slowly eating up of the metals due to attack of atmospheric gases.
   (a) Metallurgy
   (b) Reduction
   (c) Corrosion
   (d) Decomposition

20. Reactions in which energy is absorbed are known as__________________.
   (a) Exothermic reaction
   (b) Endothermic reaction
   (c) Redox reaction
   (d) Decomposition reaction

21. Which of the following is not true.
   (a) The earth receives an average of 4 KWh/m^2 solar energy daily.
   (b) A thermal power plant generates only heat energy by burning fossil fuels like coal.
   (c) Ocean thermal energy is the solar energy stored in the sea water.
   (d) None of these

22. Which of the following is not an example of decomposition reaction?

   (a) $\underset{\text{(Ferrous sulphate)}}{FeSo_4} \xrightarrow{\text{heat}} \underset{\text{(Ferric Oxide)}}{Fe_2O_{3(s)}} + So_{2(g)} + So_{3(g)}$

   (b) $\underset{\substack{\text{Sodium chloride}\\\text{(molten)}}}{2NaCl_{(s)}} \xrightarrow[\text{Current}]{\text{Electric}} \underset{\substack{\text{Sodium chlorine}\\\text{(metal)}}}{2Na + Cl_2\uparrow}$

   (c) $\underset{\substack{\text{Silver chloride}\\\text{(White)}}}{2AgCl} \xrightarrow{\text{Sunlight}} \underset{\substack{\text{Silver}\\\text{(gray)}}}{2Ag} + Cl_2$

   (d) $\underset{\substack{\text{(Quick}\\\text{lime)}}}{CaO_{(s)}} + \underset{\text{(Water)}}{H_2O_{(l)}} \longrightarrow \underset{\substack{\text{(Slaked}\\\text{lime)}}}{Ca(OH)_{2\,(aq)}}$

23. Which of the following is not true?
   (a) Iris decides the colour of the eye.
   (b) The hole in the centre of cornea is called conjunctiva.
   (c) Retina acts like a screen for the image formation in eye.
   (d) None of these

24. **Statement 1:** The focal length or converging power of eye lens is not fixed.
   Statement 2: Ciliary muscles can modify the curvature of eye lens to some extent.
   (a) Statement 1 is true but statement 2 is false.
   (b) Statement 2 is true but statement 1 is false
   (c) Both statement 1 and statement 2 are true but statement 2 is not the reason for statement 1.
   (d) Both statement 1 and statement 2 are true and statement 2 is the reason for statement 1.

Direction (25-28): Fill in the blanks with an apropriate option.

25. The ability of metals to be drawn into this wire is known ___________.
   (a) Ductility (b) Conductivity
   (c) Malleability (d) Sonorousity

26. Among metals ____________ is the poorest conductor of heat
   (a) Tin (b) Bismuth
   (c) Lead (d) Mercury

27. Covalent bends are formed by__________.
   (a) Sharing of electrons (b) Donating electrons
   (c) Receiving electron (d) All of these

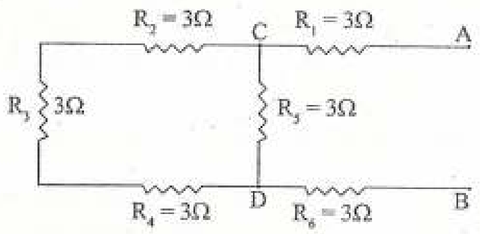
28. A ______________ is an atom or a group of atoms present in a molecule which determines its property.
   (a) Element (b) Compounds
   (c) Functional group (d) Molecule

Answer Key

1. (a)	2. (b)	3. (a)	4. (c)	5. (c)	6. (a)	7. (c)	8. (a)	9. (b)	10. (d)
11. (a)	12. (a)	13. (a)	14. (b)	15. (c)	16. (d)	17. (b)	18. (c)	19. (c)	20. (b)
21. (b)	22. (d)	23. (b)	24. (d)	25. (a)	26. (c)	27. (a)	28. (c)		

High Order Thinking Skills (HOTS)

1. The electric resistance of a certain wire of iron is R. If its length and radius are both doubled, then
   (a) The resistance will be doubled and the specific resistance will be halved.
   (b) The resistance will be halved and the specific resistance will be doubled.
   (c) The resistance will be halved and the specific resistance will remain unchanged.
   (d) The resistance and the specific resistance will both remain unchanged.
2. A combination of six resistors R_1, R_2, R_3, R_4, R_5 and R_6 are shown in the figure. Find the equivalent resistance between points A and B on the circuit.
   (a) 8.25 Ω
   (b) 8.0 Ω
   (c) 7.25 Ω
   (d) 7.85 Ω



3. Heat of 100J is produced each second in a 4 Ω resistance. The potential difference across the resistor is
   (a) 200 V
   (b) 20V
   (c) 40 V
   (d) 220 V
4. An induced emf is produced when a magnet is plunged into a coil. The magnitude of induced emf does not depend on
   (a) The number of turns in the coil
   (b) The resistivity of the material of the coil
   (c) The speed with which the magnet is moved
   (d) The strength of the magnet.
5. Which of the following statements is NOT true ?
   (a) The relative strength of magnetic field is shown by the degree of closeness of the field lines.
   (b) Magnetic field lines are closed curves.
   (c) The direction of magnetic field at a point is taken to be the direction in which the north pole of the magnet compass needle points.
   (d) If magnetic field lines are parallel and equidistant, they represent zero field strength.
6. A major problem in harnessing nuclear energy through nuclear fission is
   (a) splitting the nucleus.
   (b) disposal of nucleus wastes.
   (c) converting nuclear energy to electric energy.
   (d) sustaining chain reaction.

7. In a hydro power plant,
   (a) potential energy possessed by stored water is converted into electricity.
   (b) kinetic energy possessed by stored water is converted into potential energy
   (c) electricity is extracted from water
   (d) water is converted into steam to produce electricity.

8. Acid rain occurs because
   (a) the earth's atmosphere contains acids.
   (b) electrical charges are produced due to friction amongst clouds.
   (c) The sun leads to heating of upper layer of atmosphere.
   (d) burning of fossil fuels releases oxides of carbon, nitrogen and sulphur in the atmosphere.

9. An erect image, 3 times the size of the object is obtained with a concave mirror of radius of curvature 36cm. What is the position of the object 'u' from the mirror?
   (a) –10 cm (b) –12cm
   (c) 12 cm (d) –6 cm

10. The linear magnification produced by a convex mirror is always positive. This is because
    (a) The image formed by a convex mirror is always virtual and erect.
    (b) The image formed by a convex mirror is always smaller in size than the object.
    (c) The convex mirror is a small mirror.
    (d) The image formed by a convex mirror is real.

11. How much time will light take to cross 2mm thick glass pane if refractive index of glass is $\frac{3}{2}$?
    (a) 10^{-7}s (b) 10^{-8}s
    (c) 10^{-10} s (d) 10^{-11}s

12. A ray of light falling normally on a mirror retraces its path on reflection. This is because
    (a) $\angle i = 90°$ (b) $\angle i = 0°$
    (c) $\angle i = 45°$ (d) none of these

13. A ray of light falls on one face of an equilateral glass prism at 40° and emerges from the face at the same angle. The deviation suffered by the ray is
    (a) 20° (b) 40°
    (c) 60° (d) 80°

14. Which one of the following does not result in the evolution of H_2 gas?
    (a) Zinc and hydrochloric acid
    (b) Aluminum and nitric acid
    (c) Iron and sulphuric acid
    (d) Magnesium and very dilute nitric acid

15. On heating ferrous sulphate crystals, one would get
    (a) sweet smell (b) rotten egg smell
    (c) irritating choking smell (d) none of these

16. Copper sulphate solution is added to a test tube containing a clean nail. The correct description regarding the deposition of copper on the iron nail would be that it starts depositing

(a) at the tip of the nail
(b) from the head of the nail
(c) in the middle of the nail
(d) anywhere on the rail

17. On electrolysis of brine solution, the products formed are
(a) sodium and chlorine and oxygen
(b) hydrogen, chlorine and oxygen
(c) hydrogen, chlorine and sodium hydroxide
(d) sodium hydroxide, chlorine and orygen

18. A solution reacts with crushed egg–shells to give a gas that turns lime water milky. The solution contains
(a) NaCl
(b) HCl
(c) Licl
(d) KCl

19. The best conductor of electricity is
(a) copper
(b) silver
(c) aluminum
(d) none of these

20. 18 carat gold contains
(a) 50% gold
(b) 18% gold
(c) 75% gold
(d) 60% gold

21. Stainless steel, in addition to iron, contains
(a) nickel and chromium
(b) copper and tin
(c) aluminum and magnesium
(d) carbora and manganese

22. Which of the following can undergo a chemical reaction ?
(a) $MgSo_4 + Fe$
(b) $MgSo_4 + Pb$
(c) $ZnSo_4 + Fe$
(d) $CuSo_4 + Fe$

23. Which of the following is not a saturated hydrocarbon?
(a) Cyclohexane
(b) Benzene
(c) Butane
(d) Isobutane

24. Carbon forms a large number of organic compounds due to
(a) catenation
(b) phenomenon of isomerism
(c) tendency to form multiple bonds
(d) all of these

25. The reaction, $2C_2H_5\,OH + 2Na \rightarrow 2C_2H_5\,ON_a + H_2$ suggests that ethanol is
(a) acidic in nature
(b) amphoteric
(c) basic in nature.
(d) neutral

26. Atomic number of the element which is surrounded by elements with atomic numbers 17, 34, 36 and 53 in the modern periodic table is
(a) 18
(b) 52
(c) 37
(d) 35

27. Which among the following elements has the largest atomic radii?
(a) Na
(b) Mg
(c) K
(d) Ca

28. When sodium carbonate is added to acetic acid, Co_2 is produced. The other products of reaction are/is

(a) sodium acetate and water
(b) sodium acetate
(c) water
(d) none of these

29. During respiration, the exchange of gases takes places in bronchi

(a) bronchi
(b) alveoli
(c) bronchioles
(d) trachea

30. What prevents the backflow of blood inside the heart during contraction?

(a) thin walls of atria
(b) valves
(c) thick muscular walls of ventricles
(d) all of these

31. The phloem tissue in plants is responsible for the transport of

(a) water
(b) sugar
(c) water and minerals
(d) all of these

32. A big tree falls in a forest but its roots are still in contact with the soil. The branches of this fallen tree grow straight up. This happens in response to

(a) water and light
(b) water and air
(c) light and gravity
(d) gravity and air

33. Which of the following acts as a stimulus in the process of hydrotropism?

(a) Hydrocarbon
(b) Hydrogen oxide
(c) Hydrogen chloride
(d) Hydrogen peroxide

34. Most of the plant hormones promote plant growth. A plant hormone which inhibits growth is

(a) abscisic acid
(b) ethane
(c) ascorbic acid
(d) cytokinin

35. Which of the following helps in maintain posture and balance of the human body?

(a) Cerebellum
(b) cerebrum
(c) medulla
(d) pons

36. The ability of a cell to divide into several cells during reproduction in plasmodium is called

(a) budding
(b) fragmentation
(c) binary fission
(d) multiple fission

37. In human males, the testes lie in the scrotam outside the body because it helps in the

(a) Process of mating.
(b) formation of sperms
(c) easy transfer of sperms
(d) all of these

38. A trait in an organism is influenced by

(a) paternal DNA only
(b) maternal DNA only
(c) both maternal and paternal DNA
(d) neither by paternal nor by maternal DNA

39. In the food chain comprising of a snake, grass, insect, and frog, the secondary consumer is

(a) frog
(b) insect
(c) grass
(d) snake

40. The main reason for the abundant coliform bacteria in the water of River Ganga is
   (a) immersion of ashes of the dead body into the river.
   (b) washing of clothes on the banks of the river.
   (c) discharge of industrial wastes into the river.
   (d) disposal of unburnt corpses into river water.

Answer Key

1. (c)	2. (a)	3. (b)	4. (b)	5. (d)	6. (b)	7. (a)	8. (d)	9. (b)	10. (a)
11. (d)	12. (b)	13. (a)	14. (b)	15. (b)	16. (d)	17. (c)	18. (b)	19. (b)	20. (c)
21. (a)	22. (d)	23. (b)	24. (d)	25. (a)	26. (d)	27. (c)	28. (a)	29. (b)	30. (b)
31. (b)	32. (c)	33. (b)	34. (a)	35. (a)	36. (d)	37. (b)	38. (c)	39. (a)	40. (d)

Hints and Solutions

1. (c)

$$R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2} = \frac{1}{2}(R)$$

$$R' = \frac{\rho(2l)}{\pi 2r^2} = \frac{1}{2}\frac{\rho l}{\pi r^2} = \frac{1}{2}(R)$$

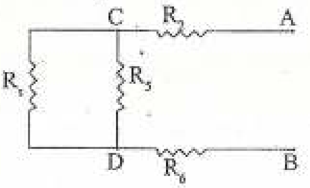
Specific resistance remains unchanged as it depends on the nature of the material of the wire and not on the thickness or length of the wire.

2. (a)

The resistors R_2, R_3 & R_4 are in series. Their equivalent resistance $R_s = 3 + 3 + 3 = 9\Omega$. R_s and R_s are in parallel.

Their equivalent resistance R_p is

$$R_p = \frac{R_s \times R_5}{R_s + R_5} = \frac{9\times 3}{9+3} = 2.25$$



Now R_1, R_p and R_6 are in series. Thus, equivalent resistance between

A and B = $R_1 + R_p + P_6$

$= 3 + 2.25 + 3 = 8.25\,\Omega$

3. (b)

$$H = I^2Rt \quad \Rightarrow I = \sqrt{\frac{H}{Rt}} = \sqrt{\frac{100j}{4_\Omega \times 1_s}} = 5A$$

$V = IR = 5A \times 4\Omega = 20$ volt

4. (b)

Resistivity of the coil will determine the resistance of the coil and the induced current through it as induced current = induced emf/ resistance of the coil.

5. (d)

If the magnetic field lines are parallel and equidistant, they represent a uniform magnetic field.

7. (a)

P.E. of water stored in a storage dam is converted into K.E. when it falls down. This K.E. turns the turbines to produce electricity.

8. (d)

Oxides of carbon, nitrogen and sculpture react with water of rain to produce acid rain.

9. (b)

Here, M = 3, R = – 36 cm

$$M = -\frac{v}{u} \quad \Rightarrow 3 = -\frac{v}{u} \quad \Rightarrow v = -3u$$

$$\text{As } \frac{1}{v} + \frac{1}{u} = \frac{1}{f} = \frac{2}{R} = \frac{2}{-36} = -\frac{1}{18}$$

$$\Rightarrow \frac{1}{-3u} + \frac{1}{u} = -\frac{1}{18}$$

$$\Rightarrow \frac{-1+3}{3u} = -\frac{1}{18} \Rightarrow 3u = -36,$$

U = –12 cm

11. (d)

Here, $x = 2\text{mm} = 2\times 10^{-3}$ m, $n = \frac{3}{2}$

$$\text{From } n = \frac{c}{v},\ v = \frac{c}{n} = \frac{3\times 10^8}{3/2} = 2\times 10^8 \text{ m/s}$$

$$\text{Now } + = \frac{c}{v} = \frac{2\times 10^{-3}}{2\times 10^8\ m/s} = 10^{-3}\times 10^{-8} \text{ s}$$

$= 10^{-11}$s

12. (b)

When $\angle i = 0, \angle r = \angle i = \angle 0°$, That is why the path is retraced back normally on reflection.

13. (a)

As D = i + e – A,

∴ D = 40° + 40° – 60° = 20°

15. (b)

It is a decomposition reaction in which SO_2 and SO_3 gases are produced. These are pungent smelling gases which choke the throat.

16. (d)

It is a displacement reaction. As whole of the nail is in contact with copper sulphate solution, the reaction can take place anywhere on the nail

18. (b)

Egg shells contain calcium carbonate which reacts with HCl to give out CO_2 which turns water milky.

26. (d)

Elements in a period have consecutive atomic numbers, i.e, 34, 35, 36.

27. (c)

Atomic radii increase down a group but decrease along a period. Therefore, the atomic radius of K >Na, Na> Mg and K > Ca. Thus, K has the largest atomic size .

28. (a)

The other products are sodium acetate and water.

$2CH_3\ COOH + Na_2O_3$

Acetic acid

$\rightarrow 2CH_3COONa + H_2O + CO_2$

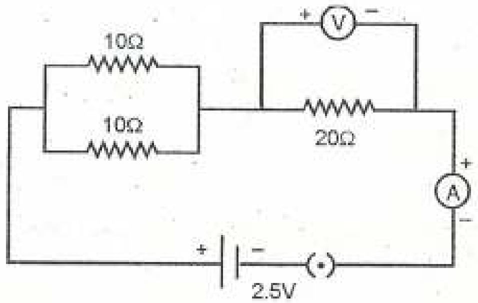
Sodium acetate Water

Model Papers

Model Test Paper – 1

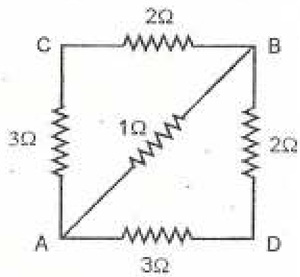
1. The resistance of a 1 km long copper wire of radius 1 mm whose resistivity is $1.72 \times 10^{-8}\ \Omega$ m is
   (a) 5.20 Ω
   (b) 5.48 Ω
   (c) 3.75 Ω
   (d) 6.50 Ω

2. Find the potential difference across the 20 Ω resistor in the given circuit having a battery of emf 2.5 V.



   (a) 2 V
   (b) 3 V
   (c) 4 V
   (d) 5 V

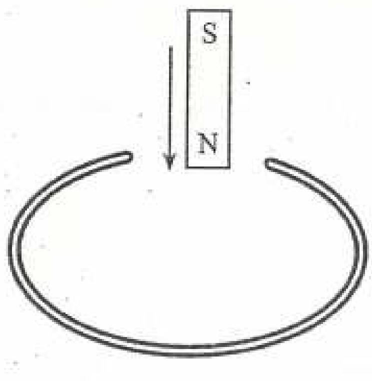
3. The effective resistance between the points A and B in the circuit shown is



   (a) 0.31 Ω
   (b) 0.51 Ω
   (c) 0.71 Ω
   (d) 0.91 Ω

4. A straight wire of diameter 0.5 mm carrying a current of 1 A is replaced by another wire of 1 mm diameter. The strength of the magnetic field far away is
   (a) Twice the earlier value
   (b) One half of the earlier
   (c) One quarter the earlier value
   (d) Same as the earlier value

5. A copper ring having a cut so as not to form a complete loop, is held horizontally and a bar magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet is



6. Biogas is a mixture of methane (75%), CO_2 (25%) and traces of
(a) Nitrogen and helium
(b) Helium and hydrogen
(c) Nitrogen and hydrogen
(d) Hydrogen and ethane

7. In a hydro power plant
(a) Potential energy possessed by stored water is converted into electricity
(b) Kinetic energy possessed by stored water is converted into potential energy
(c) Electricity is extracted from water
(d) Water is converted into steam to produce electricity

8. The image formed by a convex mirror of focal length 20 cm is a quarter of the object. What is distance of the object from the mirror ?
(a) + 60 cm
(b) − 60 cm
(c) + 30 cm
(d) − 30 cm

9. A ray of light falls on a plane mirror making an angle of 30° with the mirror. On reflection, the ray deviates through an angle of
(a) 30°
(b) 90°
(c) 120°
(d) 60°

10 When light rays enter the eye, most of the reflection occurs at the
(a) Crystalline lens
(b) Iris
(c) Pupil
(d) Outer surface of the cornea

11. A dentist advises his patient to rinse his mouth using a mouthwash after every meal. What should be the approximate pH of the mouthwash ?
(a) pH = 7
(b) pH > 7
(c) pH = 5.5
(d) None of these

12. Which one of the following will turn red litmus blue ?
(a) Vinegar
(b) Soft drink
(c) Lemon juice
(d) Baking soda solution

13. Which of the following are combination reactions ?
(i) $2\,KClO_3 \xrightarrow{Heat} 2\,KCl + 3O_2$
(ii) $MgO + H_2O \longrightarrow Mg(OH)_2$
(iii) $4\,Al + 3O_2 \longrightarrow 2\,Al_2O_3$
(iv) $Zn + FeSO_4 \longrightarrow ZnSO_4 + Fe$
(a) (i) and (iii)
(b) (ii) and (iii)
(c) (ii) and (iv)
(d) (iii) and (iv)

14. Copper sulphate solution is added to a test tube containing a clean iron nail. The correct description regarding the deposition of copper of the iron nail would be that it starts depositing
(a) At the tip of the nail
(b) In the middle of the nail
(c) Anywhere on the nail
(d) From the head of the nail

15. Mineral acids are stronger acids than carboxylic acids because
   (i) Mineral acids are completely ionised
   (ii) Carboxylic adids are completely ionised
   (iii) Mineral acids are partially ionised
   (iv) Carboxylic acids are partially ionised
   (a) (ii) and (iii)
   (b) (i) and (ii)
   (c) (i) and (iv)
   (d) (ii) and (iv)

16. Which one of the following process involve chemical reactions ?
   (a) Liquefaction of air
   (b) Keeping petrol in a china dish in the open
   (c) Storing of oxygen gas under pressure in a gas cylinder
   (d) Heating copper wire in presence of air at high temperature

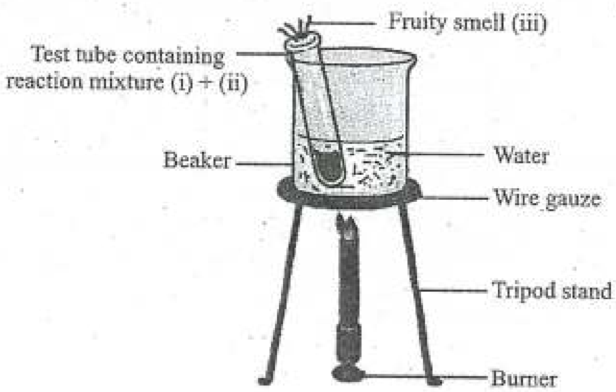
17. Stainless steel is very useful materials for our life. In stainless steel, iron is mixed with
   (a) Ni and Cu
   (b) Ni and Cr
   (c) Cu and Cr
   (d) Cu and Au

18. Consider the elements given here as a part of the periodic table

a	b	c	d
e	f	g	h
i	j	k	*l*

Choose the correct statements regarding the elements
   (i) 'a' is more electropositive than 'd'
   (ii) 'h' will form an oxide that is more basic than that formed by 'e'
   (iii) The atomic size of the elements increase from 'c' to 'k'
   (a) (i) and (ii)
   (b) (ii) and (iv)
   (c) (i) and (iii)
   (d) None of these

19. What are (i), (ii) and (iii) in the figure ?



	(i)	(ii)	(iii)
(a)	CH_3COONa	NaOH	CH_3COOH
(b)	CH_3CH_2COOH	CH_3CH_2OH	$CH_3CH_2COOCH_2CH_3$
(c)	NaOH	CH_3COOH	CH_3COONa
(d)	$CH_3CH_2COOCH_2CH_3$	CH_3CH_2OH	CH_3CH_2COOH

20 Arrange the following elements in the order of their increasing non-metallic character

Li, O, C, Be, F

(a) Li < Be < C < O < F
(b) F < O < C Be < Li
(c) F < C < O < Be < Li
(d) F < O < Be < C < Li

21. Which of the following statements regarding holozic nutrition is false?

(a) Holozoic nutrition does not involve engulfment of whole or part of a plant or animal.
(b) Herbivores show holozoic nutrion.
(c) Ingestion, digestion, absorption and assimilation are some of the steps of holozoic nutrition
(d) Cannibals also come under the category of holozoic nutrition.

22. Which of the following increases in muscle cells when they are lacking in oxygen?

(a) Carbon dioxide
(b) Lactic acid
(c) Lactose
(c) Uric acid

23. Which of the following is most likely to have a much higher breathing rate?

(a) Man
(b) Dog
(c) Fish
(d) Sparrow

24. A blood vessel which carries blood back to the heart is :

(a) Artery
(b) Vein
(c) Capillary
(d) Platelet

25. Darwin's theory of Natural Selection is objected because.

(a) It stresses upon slow and small variations.
(b) It stresses on interspecific competition
(c) It explains that natural calamities take a heavy annual toll of lives
(d) None of these

26. The unicellular organism which reproduces by budding is

(a) Spirogyra
(b) Hydra
(c) Planaria
(d) Yeast

27. One of the following is a surgical method which prevents the sperms from reaching the ovum and pregnancy does not occur. This method is

(a) Condom
(b) Vasectomy
(c) Tubectomy
(d) IUCD

28. Which of the following statements are true?
   (i) In males, the Adam's apple is the protruding cartilage of the larynx
   (ii) Stomata and lenticels function in gas exchange between the atmosphere and internal tissues.
   (iii) While swallowing food, glottis gets covered by small bony flap of skin called epiglottis.
   (iv) Reptiles have two chambers in their heart while on the other hand, fish have only one chamber in their heart
   (a) (i) and (ii)
   (b) (ii) and (iii)
   (c) (i) and (iii)
   (d) (ii) and (iv)

29. A trait in an organism is influenced by
   (a) Maternal DNA only
   (b) Paternal DNA only
   (c) Both maternal and paternal DNA
   (d) Neither by paternal nor by maternal DNA

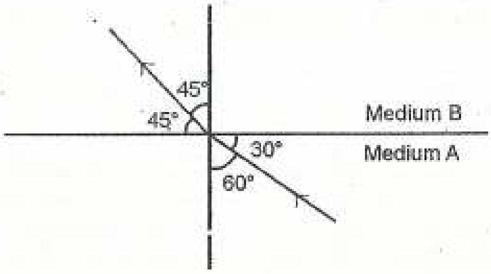
30. Which of the following is in an artificial ecosystem ?
   (a) Lake
   (b) Crop field
   (c) Forest
   (d) Pond

Model Test Paper – 2

1. The clear sky appears blue because
   (a) Blue light gets absorbed in the atmosphere
   (b) Ultraviolet radiations are absorbed in the atmosphere
   (c) Violet and blue lights get scattered more than lights of all other colours by the atmosphere
   (d) Light of all other colours is scattered more than the violet and blue colour lights by the atmosphere

2. The focal length of the eye lens increases when eye muscles
   (a) are relaxed and lens becomes thinner
   (b) contract and lens becomes thicker
   (c) are relaxed and lens becomes thicker
   (d) contract and lens becomes thinner

3. Figure shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is



   (a) $\frac{\sqrt{3}}{\sqrt{2}}$
   (b) $\frac{\sqrt{2}}{\sqrt{3}}$
   (c) $\frac{1}{\sqrt{2}}$
   (d) $\sqrt{2}$

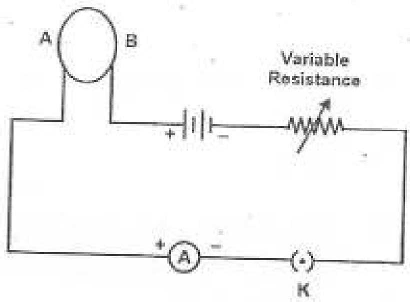
4. A person needs a lens of power – 4.5 D for correcting his vision. The focal length of the corrective lens should be
   (a) – 18.5 cm
   (b) – 22.2 cm
   (c) – 24.5 cm
   (d) – 12.4 cm

5. Wind power of a windmill is
   (a) Directly proportional to the radius of the blades of the windmill
   (b) Directly proportional to the wind speed
   (c) Directly proportional to the square of the wind speed
   (d) Directly proportional to the cube of the wind speed

6. Acid rain happens because
   (a) Sun leads to heating of upper layer of atmosphere
   (b) Burning of fossil fuels release oxides of carbon, nitrogen and sulphur in the atmosphere
   (c) Electrical changes are produced due to friction amongst clouds
   (d) Earth's atmosphere contains acids

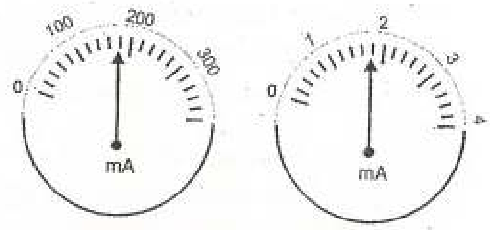
7. Choose the incorrect statement
   (a) Fleming's right-hand rule is a simple rule to know the direction of induced current
   (b) The right-hand thumb rule is used to find the direction of magnetic fields due to current carrying conductors.
   (c) The difference between the DC and AC is that the DC always flows in one direction whereas the AC reverses its direction periodically
   (d) In India, the AC changes direction after every $\left(\frac{1}{50}\right)$ second

8. A circular loop placed in a plane perpendicular to the plane of paper carries a current when the key is ON. The current as seen from point A and B (in the plane of paper and on the axis of the coil) is anticlockwise and clockwise respectively. The magnetic field lines from point B to A. The N-pole of the resultant magnet is on the face close to



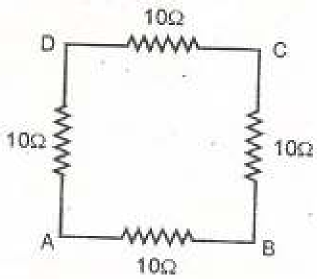
(a) A
(b) B
(c) A if the current is small, and B if the current is large
(d) B if the current is small and A if the current is large

9. The current flowing through a resistor connected in an electrical circuit and the potential difference developed across its ends are shown in the figure given below.



(a) 25 Ω
(b) 20 Ω
(c) 15 Ω
(d) 10 Ω

10. Four resistances, each of 10 Ω are connected to form a square as shown below. The equivalent resistance between two points on any one side (AB) is



(a) 40 Ω
(b) 20 Ω
(c) 7.5 Ω
(d) 15 Ω

11. 10 mL of freshly prepared iron sulphate solution was taken in each of the four test tubes. Strips of copper, iron, zinc and aluminum were introduced, each metal in a different test tube. A black residue was obtained in two of them. The right pair of metals forming precipitates is

(a) Aluminium and copper
(b) Zinc and aluminium
(c) Iron and aluminium
(d) Copper and zinc

12. An aqueous solution turns red litmus solution blue. Excess addition of which of the following solution would reverse the change?

(a) Lime
(b) Baking powder
(c) Hydrochloric acid
(d) Ammonium hydroxide solution

13. Match the acids given in column (A) with the their correct sources given in column (B)

Column (A)	Column (B)
(A) Lactic acid	(i) Tomato
(B) Acetic acid	(ii) Lemon
(C) Citric acid	(iii) Vinegar
(D) Oxalic acid	(iv) Curd

(a) A – (iii), B – (iv), C – (i), D – (ii)
(b) A – (iv), B – (iii), C – (ii), D – (i)
(c) A – (ii), B – (i), C – (iv), D – (iii)
(d) A – (iv), B – (i), C – (ii), D – (iii)

14. Calculate the pH of 10^{-5} M NaOH solution

(a) 6
(b) 5
(c) 9
(d) 14

15. The element with atomic number 14 is hard and forms acid oxide and covalent halide. To which of the following category does the element belong ?

(a) Metal
(b) Non-metal
(c) Left hand side element
(d) Metalloid

16. Ethanol reacts with sodium and forms two products. These are

(a) Sodium ethoxide and oxygen
(b) Sodium ethoxide and hydrogen
(c) Sodium ethanoate and hydrogen
(d) Sodium ethanoat and oxygen

17. The soap molecule has a

(a) Hydrophilic head and a hydrophobic tail
(b) Hydrophilic head and a hydrophilic tail
(c) Hydrophobic head and a hydrophilic tail
(d) Hydrophobic head and a hydrophobic tail

18. Which among the following alloys contain mercury as one of its constituents ?

(a) Alnico
(b) Zink amalgam
(c) Solder
(d) Stainless steel

19. Solder alloy is a constituent of

(a) Lead and tin
(b) Lead and zinc
(c) Lead and nickel
(d) Tin and zinc

20. Which of the following is a correct observation when water is added to lime ?

(a) Slow bubbling with no sound
(b) Vigorous bubbling and a hissing sound
(c) Vigorous bubbling with evolution of heat and hissing sound
(d) No change and a hissing sound

21. The three elements A, B and C with similar properties have atomic masses X, Y and Z respectively. The mass of Y is approximately equal to the average mass of X and Z. What is such an arrangement of elements called as

(a) Mendeleev's periodic law
(b) Dobereiner's triad
(c) Newland's law of octaves
(d) None of these

22. The correct order of electrical conductivity is

(a) Al > Au > Cu > Ag
(b) Cu > Ag > Al > Au
(c) Au > Ag > Al > Cu
(d) Ag > Cu > Au > Al

23. Metal M occurs in earth's crust as its oxide, M_2O_3. An alloy of this metal is used in making aircraft. Name the ore of this metal containing M_2O_3.

(a) $Al_2O_3.2\ H_2O$

(b) Al_2O_3

(c) Fe_2O_3

(d) Cr_2O_3

24. The organs which perform similar functions but have different basic structure are called

(a) Homologus organs

(b) Analogous organs

(c) Asymmetric organs

(d) Homophonic organs

25. Which of the following types of meals would stay in the stomach for the longest period of time ?

(a) Meal high in proteins

(b) Meal high in lipids

(c) Meal high in carbohydrates

(d) All would stay in the stomach about the same amounts of time

26. Indicate which is the proper sequence of blood flow through the circulatory system

(1) Right atrium

(2) Left atrium

(3) Right ventricle

(4) Left ventricle

(5) Pulmonary artery

(6) Pulmonary vein

(7) Lungs

(8) Systemic tissues

(9) Aorta

(10) Vena cava

(a) 1–2–3–4–5–6–7–8–9–10

(b) 10–2–4–5–7–6–2–3–9–8

(c) 10–1–3–5–9–7–6–2–4–8

(d) None of these

27. The correct sequence of reproductive stages occuring in flowering plants is

(a) Zygote gametes

(b) Gametes, zygote, embryo, seed, smbroy seed

(c) Seed, embryo, zygote, gametes

(d) Gametes, embryo, zygote, seed

28. Which among the following are not the functions of testes at puberty?

(i) Formation of germ cells

(ii) Secretion of testosterone

(iii) Development of placenta

(iv) Secretion of estrogen

(a) (i) and (ii)

(b) (i) and (iii)

(c) (iii) and (iv)

(d) (ii) and (i)

29. Darwin's theory of pangenesis shows similarity with the theory of inheritance of acquired characters. Then what shall be correct according to it.

(a) Size of organs increases with ageing

(b) Development of organs is due to will power

(c) Useful organs become strong and developed while useless organs become extinct

(d) There should be some physical basis of inheritance

30. It has been found that people living in very high mountains have many red corpuscles in their blood than people living in plains. Which one of the following best accounts for this phenomenon ?

(a) People of high mountains breathe more quickly

(b) The low air pressure requires more red corpuscles to supply the body cells with oxygen

(c) The cold climate stimulates the production of red corpuscles to keep the body warm

(d) The low air pressure in high mountains speeds up the blood circulation so that more red corpuscles are needed

International Olympia Foundation

Model Test Paper-1

ANSWER

1.(b)	2.(a)	3.(c)	4.(d)	5. NA	6.(d)
7.(a)	8.(b)	9.(d)	10.(d)	11.(b)	12.(d)
13.(b)	14.(c)	15.(c)	16.(d)	17.(b)	18.(c)
19.(c)	20.(c)	21.(a)	22.(b)	23.(c)	24.(c)
25.(b)	26.(d)	27.(c)	28.(a)	29.(c)	30.(b)

Model Test Paper-2

ANSWER

1.(c)	2.(a)	3.(a)	4.(b)	5.(b)	6.(b)
7.(d)	8.(a)	9.(d)	10.(c)	11.(b)	12.(c)
13.(b)	14.(b)	15.(b)	16.(b)	17.(a)	18.(b)
19.(a)	20.(c)	21.(b)	22.(d)	23.(b)	24.(b)
25.(b)	26.(d)	27.(b)	28.(c)	29.(b)	30.(b)